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Stages in the Life History of *Calanus finmarchicus* (Gunnerus), Experimentally Reared by Mr. L. R. Crawshay in the Plymouth Laboratory.

By

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With Plates 1 to 5 in the Text.

[The stages in the development of *Calanus finmarchicus* described and figured by Miss Lebour in the present paper were taken from culture jars given into my charge by Mr. L. R. Crawshay, when he left the Laboratory to undertake military duties in connection with the war. In one jar at that time the first copepodid stage, from eggs laid in the jar, had just been reached, and the technical details for the successful rearing of the animals had been mastered. The experiments had been conducted with great care, and all possible precautions had been taken to prevent contamination. Subsequently the experiments were repeated up to a certain point by myself and some additional stages obtained to complete the series.

The cultures were made in 2-litre glass beakers, containing " outside " sea-water filtered through a Berkefeld filter. In order to secure an even temperature the beakers stood in the circulating water of the Laboratory tanks, and a pure culture of the diatom *Nitzschia closterium* was used as food.—E. J. ALLEN.]

ALL the 5 copepodid stages (the 6th being the fully formed copepod) and 5 out of the 6 nauplius stages were found. Unfortunately the 6th nauplius stage was missed and could not be found in the material, but it is described and well figured by Grobben (1903), and his figures and description show that it is very like the same stage of Pseudocalanus and Paracalanus described by Oberg (1906). The latter author's descriptions agree very closely with all the corresponding stages of *Calanus finmarchicus*, the size in all cases being the chief difference. In the very

young nauplius stage the feelers differ in being long and thin in *Calanus finmarchicus* and short and hook-like in *Pseudocalanus elongatus*.

Nauplius Stage III is much the commonest stage and occurred all the time the material was being examined. The animal probably stays some time in this stage.

The number of bristles on the antennules of the nauplius is a sure guide to the stage, as they are constant and very easily seen. They also agree exactly in number with similar stages in Pseudocalanus and Paracalanus.

The colouring was much the same throughout all the stages, although not so marked in the early nauplius. The first nauplius stage has pigment present only in the region of the alimentary canal, where a few orange and red spots occur, and the tips of the appendages are a light orange. Later on the colouring is more marked. In the first copepodid stages and after the antennules are beautifully spotted with dark red, the bristles being red, and the furcal bristles are red merging into orange ; the tips of the antennæ and mandibles are red, and the distal portions of all the appendages as far as the maxillipeds and also the hind end of the body are yellow. This colouring appears in all the copepodid stages with slight variations.

Grobben's descriptions agree well with the present material. Those stages which he figures are probably I, III, IV or V, and VI, also the first copepodid stage.

THE NAUPLIUS.

Stage I (Plate 1, Fig. 1). Only one specimen. This is very like Grobben's figure of the early nauplius, but he figures only 2 bristles on the antennule where the present specimen has 3. It appears to be an earlier stage than any of Oberg's. His Stage I of Pseudocalanus agrees with Stage II of the present species. His Stages III–V agree with the corresponding stages of Calanus as described in the present paper. Length of body 0·21 mm., oval, slightly more pointed posteriorly than anteriorly, faintly pink with orange tips to the appendages. Eye dark red. A pair of thin feelers at the hind end of the body.

Appendage I. Antennule (Plate 2, Fig. 1). The end segment divided off, the other 2 merely indicated. A small bristle just behind the end segment, the latter bearing 3 bristles.

Appendage II. Antenna (Plate 2, Fig. 6).
Coxopodite with a large thorn-like masticatory process.
Basipodite with 2 roundish prominences, the proximal portion with 2 small bristles.
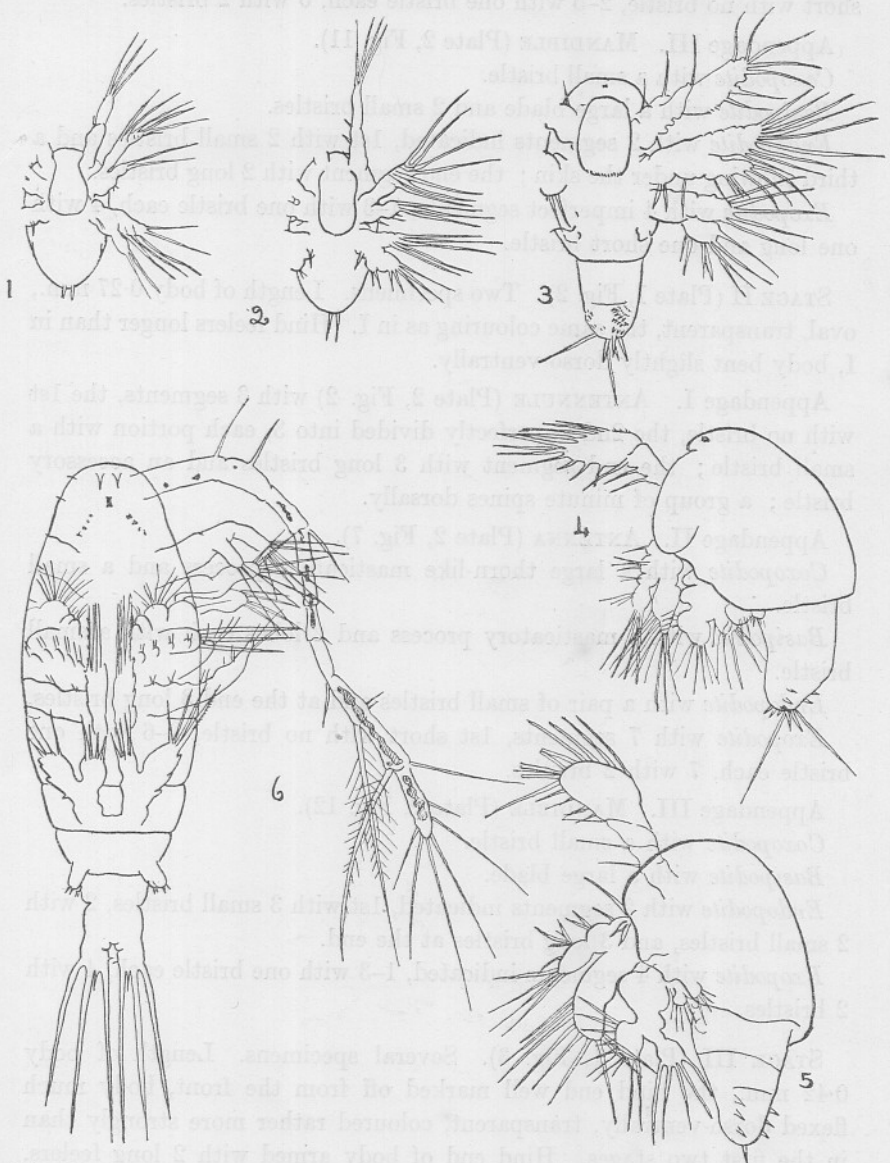
Endopodite with 2 long bristles at the end.

Exopodite with 6 segments, the 7th showing under the skin, 1st segment short with no bristle, 2–5 with one bristle each, 6 with 2 bristles.

Appendage III. MANDIBLE (Plate 2, Fig. 11).

Coxopodite with a small bristle.

Basipodite with a large blade and 2 small bristles.

Endopodite with 2 segments indicated, 1st with 2 small bristles and a third showing under the skin ; the end segment with 2 long bristles.

Exopodite with 4 imperfect segments, 1–3 with one bristle each, 4 with one long and one short bristle.

STAGE II (Plate 1, Fig. 2). Two specimens. Length of body 0·27 mm., oval, transparent, the same colouring as in I. Hind feelers longer than in I, body bent slightly dorso-ventrally.

Appendage I. ANTENNULE (Plate 2, Fig. 2) with 3 segments, the 1st with no bristle, the 2nd imperfectly divided into 3, each portion with a small bristle ; the end segment with 3 long bristles and an accessory bristle ; a group of minute spines dorsally.

Appendage II. ANTENNA (Plate 2, Fig. 7).

Coxopodite with a large thorn-like masticatory process and a small bristle.

Basipodite with a masticatory process and 2 lobes each with a small bristle.

Endopodite with a pair of small bristles and at the end 3 long bristles.

Exopodite with 7 segments, 1st short with no bristle, 2–6 with one bristle each, 7 with 2 bristles.

Appendage III. MANDIBLE (Plate 2, Fig. 12).

Coxopodite with a small bristle.

Basipodite with a large blade.

Endopodite with 2 segments indicated, 1st with 3 small bristles, 2 with 2 small bristles, and 3 long bristles at the end.

Exopodite with 4 segments indicated, 1–3 with one bristle each, 4 with 2 bristles.

STAGE III (Plate 1, Fig. 3). Several specimens. Length of body 0·42 mm., the hind end well marked off from the front, body much flexed dorso-ventrally, transparent, coloured rather more strongly than in the first two stages. Hind end of body armed with 2 long feelers, one dorsal and one ventral, a pair of lateral and a pair of posterior hooks. Near the hooks are 3 rows of very short, sharp spines and the same sort of spines surround the bases of the hooks. Besides the 3 pairs of appendages there is a slight indication of a 4th (maxillule).

Plate 2.

M. V. Lebour.   Calanus finmarchicus.
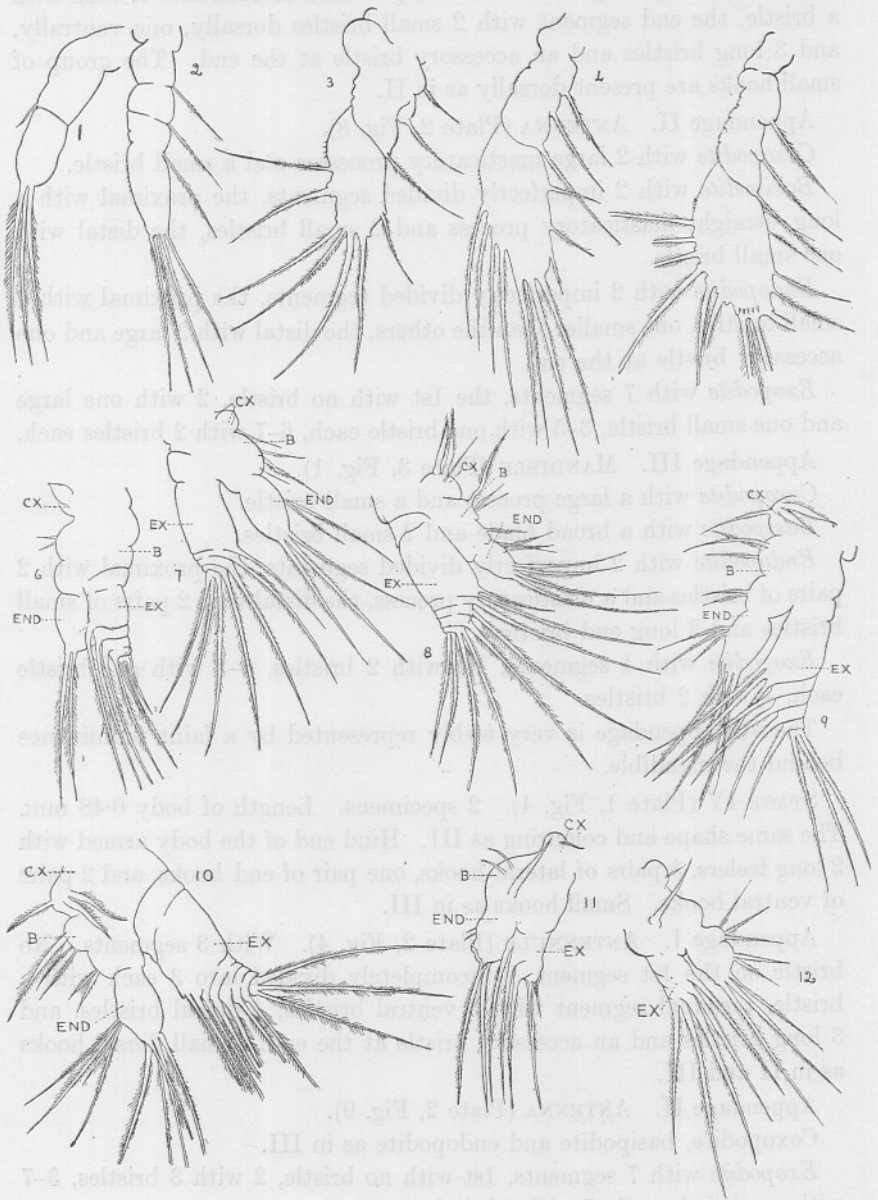
M.V.L. del.

Appendage I. ANTENNULE (Plate 2, Fig. 3). With 3 segments, no bristle on the first segment, second imperfectly divided into 3, each with a bristle, the end segment with 2 small bristles dorsally, one ventrally, and 3 long bristles and an accessory bristle at the end. The group of small hooks are present dorsally as in II.

Appendage II. ANTENNA (Plate 2, Fig. 8).

Coxopodite with 2 large masticatory processes and a small bristle.

Basipodite with 2 imperfectly divided segments, the proximal with a long, straight masticatory process and 2 small bristles, the distal with one small bristle.

Endopodite with 2 imperfectly divided segments, the proximal with 3 small bristles, one smaller than the others, the distal with 3 large and one accessory bristle at the end.

Exopodite with 7 segments, the 1st with no bristle, 2 with one large and one small bristle, 3–5 with one bristle each, 6–7 with 2 bristles each.

Appendage III. MANDIBLE (Plate 3, Fig. 1).

Coxopodite with a large process and a small bristle.

Basipodite with a broad blade and 2 small bristles.

Endopodite with 2 imperfectly divided segments, the proximal with 2 pairs of bristles and a masticatory process, the distal with 2 pairs of small bristles and 2 long end bristles.

Exopodite with 4 segments, 1st with 2 bristles, 2–3 with one bristle each, 4 with 2 bristles.

The 4th appendage is very feebly represented by a faint prominence behind the mandible.

STAGE IV (Plate 1, Fig. 4). 2 specimens. Length of body 0·48 mm. The same shape and colouring as III. Hind end of the body armed with 2 long feelers, 3 pairs of lateral hooks, one pair of end hooks, and 2 pairs of ventral hooks. Small hooks as in III.

Appendage I. ANTENNULE (Plate 2, Fig. 4). With 3 segments. No bristle on the 1st segment, 2 incompletely divided into 3 each with a bristle, terminal segment with 3 ventral bristles, 4 dorsal bristles, and 3 long bristles and an accessory bristle at the end. Small dorsal hooks as in II and III.

Appendage II. ANTENNA (Plate 2, Fig. 9).

Coxopodite, basipodite and endopodite as in III.

Exopodite with 7 segments, 1st with no bristle, 2 with 3 bristles, 3–7 with one bristle each, 7 with 3 bristles.

Appendage III. MANDIBLE (Plate 3, Fig. 2).

Coxopodite with a well-developed toothed process like the adult but with fewer teeth.

CX
B
EX
END

CX
END
EX
EX
END

CX
B
END
EX
3

END
6
END
EX
B

B
EX
END
5

EX
END
L

END
CX
9

CX
10
END

7
B
EX
END

CX(G)
EP
B
END
8
EX
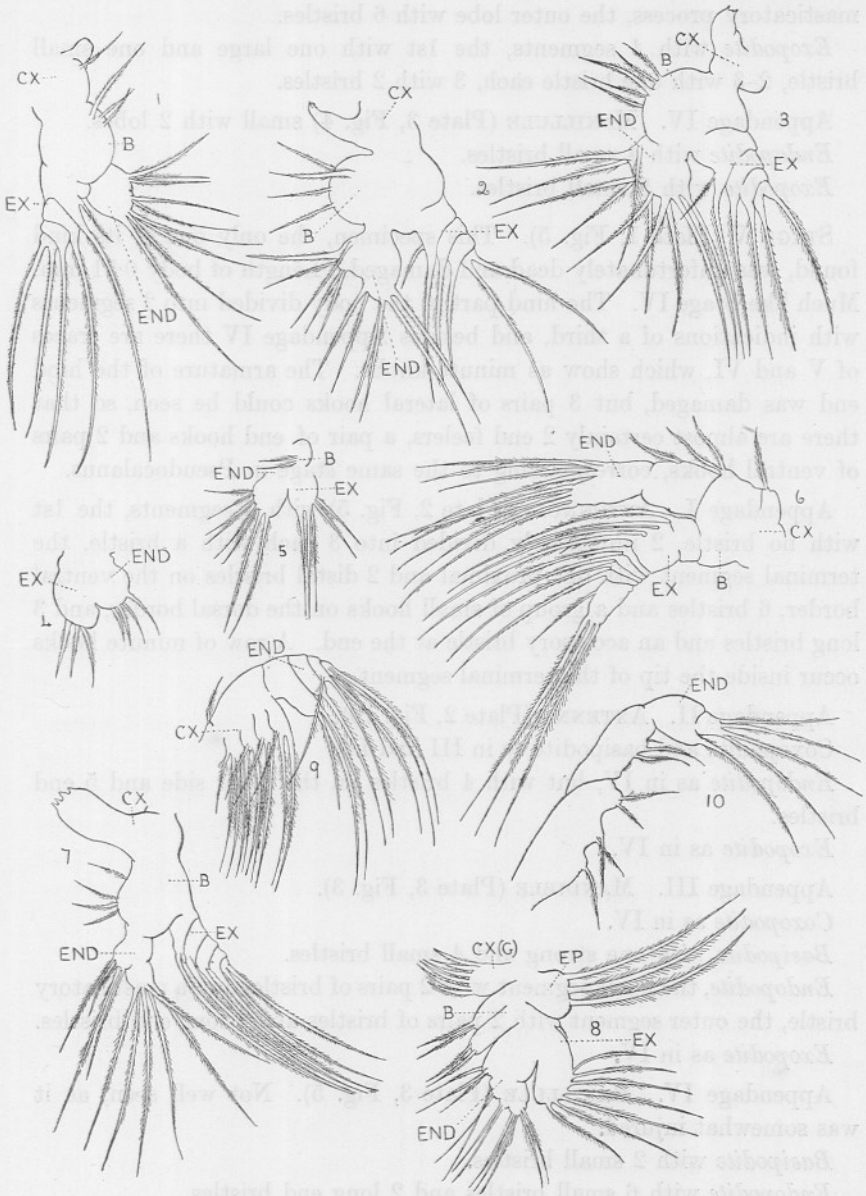
M. V. L. del.

Basipodite with a large blade and 3 small bristles.

Endopodite with 2 lobes, the inner lobe with 4 bristles and a small masticatory process, the outer lobe with 6 bristles.

Exopodite with 4 segments, the 1st with one large and one small bristle, 2–3 with one bristle each, 3 with 2 bristles.

Appendage IV. MAXILLULE (Plate 3, Fig. 4) small with 2 lobes.

Endopodite with 4 small bristles.

Exopodite with 3 small bristles.

STAGE V (Plate 1, Fig. 5). This specimen, the only one of its kind found, was unfortunately dead and damaged. Length of body 0·51 mm. Much like Stage IV. The hind part of the body divided into 2 segments with indications of a third, and besides Appendage IV there are traces of V and VI, which show as minute knobs. The armature of the hind end was damaged, but 3 pairs of lateral hooks could be seen, so that there are almost certainly 2 end feelers, a pair of end hooks and 2 pairs of ventral hooks, corresponding to the same stage in Pseudocalanus.

Appendage I. ANTENNULE (Plate 2, Fig. 5) with 3 segments, the 1st with no bristle, 2 imperfectly divided into 3 each with a bristle, the terminal segment with one proximal and 2 distal bristles on the ventral border, 6 bristles and a group of small hooks on the dorsal border, and 3 long bristles and an accessory bristle at the end. A row of minute hooks occur inside the tip of the terminal segment.

Appendage II. ANTENNA (Plate 2, Fig. 10).

Coxopodite and basipodite as in III and IV.

Endopodite as in IV, but with 4 bristles on the inner side and 5 end bristles.

Exopodite as in IV.

Appendage III. MANDIBLE (Plate 3, Fig. 3).

Coxopodite as in IV.

Basipodite with one strong and 4 small bristles.

Endopodite, the inner segment with 2 pairs of bristles and a masticatory bristle, the outer segment with 2 pairs of bristles and 2 long end bristles.

Exopodite as in IV.

Appendage IV. MAXILLULE (Plate 3, Fig. 5). Not well seen, as it was somewhat injured.

Basipodite with 2 small bristles.

Endopodite with 6 small bristles and 2 long end bristles.

Exopodite with 2 short bristles and 3 long end bristles.

STAGE VI. Not seen. Grobben gives a good figure of this stage, which is very like the description and figure of Pseudocalanus by Oberg. The

rather long body is armed at the hind end with 4 pairs of lateral hooks, 2 feelers, 2 end hooks, and 2 pairs of ventral hooks.   The maxillæ and maxillipeds are well developed and swimming feet I and II are present as bilobed structures.

This is the last nauplius stage.

COPEPODID STAGES.

There are 5 copepodid stages before the animal is fully formed.   These were recognised by Gran (1902), who gives 6 stages, the last being the mature Calanus.   All the 5 stages occurred and were taken from experimental jars started on March 30th, 1915.   Nauplii first appeared between the 17th and 24th of April, and on May 19th Stage V was taken from the jar, having taken certainly less than two months to grow from the egg to this stage.

The species can be recognised from the first copepodid stage by the 2 long sensory bristles on the penultimate segments of the antennules.   The rostral processes are distinct even in the first stage, which, according to Oberg, is not the case with Pseudocalanus, where they appear only in the second stage.

Stage I (Plate 1, Fig. 6, and Plate 4, Fig. 1).   Length of body 0·80 mm. Three free thoracic segments and urosome of one segment with an anterior constriction.   In shape like the adult, but broader in comparison with its length.   Caudal furca like the adult, but with 3 long bristles and one short bristle, besides a short inner bristle each side.   The antennules are now long like the adult, and usually held out almost at right angles to the body.   Colour pale yellow all round the edges of the body, antennules, antennæ, mandibles, part of maxillule, maxilliped, and caudal furca, the tips of all these appendages changing from yellow to red as the extremities are reached.   Red pigment occurs all along the antennules, the 3 end segments being almost completely red, and dark red blotches run from the base to about the centre.   Traces of red pigment are to be seen in the anterior part of the body.   Eye dark red.   Rostral processes present. There are 2 pairs of well-developed swimming feet and one rudimentary pair.   All the other appendages are well developed.

Appendage I.   Antennule 10 jointed, long, red sensory bristles, one on the antepenultimate and one on the penultimate segment.

Appendage II.   Antenna (Plate 3, Fig. 6).
Coxopodite very small with one bristle.
Basipodite, the masticatory bristle has disappeared.   2 bristles present.

1   2   3   4

5   6   7   8   9

10   11   12   13   14   15

16   17   18   19   20   21
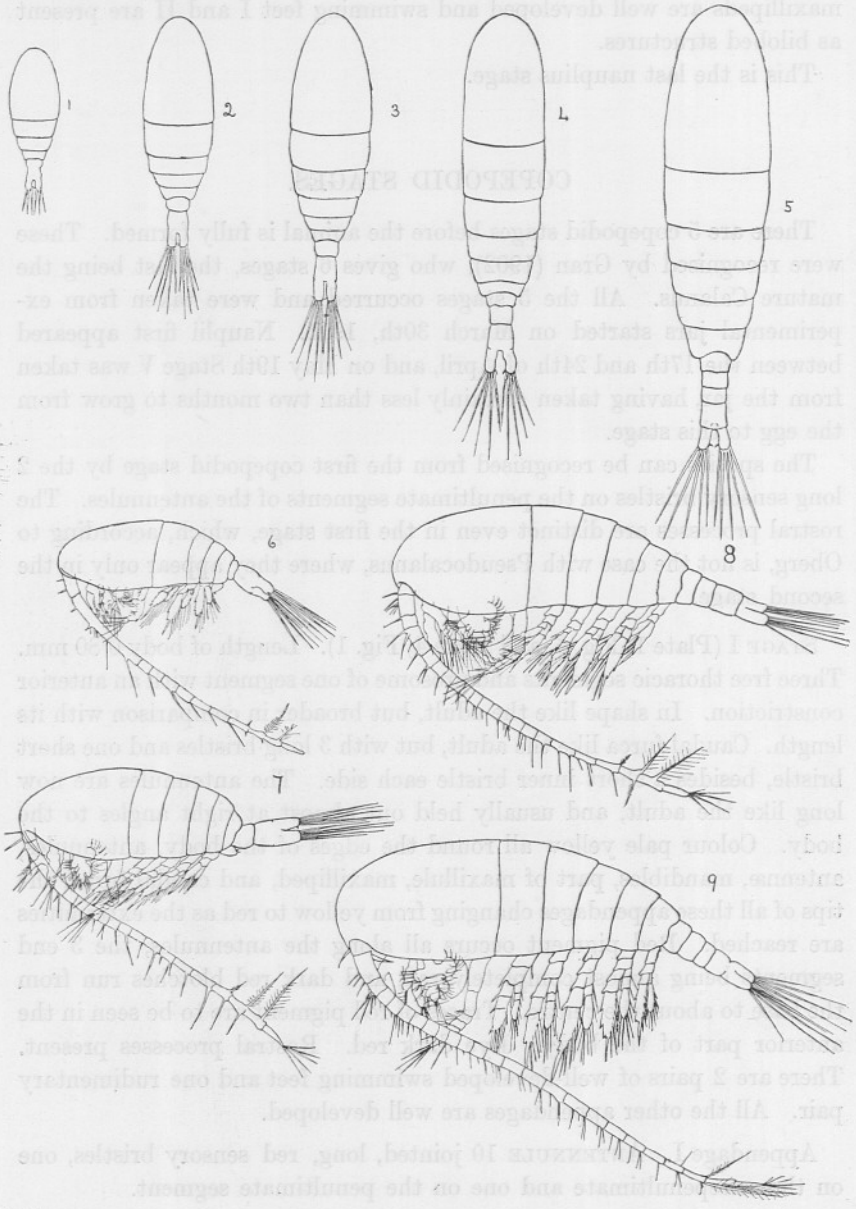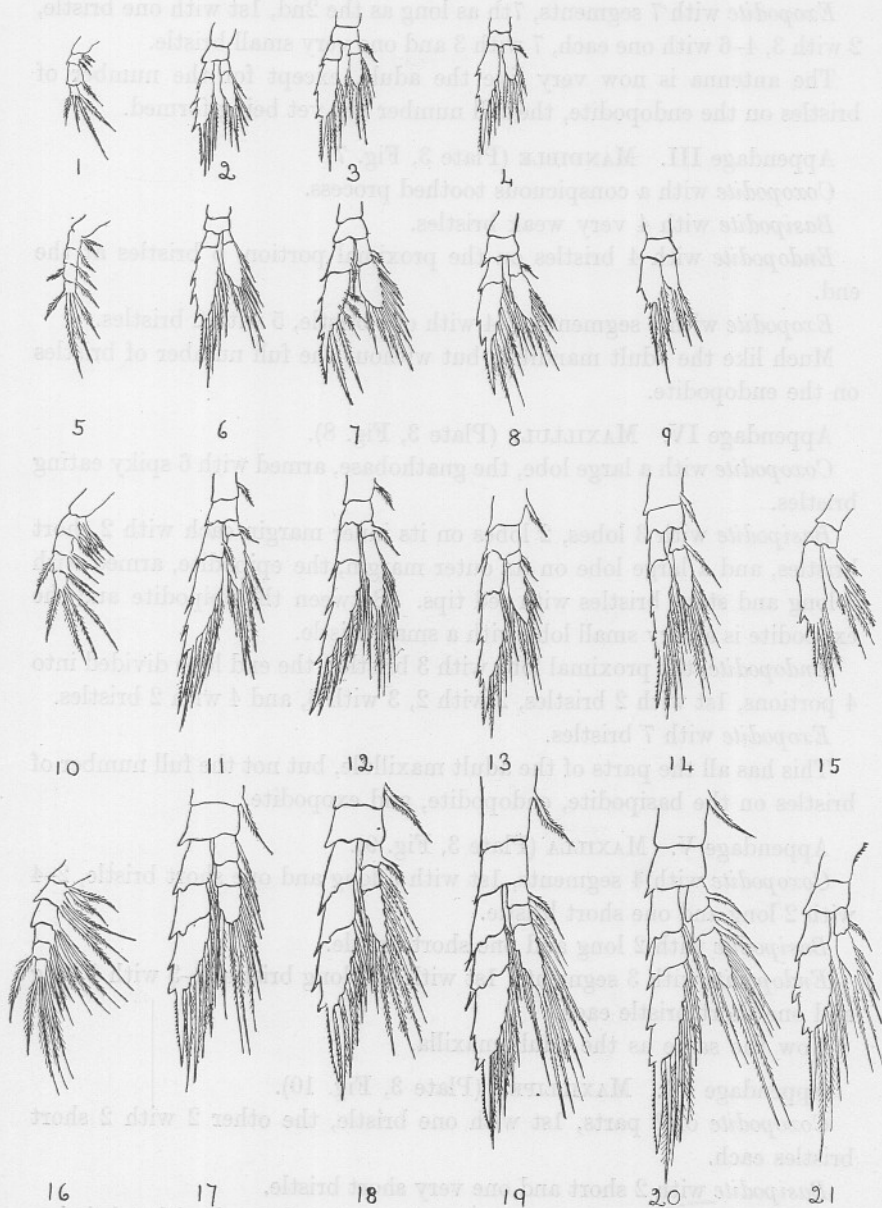
M.V.L. del.

Endopodite with 2 segments, 1st with 2 bristles, 2 with 4 lateral bristles and 5 end bristles.

Exopodite with 7 segments, 7th as long as the 2nd, 1st with one bristle, 2 with 3, 4–6 with one each, 7 with 3 and one very small bristle.

The antenna is now very like the adult, except for the number of bristles on the endopodite, the full number not yet being formed.

Appendage III. MANDIBLE (Plate 3, Fig. 7).

Coxopodite with a conspicuous toothed process.

Basipodite with 4 very weak bristles.

Endopodite with 4 bristles on the proximal portion, 6 bristles at the end.

Exopodite with 5 segments, 1–4 with one bristle, 5 with 2 bristles.

Much like the adult mandible, but without the full number of bristles on the endopodite.

Appendage IV. MAXILLULE (Plate 3, Fig. 8).

Coxopodite with a large lobe, the gnathobase, armed with 6 spiky eating bristles.

Basipodite with 3 lobes, 2 lobes on its inner margin each with 2 short bristles, and a large lobe on its outer margin, the epipodite, armed with 3 long and stout bristles with red tips. Between the epipodite and the exopodite is a very small lobe with a small bristle.

Endopodite, the proximal lobe with 3 bristles, the end lobe divided into 4 portions, 1st with 2 bristles, 2 with 2, 3 with 3, and 4 with 2 bristles.

Exopodite with 7 bristles.

This has all the parts of the adult maxillule, but not the full number of bristles on the basipodite, endopodite, and exopodite.

Appendage V. MAXILLA (Plate 3, Fig. 9).

Coxopodite with 4 segments, 1st with 3 long and one short bristle, 2–4 with 2 long and one short bristle.

Basipodite with 2 long and one short bristle.

Endopodite with 3 segments, 1st with one long bristle, 2–3 with 2 long and one short bristle each.

Now the same as the adult maxilla.

Appendage VI. MAXILLIPED (Plate 3, Fig. 10).

Coxopodite of 3 parts, 1st with one bristle, the other 2 with 2 short bristles each.

Basipodite with 2 short and one very short bristle.

Endopodite with 2 segments, 1st with one bristle, 2nd with 4 bristles.

Appendage VII. 1ST SWIMMING FOOT.

Coxopodite and *basipodite* with no bristles.

Endopodite unsegmented, with 4 long bristles.

Exopodite unsegmented, with 4 thorns on the outer margin, a terminal blade, and 3 bristles inside.

Appendage VIII. 2ND SWIMMING FOOT. Like the first, but with one more bristle on the inside of the endopodite. The exopodite has 4 thorns outside and a terminal bristle, with 3 bristles inside.

Appendage IX. 3RD SWIMMING FOOT with 2 lobes, each lobe with 2 hooks at the end.

STAGE II (Plate 4, Figs. 2 and 6).

Length of body 1·20 mm., 4 free thoracic segments, urosome of 2 segments. Caudal furca like the adult, with 5 bristles and a small lateral inner bristle. Colouring the same as I, but slightly lighter. 3 pairs of swimming feet and the rudiments of a 4th pair.

Appendage I. ANTENNULE with 12 segments, the last 7 the same as I.

Appendage II. ANTENNA the same as I.

Appendage III. MANDIBLE the same as I.

Appendage IV. MAXILLULE the same as I, but with 7 bristles on the epipodite.

Appendage V. MAXILLA the same as I.

Appendage VI. MAXILLIPED (Plate 5, Fig. 1).

Endopodite with a 3rd segment, 1st segment with one broad and 2 small bristles, other segments as in I.

Appendage VII. 1ST SWIMMING FOOT (Plate 5, Fig. 2).

Endopodite with 2 segments, no bristle on 1st segment, 2 with 2 long bristles on the outside, one terminal bristle, and 4 bristles inside.

Exopodite with 2 segments, a thorn on the outside of the first, 2 thorns on the outside of the 2nd, a terminal blade, and 4 long bristles inside.

Appendage VIII. 2ND SWIMMING FOOT (Plate 5, Fig. 3).

Endopodite with 2 segments, 1st with one bristle, 2nd with 4 bristles inside, a terminal bristle, and 2 bristles outside.

Exopodite with 2 segments, 1st with a thorn, 2nd with 3 thorns outside, a terminal blade, and 4 bristles inside.

Appendage IX. 3RD SWIMMING FOOT (Plate 5, Fig. 4).

Endopodite unsegmented, one proximal and 3 distal bristles inside, a terminal bristle, and one bristle outside.

Exopodite unsegmented, 3 thorns outside, a terminal blade, and 3 bristles inside.

Appendage X. 4TH SWIMMING FOOT with 2 lobes each with 2 hooks.

STAGE III (Plate 4, Figs. 3 and 7). Like Stage II in colouring. Body more elongated. Length 1·20 mm., 5 free thoracic segments. Urosome of 2 segments. All 5 swimming feet present, the 5th rudimentary.

Appendage I. ANTENNULE with 16 segments, otherwise like II.

Appendage II. ANTENNA like I and II, but with 6 bristles on the inner part of the endopodite.

Appendage III. MANDIBLE like I and II, but with 8 bristles at the end of the exopodite.

Appendage IV. MAXILLULE.
Coxopodite with the gnathobase bearing 8 bristles.
Basipodite like I and II, but with 3 bristles on the proximal lobe.
Endopodite like I and II, but with 4 bristles on the first lobe and 10 on the end lobe.

Appendage V. MAXILLA like adult.

Appendage VI. MAXILLIPED (Plate 5, Fig. 5).
Endopodite of 4 segments, 1st with 3 bristles, 2 with one, 3 with one and a small outer bristle, 4 with 4 bristles at the end.

Appendage VII. 1ST SWIMMING FOOT (Plate 5, Fig. 6).
Endopodite with 2 segments, distal segment with 4 bristles inside, 2 terminal bristles, and one bristle outside.
Exopodite with 2 segments, distal segment with 4 bristles inside, a terminal blade, and 4 thorns outside.

Appendage VIII. 2ND SWIMMING FOOT (Plate 5, Fig. 7).
Endopodite with 2 segments, proximal segment with one bristle inside, distal segment with 5 bristles inside, 2 terminal bristles, and 2 bristles outside.
Exopodite with 2 segments, one bristle on the proximal segment inside and a thorn outside, 5 bristles on the distal segment inside, a terminal blade, and 3 thorns outside.

Appendage IX. 3RD SWIMMING FOOT (Plate 5, Fig. 8).
Endopodite with 2 segments, one bristle on the proximal segment inside, distal segment with 3 bristles inside, 2 terminal bristles, and 2 bristles outside.
Exopodite with 2 segments, the proximal segment with one bristle inside and a thorn outside, the distal segment with 4 bristles inside, a terminal blade, and 2 thorns outside.

Appendage X. 4TH SWIMMING FOOT (Plate 5, Fig. 9).
Endopodite unsegmented, with 3 bristles.
Exopodite unsegmented, with 3 bristles inside, a terminal blade, and 3 thorns outside.

Appendage XI. 5TH SWIMMING FOOT 2-lobed, each lobe with 2 hooks.

STAGE IV (Plate 4, Figs. 4 and 8). Very like III. Thorax with 5 free segments each with a well-developed swimming foot. Urosome of 3 segments.

Appendage I. ANTENNULE with 23 segments.

Appendage II. ANTENNA like I, but with 7 bristles on the inner lobe of the endopodite. Very like the adult.

Appendage III. MANDIBLE like I–III.

Appendage IV. MAXILLULE like I–III, but the epipodite is larger with 9 bristles now like the adult, the 1st inner lobe of the basipodite has 3 bristles like the adult, endopodite with 5 bristles at the end.

Appendage V. MAXILLA like the adult.

Appendage VI. MAXILLIPED (Plate 5, Fig. 10).
Endopodite of 4 segments, 1st with 4 bristles, 2 with 2, 3 with 2 inside and one outside, terminal segment with 4 bristles.

Appendage VII. 1ST SWIMMING FOOT (Plate 5, Fig. 11). The proximal joint of the basipodite with an inside bristle.
Endopodite with 2 segments, the proximal segment with an inside bristle, the distal segment with 3 inside bristles, 2 terminal bristles, and one outside bristle.
Exopodite with 2 segments, the proximal segment with an inside bristle and an outside thorn, the distal segment with 4 bristles inside, a terminal blade, and 3 thorns outside.

Appendage VIII. 2ND SWIMMING FOOT (Plate 5, Fig. 12).
The proximal segment of the basipodite with an inside bristle, the distal segment with an outside thorn.
Endopodite with 2 segments, the proximal segment with one bristle inside, the distal segment with 5 bristles inside, 2 terminal bristles, and 2 bristles outside.
Exopodite with 2 segments, the proximal segment with one bristle inside and a thorn outside, the distal segment with 5 bristles inside, a terminal blade, and 3 thorns outside.

Appendage IX. 3RD SWIMMING FOOT (Plate 5, Fig. 13). The proximal segment of the basipodite with a bristle inside, the distal segment with a thorn outside.
Endopodite with 2 segments, the proximal segment with one bristle inside, the distal segment with 4 bristles inside, 2 terminal bristles, and 2 bristles outside.

Exopodite with 2 segments, the proximal segment with a bristle inside and a thorn outside, the distal segment with 4 bristles inside, a terminal blade, and 3 thorns outside.

Appendage X. 4TH SWIMMING FOOT (Plate 5, Fig. 14). The proximal segment of the basipodite with an inside bristle, the distal segment with a thorn outside.

Endopodite with 2 segments, the proximal segment with one bristle inside, the distal segment with 3 bristles inside, 2 terminal bristles, and 2 bristles outside.

Exopodite with 2 segments, the proximal segment with an outside thorn, the distal segment with 4 bristles inside, a terminal blade, and 3 thorns outside.

Appendage XI. 5TH SWIMMING FOOT (Plate 5, Fig. 15).

Endopodite unsegmented, with 6 bristles.

Exopodite unsegmented, with 3 bristles inside, a terminal blade, and 3 thorns outside.

STAGE V (Plate 4, Figs. 5 and 9). Body much longer, the full number of segments in the thorax and urosome. Antennules, antennæ, mandibles, maxillules, maxillæ, and swimming feet I to IV like the adult. The maxilliped has not yet the full number of bristles (Plate 5, Fig. 16). 1st segment with 5 bristles, 2 with 3, 4 with 2 inside and one outside, terminal segment with 4 bristles. The swimming feet (Plate 5, Figs. 17–21) are all like the adult with the exception of the last, which, although having the full number of bristles, has only 2 segments to the endopodite and exopodite.

Stage VI is the fully developed copepod.

LITERATURE.

1902. GRAN, H. H.—Das Plankton des Norwegischen Nordmeeres. Report on Norwegian Fishery and Marine Investigations. Vol. II, 1902, No. 5.

1881. GROBBEN, C.—Die Entwicklungsgeschichte von Cetochilus septentrionalis Goodsir. Arbeiten aus dem Zoologischen Institute der Universität Wien, etc. Vol. III, Part 3.

1906. OBERG, M.—Die Metamorphose der Plankton-Copepoden der Kieler Bucht. Wissenschaftliche Meeresuntersuchungen herausgegeben von der Kommission zur Wissenschaftlichen Untersuchung der deutschen meer in Kiel, etc. N.S. Vol. IX. Abt. Kiel.

1903. SARS, G. O.—An Account of the Crustacea of Norway. Vol. IV. Copepoda Calanoida.

The work on the Copepoda of the Danish Ingolf Expedition, Vol. III, Part 4, 1915, by Carl With, came to hand after the present paper was in print.

EXPLANATION OF FIGURES.

PLATE 1.—1. Nauplius Stage I. × 80.
    2.   ,,   ,, II.   ,,
    3.   ,,   ,, III.   ,,
    4.   ,,   ,, IV.   ,,
    5.   ,,   ,,   V.   ,,
    6. Copepodid ,,   I.   ,,

PLATE 2.—1. 1st Appendage (Antennule) of Nauplius I.
    2.   ,,   ,,   ,,   ,,   II.
    3.   ,,   ,,   ,,   ,, III.
    4.   ,,   ,,   ,,   ,, IV.
    5.   ,,   ,,   ,,   ,,   V.
    6. 2nd   ,,   (Antenna)   ,,   I.
    7.   ,.   ,,   ,,   ,,   II.
    8.   ,,   ,,   ,,   ,, III.
    9.   ,,   ,,   ,,   ,, IV.
   10   ,,   ,,   ,,   ,,   V.
   11. 3rd   ,,   (Mandible)   ,,   I.
   12.   ,,   ,,   ,,   ,,   II.

                    × 175.

PLATE 3.—1. 3rd Appendage (Mandible) of Nauplius III.
    2.   ,,   ,,   ,,   ,, IV.
    3.   ,,   ,,   ,,   ,,   V.
    4. 4th   ,.   (Maxillule)   ,, IV.
    5.   ,,   ,,   ,,   ,,   V.
    6. 2nd   ,,   (Antenna) of Copepodid Stage I.
    7. 3rd   ,,   (Mandible)   ,,   ,,
    8. 4th   .,   (Maxillule)   ,,   ,,
    9. 5th   ,.   (Maxilla)   ,,   ,,
   10. 6th   ,,   (Maxilliped)   ,,   ,,

                    × 175.

             CX   Coxopodite.
             B   Basipodite.
             EP   Epipodite.
           END Endopodite.
             EX   Exopodite.
             G   Gnathobase.

PLATE 4.—1–5. Dorsal view of Copepodid Stages I–V.
                    × 18.

      6–9. Lateral view of Copepodid Stages II–V.
                    × 18.

PLATE 5.—Distal portion of Maxilliped and Swimming Feet of Copepodid Stages
                    II–V.
                   × 26·6.

Experiments on the Mendelian Inheritance of Eye-colour in the Amphipod *Gammarus chevreuxi*.

By

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AND

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With Plate I.

CONTENTS.

THE Amphipod which was used in the following experiments was described in 1913 (*Journ. M.B.A.*, Vol. IX, pp. 542–545) under the name of *Gammarus chevreuxi*, and its life history was then worked out (see Sexton and Matthews, *l.c.*, pp. 546–556).

The usual colour of the eye in this species, as in the other species of the genus *Gammarus*, is black, but several females and young with red eyes were observed while the above work was in progress. Beyond recording

the fact, however (*l.c.*, pp. 543 and 552), no special attention was given to the matter.

The descendants of two original pairs taken in June, 1912, were kept under observation for moults, etc., in the Laboratory until August, 1913, when the present writers undertook to investigate the variation in eye-colour, with a view to determining first if it were a sex-limited character, and secondly, if it conformed to the Mendelian law of inheritance.

In the course of these investigations we have received constant assistance and advice from the Director, Dr. E. J. Allen, f.r.s., at whose suggestion they were first undertaken, and we wish here to acknowledge our great indebtedness to him.

GENERAL CONDITIONS.

Before entering into the detailed results of the experiments it will be necessary to give a brief description of the habits of the species as well as of the conditions under which the animals were kept in the Laboratory.

Gammarus chevreuxi is an ideal species for experimental work. It is very hardy, quickly reaches maturity, and breeds all the year round. The young are extruded from the marsupial pouch and another batch of eggs laid generally within 24 hours of the time of hatching. During the summer season a brood takes from 12 to 14 days to hatch, and the period of sexual activity is reached at the age of 36 days ; in winter in natural conditions a brood takes 30 days to hatch, and does not become sexually mature for at least 3 months, low temperature, as would be expected, retarding development. In the Laboratory, however, which is heated in the winter, there is practically no difference in the seasons, and it therefore becomes possible to obtain several generations in the year.

It may be well to state here that in this species of *Gammarus* the female never lays eggs unless a male is present, and also that it is absolutely impossible for a male to fertilise two broods of eggs with one deposition of sperm. The male generally takes the female a few days before the eggs hatch, and carries it until the young are extruded from the pouch. The female then moults, assisted by the male, as described in the paper referred to above (*l.c.*, p. 550). The aperture of the oviduct is opened by the removal of the old cuticle, and the male deposits the sperm in the pouch around it, but unless the eggs are laid within a few hours they cannot be laid at all. The cuticle hardens rapidly, and a plug of the glutinous lubricatory matter which accompanies moulting and oviposition closes the aperture and hardens to the consistency of the cuticle, effectually

blocking the oviduct, until another moult takes place and the plug is sloughed with the old cuticle.

Another point must be mentioned in regard to the suitability of this species for laboratory work, and that is the ease with which it adapts itself to artificial conditions. This is probably due to the fact that it comes from brackish water ditches where it is habituated to great variations of temperature, salinity, pressure due to depth of water, etc. The density, for example, varies to an extraordinary degree according to the season, tides, excessive rainfall or drought, ranging from 1 to 1·028.

In the experimental work, it has been necessary to keep the water as nearly as possible at the same salinity, as any sudden change of conditions always affects the animals' growth and breeding. A mixture of one part of sea-water to six parts of fresh water gives the same density (1·004) as that found in the ditches when the animals were taken, and such water we have generally used.

The best results have been obtained by keeping the animals in finger-bowls, generally one pair in a bowl. Each bowl contained about 200 c.cs. of water, and was covered with a glass plate to check evaporation and exclude dust. No aerating apparatus was used, the animals obtaining sufficient air for their needs from the surface of the water exposed in the bowls. In the same amount of water but with a smaller surface exposed to the air they did not flourish at all, as was found later when using jam jars and honey jars for the broods ; only a very small proportion of the young reached maturity.

For food dry leaves of all kinds were used, after they had been allowed to rot in water. It was found that the animals preferred the soft tissues of the leaves of elm, hazel, and sycamore, rather than the harder leaves of oak, beech, etc. A fine delicate Ulva from the ditches they ate freely, but when the supply failed and the harder marine variety (*Ulva latissima*) was given, they did not eat it until it macerated. They flourish better and are much healthier with some of the mud from the ditches in the bowls, but in all these experiments we were obliged to keep the water clear, in order to watch the animals without disturbing them unnecessarily. The young are so minute—about 1 mm. in length when hatched—that they completely escape observation in the mud, clinging as they do to any particles of dirt or weed.

The bowls were kept in ordinary diffused light, strong sunlight being avoided.

A word of explanation is necessary as to the terms employed in this paper. The Black eye-colour is dominant to the Red, and therefore Red is referred to as Recessive (R.). Black divides into Pure (P.) and Impure, but instead of the term " impure " the word Hybrid (H.) is used.

THE PIGMENTATION OF THE EYE.

The structure of the eye of *Gammarus* has been well described and figured by Parker (" The Compound Eyes in Crustaceans," *Bull. Mus. Comp. Zool.*, Harvard, Vol. XXI, Plate I), the species investigated by him being the *Gammarus ornatus* of Milne-Edwards (=*Gammarus locusta*, Linn., Stebbing, *Das Tierreich*, V. 21, p. 476).

Sections of the eye of *Gammarus chevreuxi* show precisely the same internal structure. The eye in this species is reniform in the adult, oval in the young animal, much raised and rounded. The superficial aspect presents a reticulation of opaque white pigment, with the ommatidia appearing as coloured spots, black or red, in the spaces of the network.

The black pigment of the retinular cells of the ommatidia of the *Black* eye appears to be produced by a combination of black and red, even in the so-called " Pure Black " animals (Fig. 1), with a larger admixture of the red in the " Hybrid Blacks " (Figs. 2 and 4).

The pigment of the *Red* eye is pure red, with no alloy of the black (Figs. 3 and 5).

Sometimes the retinular cells are unpigmented and the white reticulation shows up in a very striking way, giving the effect of chalk-white eyes — the " *All-white* " eye referred to in the paper (Figs. 8, 9, and 10).

Occasionally again, some of the ommatidia are pigmented and some not ; this variation is called the " *Part-white* " eye (Fig. 7).

The white opaque pigment is subject to great variation, sometimes showing as faint thread-like lines, sometimes broken up and irregular, sometimes present in excess, obscuring the ommatidia, and sometimes it is entirely lacking, the " *No-white* " eye (Fig. 6). Animals are often found with one or both eyes affected. The defect can be transmitted by normal-eyed animals to both black and red eyed offspring.

THE FIRST APPEARANCE OF THE RED EYES.

Two pairs of *Gammarus chevreuxi* were taken in June, 1912, those referred to in the previous paper as Pair I and Pair II. All four animals were black-eyed.

All the broods from Pair II were black-eyed. This stock (which is referred to as the " Pure Black " stock) has been kept under observation from June, 1912, till now, December, 1915, fresh black-eyed material from the ditches being added from time to time. Not a single red-eyed animal has appeared in it. The strain was tested by mating also, to make absolutely certain of its purity before using it in the experiments.

The first brood from Pair I were all black-eyed : 9 young ones coming to maturity, 3 males and 6 females. The first pair to mate (Pair A) were evidently the strongest, and had the largest broods, although owing to unfavourable conditions only a few in each brood survived. The first brood from this Pair A numbered 18 ; the young were counted on hatching, but not examined for eye-colour ; of these 1 male and 6 females came to maturity, one of the females with red eyes. The second brood was 28 in number, 1 male and 5 females surviving, and again one female had red eyes. For the third mating of the female A a different male was used (male S), one which was freshly captured. The ensuing brood was extruded on October 26, 1912, 44 in number, and as these were being separated into finger-bowls for observation of moults 4 red-eyed ones were found. Male A was then put back with the female A, for the fourth mating ; the brood numbered 39, 3 with red eyes.

It will be seen that this female, mated with two different black-eyed males, produced some red-eyed young in each brood. No red eyes were observed in any of the other offspring of Pair I nor in their progeny.

The four red-eyed young of the third brood died before reaching maturity, and the remainder of the brood were kept separate, each in a finger-bowl, until they were 66 days old. On December 31 they were put together in a bell-jar, and some mated at once. The first female to mate of this brood was separated from the others, and from her and her offspring all the red-eyed stock has descended.

By August 7, 1913, this female and its mate were dead, and only 20 young were found in the jar, 16 black-eyed and 4 red-eyed. The four were removed, and the black-eyed left together for three months longer ; when again examined on November 5 the numbers were 65 black-eyed and 8 red, and with these work was commenced.

The following scheme shows the origin of this red-eyed stock, clear circles indicating the red-eyed, black circles the black-eyed animals :—
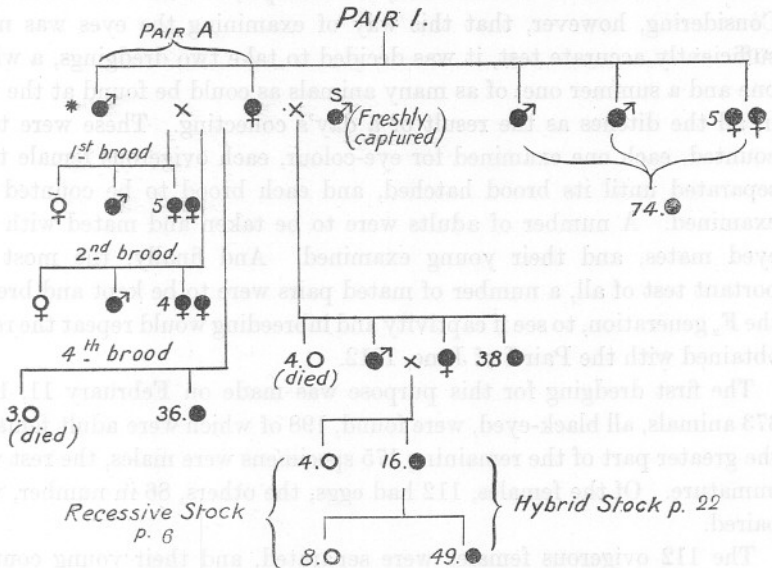
* The male of Pair A mated with two of the other females of the same brood ; the resulting young numbered 27, all black-eyed.

It cannot, of course, be stated as an absolute fact that red-eyed specimens never occur in the ditches in natural conditions, but so far not a single one has been found, although thousands of specimens brought in at different seasons of the year have been examined. The red strain has only shown itself in the one female, female A and her progeny. It seemed possible at first that the red-eyed strain could be accounted for on Mendelian lines. If the original Pair I had been a Pure Black mated with a Hybrid Black all the offspring would have been black-eyed, half the number Pure Blacks and half Hybrid Blacks ; and if in their matings a Hybrid should mate with a Hybrid the red-eye strain should have appeared. But, as far as can be seen, only the female A had the red strain ; both her mates, male A and male S, when mated with other females (some from the same brood as female A and some from other stocks) had only black-eyed offspring, and, moreover, in none of the other members of the brood nor in their offspring has the red strain appeared. It might have been that male A was a Hybrid Black and that female A was the only Hybrid Black female in the brood, but it seems pushing coincidence too far to suggest that male S captured some months later and taken at random from a large dredging should be a Hybrid and

the only Hybrid in it. None of the others captured then or at any other time have shown the red strain.

One series of 5000 was counted, for example, and all were black-eyed. Considering, however, that this way of examining the eyes was not a sufficiently accurate test, it was decided to take two dredgings, a winter one and a summer one, of as many animals as could be found at the time in all the ditches as the result of a day's collecting. These were to be counted, each one examined for eye-colour, each ovigerous female to be separated until its brood hatched, and each brood to be counted and examined. A number of adults were to be taken and mated with red-eyed mates, and their young examined. And finally, the most important test of all, a number of mated pairs were to be kept and bred to the F_2 generation, to see if captivity and inbreeding would repeat the result obtained with the Pair I of June, 1912.

The first dredging for this purpose was made on February 11, 1915. 373 animals, all black-eyed, were found, 198 of which were adult females ; the greater part of the remaining 175 specimens were males, the rest were immature. Of the females, 112 had eggs, the others, 86 in number, were paired.

The 112 ovigerous females were separated, and their young counted on extrusion. The broods in many cases were small, many of the animals having apparently not long reached maturity ; e.g. the first broods to hatch were in number as follows : 11, 3, 15, 4, 9, 11. In all, the number of young extruded was 641, all of them black-eyed.

Forty-six adults were mated with Red mates ; all produced black-eyed offspring, proving beyond doubt that they were Pure Black and not Hybrid. The number of broods counted was 62, the number of young 853.

Twelve of the 86 black-eyed pairs brought in from the ditches were taken to breed to the second generation of offspring. Of these Pairs II to XII * were kept for two or three broods each, and then returned to the rest of the dredging. The total number of young in the first generation of offspring from these broods was 473, all black-eyed.

For the second generation, one brood from each of the Pairs II to XII was taken, the first to mature in each case. This was done because the red eyes appeared in the first brood of the first F_1 pair of the original stock (p. 22).

When these broods reached maturity some of the mated pairs were separated and the others allowed to mate in the brood-bowl, the young in all cases being removed as soon as possible and examined for eye-colour.

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* Pair I produced no young, the female throwing off the eggs ; the male was then paired with three other females, two Black from the dredging, and one Red from the old stock ; all laid eggs, but no young were hatched, and the male died.

215 young were counted, all black-eyed ; some of these have commenced breeding.

This generation is very interesting from the fact that in it, as in the same generation of the original stock, a deviation from the normal occurred. In the case of the original stock the black pigment was absent, and the result was a red eye with the superficial network of opaque white pigment unaltered. In this second case the black pigment was present in every instance, but in the broods of Pair V the white pigment was affected in greater or less degree. The female of this pair had less white than is usual in the eye—the reticulation was perfect, but the lines of white were very thin and thread-like. The eyes of the young in the first generation were the same, but in the young from the first pair of these that mated there was considerable variation. One brood of 13 contained 2 young with " no-white " eyes on both sides (Fig. 6), 5 others with the white reticulation very faintly marked, and 6 with eyes like the male parent and female grandparent. This brood is being kept separate to see if the defect follows the Mendelian lines of inheritance of characters.

No individuals of the third generation from these pairs have been hatched yet (Nov. 19, 1915), but 60 which have been examined from the General Stock bowl all have normal black eyes.

The summer dredging was taken on July 6, 1915. 372 living animals were examined, all black-eyed. A good many more were brought in, but did not survive overnight, owing to the heat and overcrowding of the pots and consequent fouling of the water.

Twenty-two adults were mated with Red mates ; 31 broods were counted, containing 348 young, all black-eyed.

Thirteen black-eyed pairs of those paired in the ditches were separated from the others, and placed in finger-bowls to breed to the second generation. By November 19, 1915, there were 127 of the first generation and one brood, 5 in number, of the second generation, all with black eyes and all normal except the offspring of one pair. In this bowl, four of the first generation were left, two females with normal eyes, and two from a younger brood, one with normal eyes, and the other with a white patch on each eye at the upper end caused by three or four of the ommatidia being unpigmented, the " part-white " eye (cf. Fig. 7 for an example of this in the Recessives). This is the first occurrence recorded in the course of the work of a variation appearing in the *first* generation from animals brought in from the ditches.*

* Only one specimen has been recorded from freshly captured animals, a male, with the left eye affected.

EXPERIMENTAL WORK.

The first question to be decided was whether the red eye-colour was a sex-limited character or not—the only adult specimens previously observed having been females.

In order to settle this point the 8 red-eyed young found on November 5 (p. 22) were placed in a bowl by themselves to come to maturity. It is impossible to distinguish males from females until the animals reach sexual maturity, which occurs when they are about half-grown, the males being then easily distinguishable by the fine coiled hairs of the lower antennæ, and by the larger gnathopods. The 4 red-eyed young of August 7 were kept in the Laboratory, only two coming to maturity, both female. The 8 red-eyed young of November 5 were kept in another room, not heated, with a temperature ranging from 4°–10° C., and were in consequence much slower in maturing ; but in three months' time both males and females were seen—thus settling the question of the red eye-colour being a sex-limited character. In February three pairs mated. These were kept separate, each pair in a finger-bowl to itself, and the others, which were females, with the two August 7 females, were paired with males from the " Pure Black " stock. Males and females paired were also taken from this stock, and thus we had Recessive mated with Recessive (R. × R.), Pure Black mated with Recessive (P. × R.), and Pure Black mated with Pure Black (P. × P.). We started daily observations and records on this generation, calling it the Parent Generation, and counting from it the F_1, F_2, etc.

Our aim now was to discover if the Mendelian laws of inheritance of characters were applicable to the results of these crosses, and the experiments to this end will be given in detail under the different divisions —I Recessives and II Dominants.

I. THE RECESSIVES.

We commenced work in February, 1914, with the three pairs just referred to, adding in May seven pairs taken from the 42 red-eyed animals hatched since November 5, 1913, in the Hybrid Stock (see p. 22). Each pair and its offspring have been kept separate, the broods on hatching removed from the parents' finger-bowl and examined for eye-colour, each brood being numbered and set aside to come to maturity. In every case in which both parents were red-eyed all the offspring have been red-eyed.

The red-eyed animals appear to be more delicate than the black-eyed, shorter-lived, and less fertile. They are quite as large and as active, and

in many cases observed, reached maturity *before* the black-eyed in the same brood. Yet, if left to breed together with no admixture of the black-eyed strain, they gradually diminish in numbers, throwing off the eggs sometimes soon after deposition, or dying after having had only one or two broods. Seven of the ten stocks have failed in this way.

The results of the Experiments with the *Parent Generation* are given below in detail, and are typical of all the experiments with inbreeding Recessives. They are as follows :—

Exp. 1. Two broods, 10 and 12 respectively ; female died.

,, 2. Mated, but no eggs laid.

,, 3. One brood ; only 1 young hatched.

,, 4. One brood of 20 young.

,, 5. First brood, only 1 young hatched ; second brood, 3 young. Thinking the small numbers might be due to some defect or unhealthiness in this male, it was taken away and another added. Third brood, only 1 young hatched. Male again changed. Fourth brood, 14 young ; fifth brood, eggs thrown off before hatching. Male again changed. Sixth brood, 17 young.

,, 6. One brood, 19 young. A second brood was laid, but the female died before the eggs were hatched.

,, 7. Mated, eggs laid, but thrown off before hatching, probably unfertilised.

,, 8. Mated, eggs thrown off as in Exp. 7.

,, 9. One brood, 10 young. A second brood was laid, but the eggs were thrown off before hatching.

,, 10. Mated, eggs thrown off as in Exps. 7 and 8.

,, 11. Mated, eggs thrown off as in Exps. 7 and 8.

The total results for six months for the Parent Generation were : One pair mated, no eggs laid ; seven broods not hatched ; eleven broods hatched, the young numbering in all 108 ; average per brood 9·8. Only about half of these survived to maturity.

In the next generation, the F_1, a rather different system was followed. In some cases records of separate pairs were kept, in other cases the whole brood was left together in a finger-bowl, each female removed after oviposition, kept separate until the eggs were hatched, and then returned to the brood-bowl to mate again.

The total results in the twelve months from July, 1914, to July, 1915, for the breeding of the F_1 generation are : 2 pairs mated with no results ; 80 broods from the other pairs, 20 of these not hatched, 60 hatched,

numbering 422 young (these are the F_2 generation), average 7 per brood, a smaller average than in the preceding generation.

In the F_2 *generation* the same system was followed as in the F_1, the ovigerous females being removed from the brood-bowl till they had extruded their young, and then returned to it. But in one or two cases where only males or only females were left of a brood, mates from a different brood, but of the same family and the same generation, were added. These records were kept separately. The females of the first category laid 26 broods between September, 1914, and October, 1915, and hatched 207 young. One pair mated twice with no results, and two other pairs also mated with no results. In the second case, where male and female came from different broods, only two broods, of 7 and 8 young respectively, were hatched, the male in each case dying soon after, but these broods appear stronger than the others.

Several of this F_2 generation are still breeding (Nov. 3, 1915), but the numbers already obtained are sufficient for proof and record.

Of the F_3 *generation* 105 have survived (Nov. 19, 1915), many of them not yet mature. In several broods all the individuals have very pale eyes, with hardly any of the red pigment showing. The results for this generation are unsatisfactory, only a few young being hatched. Ten pairs have mated so far, as follows :—

From the first category (individuals of the same brood paired in their brood-bowl) 2 pairs mated, no eggs laid ; 1 pair mated, eggs thrown off ; 3 pairs with 18 young in 4 broods.

From the second category, which appears to yield a stronger stock (the two F_3 broods of the two F_2 pairs in which male and female came from different parents), 4 survive of the first brood of 7, not yet mature ; the second brood of 8 matured, and 6 matings have taken place : 4 young (all dead now) ; eggs thrown off ; no eggs ; 9 young (all dead) ; 7 young (1 left) ; and 5 young (3 left, mature females).

The total number for the F_4 *generation* thus far is only 31. Some individuals of one brood, the 9 young referred to above, came to maturity, and 2 broods of F_5 were hatched, numbering 12 young. Of these 9 survived, and are now nearly ready to breed.

II. THE DOMINANTS.

The Dominants are divided into *Pure Black* and *Hybrid Black*, which will be dealt with under separate divisions.

According to the Mendelian laws of inheritance of characters, the

matings of the Dominants with other Dominants and with Recessives should show the following results :—

(a) P. × P. : mating of Pure Black with Pure Black should give all black-eyed offspring, Pure Black, which should breed true through all succeeding generations.

(b) P. × H. : matings of Pure Black with Hybrid Black should give all black-eyed offspring, half Pure Black and half Hybrid Black.

(c) P. × R. : mating of Pure Black with Recessives should give all black-eyed offspring, Hybrid Black, which when bred together should show the red-eyed strain in the next generation.

(d) H. × H. : matings of Hybrid Black with Hybrid Black should give three black-eyed offspring to one red-eyed, i.e. in the proportion of one Pure Black and two Hybrid Black to one Recessive.

(e) H. × R. : matings of Hybrid Black with Recessive should give offspring half of which would be Hybrid Black and half Recessive.

THE PURE BLACKS.

Only a short note is necessary under this heading.

The Pure Black stock (p. 22) has been kept and interbred for over three years in a large jar. Observations have been made on it at different seasons of the year, all the animals being taken out and examined for eye-colour. Different pairs also have been kept separate from time to time and their progeny recorded to the third and fourth generations, but in all the cases not a single red-eyed one has been found.

With other dredgings brought in at intervals since June, 1912, the same results have been obtained. The last dredgings examined were those described on p. 25.

With regard to the 194 young from the P. × P. matings mentioned on p. 41, the record of the number of their offspring has not been kept, it having been thought sufficient to examine the eye-colour of all the animals in the different bowls from time to time to make sure that no red-eyed one appears.

In the P. × H. matings which have been tried, the young were all black-eyed. The difficulty with these has been in bringing a sufficient number of any one brood to maturity in order to test them for P. and H. characters. Only one case succeeded well enough to be recorded, the Brood 1 of Experiment 118 referred to on p. 41. Twenty-two young were hatched, and twenty-one reached maturity—seven males, thirteen females, and one abnormal one. Each of these was mated with a red-eyed mate except

in the two instances noted, when a proved Hybrid mate was used, with the following results :—

P.♀ 13 young. Black.
H.♂ 120 ,, 67 Black and 53 Red.
? ♀ 4 mates, 2 P. and 2 R. 5 broods laid, none hatched.
P.♂ 64 young. Black.
H.♀ 14 ,, 8 Black and 6 Red.
P.♀ 6 ,, Black.
P.♀ 71 ,, Black.
P.♀ 165 ,, Black. The eye of this female is figured. See Fig. 1.
P.♀ 56 ,, Black.
H.♀ 8 ,, 5 Black and 3 Red.
? ♀ 1 ,, Black. Female eaten.
H.♀ 15 ,, 11 Black and 4 Red.
H.♀ 4 ,, 3 Black and 1 Red. This female was tested with a
                  Hybrid Black mate.
H.♂ 14 ,, 10 Black and 4 Red. Also with a Hybrid Black mate.
? ♀   Eaten by mate.
H.♂ 57 ,, 31 Black and 26 Red.
H.♀ 20 ,, 12 Black and 8 Red.
P.♂ 37 ,, Black.
H.♂ 24 ,, 12 Black and 12 Red.
P.♂ 8 ,, Black.
? ?   This is the Abnormal one mentioned above.

In the third cross (c) P. × R., the matings have always produced black-eyed offspring, all Hybrid Black. The figures obtained in the F_2 generation may be quoted here—1563 young (see p. 39), as well as those of the Parent generation given in the next paragraph.

<div align="center">THE HYBRIDS.</div>

Parent generation.

In the *Parent generation* 33 experiments were made, starting in November, 1913, Pure Black males being mated with Recessive females, and Recessive males with Pure Black females, 16 experiments with the first cross, and 17 with the second. There were 18 broods hatched from the first cross P. ♂ × R. ♀, numbering in all 323 young ; and 21 broods from the second cross R. ♂ × P. ♀ with 313 young. In all these experiments without exception, the young had black eyes. In the first cross some paired without results, the others had from one to six broods each, the largest number in a single brood being 38. In the

second cross, all but one of the broods were hatched, the largest number being 49.

F₁ generation.

All the young of this generation were black-eyed, as was to be expected, in accordance with the Mendelian law that the offspring of Dominant mated with Recessive resemble the dominant parent in character. The further development of the law, that though the offspring are dominant in appearance, yet in constitution they are hybrid, could not be determined until the next generation, the F₂, appeared, the eye-colour alone not being a sufficiently accurate guide in distinguishing Pure Blacks from Hybrid Blacks.

In order to make sure of each individual F₁ and to keep its history clear, all the F₁ broods were kept in separate bowls till mature, and then as each pair mated it was removed and records kept of all the matings, the young being counted and examined for eye-colour immediately after extrusion from the pouch. All the F₁ that reached maturity were tested and all proved Hybrid Blacks.

The results for the eye-colour in the F₂ generation are given below.

F₂ generation.

The first idea was to take the F₂ broods in order as they hatched to the number of 1000 young, and to find if the proportions held good—three black to one red. Seventy-four broods were taken in this way, the young numbering 586, 437 of which were black-eyed and 149 red-eyed, the reds therefore being very slightly in excess of the theoretical figure. These broods appeared during the summer months, when the animals mature more rapidly and have a much quicker succession of broods than in the lower temperature. As the numbers in the broods were decreasing, the adults dying off, and the whole of the stock looking unhealthy, it was thought well to strengthen it before continuing the experiment. A change of food was given, and plenty of mud from the ditches.

It was then decided to pick out the three largest and strongest of the F₁ broods, and to count all the F₂ progeny produced by them. K, M, and N broods, which had matured under the healthier conditions, were chosen—K brood consisted of five males and nineteen females, M of nine males and six females, and N of fifteen males and seven females.

The first 72 broods from these three families (from Oct. 22, 1914, to March 2, 1915) contained 1004 young, 753 black-eyed and 251 red-eyed, in the exact proportion, as will be seen, of 3 to 1. K family was represented by 43 broods, total number of young hatched 655, of which 487 were Black and 168 Red ; M family by 19 broods, 271 young, 204

Black and 67 Red ; and N family by 10 broods, 78 young, 62 Black and 16 Red.

By this time the animals were beginning to die out. N family was finished by June 16, 1915 ; M family on that date had only 1 male and 4 females left (this male died on July 22); while K family still had 3 males and 16 females.

The next 65 broods (to May 24, 1915) brought the number of young extruded to 2000=1505 Black and 495 Red : K family with 1228, 924 Black and 304 Red ; M family with 582, 438 Black and 144 Red ; and N family with 190, 143 Black and 47 Red.

The number 3001 was reached on July 24, 1915, total number of Black 2270, and of Red 731 ; K family with 1540 Black and 490 Red ; M family with 552 Black and 181 Red ; and N family with 178 Black and 60 Red.

The figures therefore for the second and third thousand give to the Blacks a slight excess over the theoretical figure. In the first thousand (1004) the proportions, three Black to one Red, were exact ; in the 2000 they were very nearly right; but in the 3000 the Black rather predominated, the fact that the Black is the hardier strain probably accounting for this.

This same slight but steady increase can be seen on a small scale in the detailed Brood-records of the Hybrid crosses H. × R. In the first broods of each pair the proportions are nearly always exact, half Black and half Red, but the total results for all the broods show a preponderance of Black (see lists, p. 35); compare also for an example of a single brood Exp. 85, p. 38.

In Exp. 85 Brood 1 numbered 24 = 12 Black, 12 Red.

,,	2	,,	25	=	13	,,	12 ,,
,,	3	,,	23	=	12	,,	11 ,,
,,	4	,,	28	=	14	,,	14 ,,
,,	5	,,	20	=	9	,,	11 ,,
,,	6	,,	32	=	20	,,	12 ,,
,,	7	,,	17	=	8	,,	9 ,,
,,	8	,,	21	=	13	,,	8 ,,
,,	9	,,	14	=	8	,,	6 ,,
,,	10	,,	26	=	15	,,	11 ,,
,,	11	,,	34	=	15	,,	19 ,,
,,	12	,,	42	=	25	,,	17 ,,
,,	13	,,	26	=	12	,,	14 ,,

Total . 13 broods. 332 176 Black. 156 Red.
young.

The records of the individual families are very interesting. In K family, in which females preponderate, breeding commenced October 25, 1914, the first thousand was reached on April 20, 1915 : 63 broods hatched out numbering in all 1007 young, of which 756 were Black and 251 were Red, exact proportions. In the second thousand there were 59 broods hatched containing 1003 young, 767 Black as against 236 Red, the Black therefore in excess. 23 more broods were laid with 431 young, 336 Black and 95 Red. As will be seen, the proportion of Black is again higher. The last male died on September 21, 1915, on which date the records were perforce brought to a conclusion.

These figures prove conclusively that in the F_2 generation the proportions are 3 black-eyed to 1 red-eyed. The next step was the testing the black-eyed F_2 to get the proportion of Pure Black to Hybrid Black, but the results of this work are not exact and naturally cannot be. It is easy enough to separate the colours, black from red, immediately on hatching, but impossible to determine the question of the constitution of the black-eyed until they breed. Owing to various causes a high rate of mortality has to be allowed for, and the results therefore can only be given on the *survivors*.

The animals undergo many ecdyses, the young every few days, the adults at longer intervals, the males again at much longer intervals than the females. The moulting period is always critical even to the strong ones. It is absolutely fatal to the weakly ones in a brood, the others attacking them in their feeble condition and devouring them. With the adults the mortality is higher among the females. The reason is that the male carrying the female for some days prior to the extrusion of a brood, and assisting it through the moult which immediately precedes the deposition of a fresh brood, very frequently ends by eating it directly after. A great many females have been lost in this way in the course of the work.

But the principal cause of the high death rate is the development of injurious bacteria in the bowls. At first it was thought that the bacteria had been introduced with the rotting leaves given as food, and many methods of sterilising the leaves were tried. After a while it was noticed that all the broods set out on a certain date had perished, and on comparing this result with a similar one in Mr. Crawshay's experiments, he discovered that the same sea-water had been used in all, and that this water was infected, although taken as far out as the Eddystone for the sake of avoiding shore contamination.

Several kinds of bacteria have been observed, some fatal within a day or two, some after several weeks, and others which, except for retarding development, do not injure the animal. One of this last-mentioned kind turns the water a milky colour, and forms dense slimy masses all round

the bowl, and over the food, and even clings to the amphipods themselves. With a lens it is easy to see long streamers of this slime trailing behind the little creatures as they swim.

Proportions of Pure Black to Hybrid Black in the F_2 generation.

The experiments to find the proportions of Pure Black and Hybrid Black were made with the surviving F_2 progeny of the first F_1 brood, Brood A, that came to maturity. The following table shows the parentage with the number of young hatched, 210 in all, 153 black-eyed and 57 red-eyed.

P. ♂ × R. ♀ *Parent generation.*

(From Pure Black stock.) | (One of the 8 Reds, p. 26.)

First Brood—Brood A = 22 young. Hybrid. F_1 generation. extruded 16.3.1914.

A.F$_1$ pair.	B.F$_1$ pair.	C.F$_1$ pair.	D.F$_1$ pair.	E.F$_1$ pair.	F.F$_1$ pair.	G.F$_1$.
4 broods.	4 broods.	1 brood.	2 broods.	3 broods.	2 broods.	1 brood.
55 young.	48 young.	7 young.	20 young.	43 young.	27 young.	10 young.
						F_2 generation.
Hatched :—						
38 Black.	37 Black.	6 Black.	15 Black.	30 Black.	21 Black.	6 Black.
17 Red.	11 Red.	1 Red.	5 Red.	13 Red.	6 Red.	4 Red.
Survived :—						
23 Black.	15 Black.	4 Black.	13 Black.	18 Black.	15 Black.	5 Black.
10 Red.	7 Red.	0 Red.	3 Red.	7 Red.	4 Red.	3 Red.

Only 127 reached maturity, 93 black-eyed and 34 red. Of the Black 44 were males and 49 females ; of the Red 20 were males and 14 females.

The testing was done with red-eyed mates, the Blacks being separated into finger-bowls and each given a Red mate. The resulting broods would at once show the P. or H. character, for if the black-eyed animal were a Pure Black the offspring would be all black-eyed ; if a Hybrid Black, half the young would be black-eyed and half red-eyed. Later, when the constitution of each had been determined, the survivors were mated together : P. × P. ; P. × H. ; H. × H. ; and H. × P.

It sometimes happens that the individuals of the first brood of Hybrid × Recessive, if few in number, are all of one eye-colour, not the normal proportions, half red and half black. This occurred six times in the course of these experiments ; in four broods the young were all black-eyed ; in two, all red ; the highest number in any of these broods was four. To avoid error each pair was kept for at least three broods to make quite sure of the constitution ; in some cases the black-eyed were mated with two or three different red-eyed mates.

In all 141 experiments were made with the 93 Black-eyed animals. Thirteen, 7 males and 6 females, died without proof, probably through

some inherent weakness; in one or two cases broods of eggs were laid but not hatched, in others the stronger mate ate the weaker one.

Of the 80 that survived, 22 proved Pure Black, 8 males and 14 females, and 58 proved Hybrid Black, 29 males and 29 females. Ten experiments were made with P. males, 24 with P. females, 38 with H. males, and 56 with H. females.

The details of the experiments are as follows :—

TABLE

showing the details of the experiments made with the black-eyed F_2 progeny of one brood of the F_1 generation of Hybrids, from September, 1914, to September, 1915, in order to find the proportion of Pure Black to Hybrid Black. Theoretically it should be 1 P. : 2 H., but, as has been already explained, the results recorded here cannot be considered exact owing to the high mortality amongst the immature.

Experiment Number.	Black. ♂ ♀	Number of Young hatched.	Eye-colour. Black.	Eye-colour. Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 1	— ♀	—	—	—	—	No results : ♀ eaten.
,, 2	— ♀	—	—	—	—	No results : ♀ died.
,, 3	— ♀	—	—	—	—	No results : ♀ died.
,, 4a	♂	—	—	—	—	No results.
,, 4b	,,	33	All	—	4	P.
,, 5	♂ —	31	16	15	3	H.
,, 6	— ♀	25	15	10	2	H.
,, 8a	♂	—	—	—	—	No results.
,, 8b	,,	35	21	14	3	H.
,, 9a	— ♀	21	12	9	1	H.
,, 9b	— ,,	—	—	—	—	No results.
,, 10	— ♀	—	—	—	—	No results : ♀ died.
,, 11	♂ —	56	34	22	4	H.
,, 14a	♂	2	—	2	1	H.
,, 14b	,,	26	13	13	2	,,
,, 16	♂ —	49	21	28	4	H.
,, 17a	♂	21	11	10	2	H.
,, 17b	,,	—	—	—	—	Eggs laid, not hatched.
,, 19	♂ —	28	All	—	3	P.
,, 20a	♂	—	—	—	—	No results.
,, 20b	,,	9	4	5	1	H.
,, 20c	,,	44	22	22	1	,,
,, 21	♂ —	—	—	—	—	No results : ♂ died.
,, 22	— ♀	—	—	—	—	No results : ♀ eaten.

Experiment Number.	Black. ♂	♀	Number of Young hatched	Eye-colour. Black.	Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 23a	—	♀	—	—	—	—	No results.
,, 23b	—	,,	3	2	1	1	H.
,, 23c	—	,,	22	10	12	2	,,
,, 24a	—	♀	21	12	9	3	H.
,, 24b	—	,,	6	1	5	1	,,
,, 25	—	♀	11	6	5	1	,,
,, 26a	—	♀	—	—	—	—	No results.
,, 26b	—	,,	70	31	39	4	H.
,, 26c	—	,,	—	—	—	—	No results.
,, 27	—	♀	11	7	4	1	H.
,, 28a	—	♂	—	—	—	—	No results : ate its mate.
,, 28b	,,	—	116	54	62	4	H.
,, 29a	—	♀	5	3	2	1	H.
,, 29b	—	,,	36	19	17		,,
,, 30	—	♀	5	4	1	1	H.
,, 31	—	♀	23	11	12		,,
,, 32a	—	♀	—	—	—		No results.
,, 32b	—	,,	50	25	25	2	H.
,, 33a	—	♀	—	—	—		No results.
,, 33b	—	,,	46	All	—	2	P.
,, 34a	—	♀	8	All	—	2	P.
,, 34b	—	,,	14	,,	—	2	,,
,, 34c	—	,,	67	,,	—	5	,,
,, 35a	—	♀	13	3	10	1	H.
,, 35b	—	,,	10	8	2	1	,,
,, 35c	—	,,	55	23	32	2	,,
,, 35d	—	,,	34	20	14	2	,,
,, 36	—	♀	58	All	—	4	P.
,, 37a	—	♀	35	16	19	2	H.
,, 37b	—	,,	76	43	33	2	,,
,, 37c	—	,,	5	4	1	1	,,
,, 38a	—	♀	71	All	—	4	P.
,, 38b	—	,,	13	,,	—		,,
,, 39b	—	♀	—	—	—		No results.
,, 39c	—	,,	—	—	—		,,
,, 39d	—	,,	35	26	9	3	H.
,, 39e	—	,,	—	—	—		Eggs laid : ♀ eaten.
,, 40	—	♀	25	All	—	2	P.
,, 41	—	♀	81	42	39	4	H.
,, 42a	—	♀	13	All	—	3	P.
,, 42b	—	,,	11	,,	—	1	,,

some inherent weakness; in one or two cases broods of eggs were laid but not hatched, in others the stronger mate ate the weaker one.

Of the 80 that survived, 22 proved Pure Black, 8 males and 14 females, and 58 proved Hybrid Black, 29 males and 29 females. Ten experiments were made with P. males, 24 with P. females, 38 with H. males, and 56 with H. females.

The details of the experiments are as follows :—

TABLE

showing the details of the experiments made with the black-eyed F_2 progeny of one brood of the F_1 generation of Hybrids, from September, 1914, to September, 1915, in order to find the proportion of Pure Black to Hybrid Black. Theoretically it should be 1 P. : 2 H., but, as has been already explained, the results recorded here cannot be considered exact owing to the high mortality amongst the immature.

Experiment Number.	Black. ♂	Black. ♀	Number of Young hatched.	Eye-colour. Black.	Eye-colour. Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 1	—	♀	—	—	—	—	No results : ♀ eaten.
,, 2	—	♀	—	—	—	—	No results : ♀ died.
,, 3	—	♀	—	—	—	—	No results : ♀ died.
,, 4a	♂ ⎱	—	—	—	—	—	⎧ No results.
,, 4b	,, ⎰	—	33	All	—	4	⎩ P.
,, 5	♂	—	31	16	15	3	H.
,, 6	—	♀	25	15	10	2	H.
,, 8a	♂ ⎱	—	—	—	—	—	⎧ No results.
,, 8b	,, ⎰	—	35	21	14	3	⎩ H.
,, 9a	—	♀ ⎱	21	12	9	1	⎧ H.
,, 9b	—	,, ⎰	—	—	—	—	⎩ No results.
,, 10	—	♀	—	—	—	—	No results : ♀ died.
,, 11	♂	—	56	34	22	4	H.
,, 14a	♂ ⎱	—	2	—	2	1	⎧ H.
,, 14b	,, ⎰	—	26	13	13	2	⎩ ,,
,, 16	♂	—	49	21	28	4	H.
,, 17a	♂ ⎱	—	21	11	10	2	⎧ H.
,, 17b	,, ⎰	—	—	—	—	—	⎩ Eggs laid, not hatched.
,, 19	♂	—	28	All	—	3	P.
,, 20a	♂ ⎱	—	—	—	—	—	⎧ No results.
,, 20b	,,	—	9	4	5	1	⎨ H.
,, 20c	,, ⎰	—	44	22	22	1	⎩ ,,
,, 21	♂	—	—	—	—	—	No results : ♂ died.
,, 22	—	♀	—	—	—	—	No results : ♀ eaten.

Experiment Number.	Black. ♂	Black. ♀	Number of Young hatched.	Eye-colour. Black.	Eye-colour. Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 23a	—	♀	—	—	—	—	No results. ⎫ H.
,, 23b	—	,,	3	2	1	1	
,, 23c	—	,,	22	10	12	2	,,
,, 24a	—	♀	21	12	9	3	H.
,, 24b	—	,,	6	1	5	1	,,
,, 25	—	♀	11	6	5	1	H.
,, 26a	—	♀	—	—	—	—	No results.
,, 26b	—	,,	70	31	39	4	H.
,, 26c	—	,,	—	—	—	—	No results.
,, 27	—	♀	11	7	4	1	H.
,, 28a	♂	—	—	—	—	—	No results : ate its mate.
,, 28b	,,	—	116	54	62	4	H.
,, 29a	—	♀	5	3	2	1	H.
,, 29b	—	,,	36	19	17	3	,,
,, 30	—	♀	5	4	1	1	H.
,, 31	—	♀	23	11	12	1	H.
,, 32a	—	♀	—	—	—	—	No results.
,, 32b	—	,,	50	25	25	2	H.
,, 33a	—	♀	—	—	—	—	No results.
,, 33b	—	,,	46	All	—	2	P.
,, 34a	—	♀	8	All	—	2	P.
,, 34b	—	,,	14	,,	—	2	,,
,, 34c	—	,,	67	,,	—	5	,,
,, 35a	—	♀	13	3	10	1	H.
,, 35b	—	,,	10	8	2	1	,,
,, 35c	—	,,	55	23	32	2	,,
,, 35d	—	,,	34	20	14	2	,,
,, 36	—	♀	58	All	—	4	P.
,, 37a	—	♀	35	16	19	2	H.
,, 37b	—	,,	76	43	33	2	,,
,, 37c	—	,,	5	4	1	1	,,
,, 38a	—	♀	71	All	—	4	P.
,, 38b	—	,,	13	,,	—		,,
,, 39b	—	♀	—	—	—	—	No results.
,, 39c	—	,,	—	—	—	—	,,
,, 39d	—	,,	35	26	9	3	H.
,, 39e	—	,,	—	—	—	—	Eggs laid : ♀ eaten.
,, 40	—	♀	25	All	—	2	P.
,, 41	—	♀	81	42	39	4	H.
,, 42a	—	♀	13	All	—	3	P.
,, 42b	—	,,	11	,,	—	1	,,

Experiment Number.	Black. ♂	Black. ♀	Number of Young hatched.	Eye-colour. Black.	Eye-colour. Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 43	♂	—	—	—	—	—	No results : ♂ killed by [mate.
,, 44	—	♀	35	16	19	2	H.
,, 45a	—	♀⎱	9	All	—	1	⎧P.
,, 45b	—	,, ⎰	50	,,	—	2	⎩ ,,
,, 46	♂	—	10	6	4	2	H.
,, 47a	♂⎱	—	29	12	17	3	⎧H.
,, 47b	,, ⎰	—	—	—	—	—	⎩No results : ♂ died.
,, 48a	—	♀⎱	19	All	—	2	⎧P.
,, 48b	—	,, ⎰	14	,,	—	1	⎩ ,,
,, 49a	—	♀⎱	30	16	14	2	⎧H.
,, 49b	—	,, ⎰	18	13	5	1	⎩ ,,
,, 50	—	♀	26	10	16	3	H.
,, 51	—	♀	84	32	52	3	H.
,, 52	♂	—	41	All	—	2	P.
,, 53	—	♀	82	All	—	4	P.
,, 54(1) ♂	—	—	—	—	—	—	No results.
,, 54(2) ♂	—	—	—	—	—	—	,,
,, 54(3) ♂	—	—	—	—	—	—	,,
,, 55	—	♀	108	All	—	5	P.
,, 56	—	♀	—	—	—	—	No results.
,, 57a	—	♀⎱	30	14	16	2	⎧H.
,, 57b	—	,, ⎰	63	36	27	2	⎨ ,,
,, 57c	—	,,	135	65	70	5	⎩ ,,
,, 59a	♂⎱	—	—	—	—	—	⎧No results : ♀ eaten.
,, 59b	,, ⎰	—	56	All	—	3	⎩P.
,, 60	♂	—	117	63	54	4	H.
,, 61a	—	♀⎱	58	34	24	3	⎧H.
,, 61b	—	,, ⎰	15	11	4	1	⎩ ,,
,, 62a	—	♀⎱	18	6	12	3	⎧H.
,, 62b	—	,, ⎰	—	—	—	—	⎨No results : eggs thrown off : ♀ died.
,, 63	—	♀	81	All	—	4	P.
,, 64	♂	—	—	—	—	—	No results : ate ♀ : died [in moulting.
,, 65	—	♀	63	All	—	4	P.
,, 66a	—	♀⎱	12	All	—	1	⎧P.
,, 66b	—	,, ⎰	145	,,	—	10	⎨ ,,
,, 66c	—	,,	131	,,	—	3	⎩ ,,
,, 67	♂	—	12	3	9	2	H.
,, 68	♂	—	125	62	63	4	H.
,, 69	—	♀	56	27	29	3	H.

Experiment Number.	Black. ♂	Black. ♀	Number of Young hatched.	Eye-colour. Black.	Eye-colour. Red.	Number of Broods.	Pure Black or Hybrid Black.
Exp. 70a	—	♀ }	—	—	—	—	{ No results : too young ?
,, 70b	—	,, }	135	All	—	7	{ P.
,, 71a	—	♀ }	118	63	55	4	{ H.
,, 71b	—	,, }	—	—	—	—	{ No result : ♀ eaten.
,, 72a	—	♀ }	9	7	2	1	{ H.
,, 72b	—	,, }	33	16	17	1	{ ,,
,, 72c	—	,, }	27	11	16	1	{ ,,
,, 73	♂	--	19	5	14	1	H.
,, 74a	—	♀ }	26	11	15	3	{ H.
,, 74b	—	,, }	7	3	4	1	{ ,,
,, 75a	—	♀ }	64	33	31	3	{ H.
,, 75b	—	,, }	16	8	8	1	{ ,,
,, 76	♂	—	47	23	24	4	H.
,, 77	♂	—	30	16	14	4	H.
,, 78	♂	—	9	All	—	2	P.
,, 79	♂	—	28	14	14	2	H.
,, 80	♂	—	1	1	—	1	No results of value :
,, 81	♂	—	76	All	—	4	P. [♂ eaten.
,, 82a	♂ }	—	9	6	3	4	{ H.
,, 82b	,, }	—	26	11	15	1	{ ,,
,, 85	♂	—	332	176	156	13	H.
,, 87	♂	—	191	95	96	10	H.
,, 89a	♂ }	—	—	—	—	—	{ No results : ate ♀.
,, 89b	,, }	—	4	3	1	1	{ H.
,, 90	♂	—	59	All	—	2	P.
,, 91	♂	—	57	31	26	5	H.
,, 92	♂	—	183	95	88	10	H.
,, 93a	—	♀ }	32	15	17	1	{ H.
,, 93b	—	,, }	—	—	—	—	{ No results : eggs thrown off.
,, 94	♂	—	53	21	32	4	H.
,, 95	—	♀	146	68	78	6	H.
,, 96	♂	—	94	54	40	6	H.
,, 97	♂	—	2	1	1	2	H.
,, 98	♂	—	209	95	114	12	H.
,, 99	♂	—	86	All	—	7	P.
,, 100	♂	—	10	6	4	1	H.
,, 104	♂	—	256	140	116	10	H.
Total 141	37	43	5494	3555	1939	323	P.=8 ♂ and 14 ♀.
Exps.	♂	♀	Young.	Black.	Red.	Broods.	H.=29 ♂ and 29 ♀.

The total number of young hatched was 5494. Of this number 388 were the black-eyed offspring of P. ♂ × R. ♀ and 1175 of P. ♀ × R. ♂. The number of young from the other cross, H. × R., was 3931—1992 Black-eyed and 1939 Red-eyed—1134 Black and 1098 Red in the mating H. ♂ × R. ♀, and 858 Black and 841 Red in the mating H. ♀ × R. ♂. As will be seen, the proportion is not quite exact, the Blacks being rather in excess. It appears to vary a good deal with the individual, though perhaps the number of offspring from a single pair is not sufficiently large to eliminate mere chance variation. Some animals have a succession of broods fairly evenly divided into Black and Red, while others have a preponderance of one colour or the other, others, again, having first one brood unevenly divided, the next restoring the balance, and so on. Examples of the first will be found in Exps. 87 and 57.

In Exp. 87 (♂ H., with the same mate for all the broods)—

Brood 1 numbered	27	=	14 Black and	13 Red.
,, 2	,,	14 =	5	,,	9	,,
,, 3	,,	14 =	9	,,	5	,,
,, 4	,,	13 =	7	,,	6	,,
,, 5	,,	10 =	5	,,	5	,,
,, 6	,,	13 =	8	,,	5	,,
,, 7	,,	20 =	10	,,	10	,,
,, 8	,,	24 =	11	,,	13	,,
,, 9	,,	32 =	14	,,	18	,,
,, 10	,,	24 =	12	,,	12	,,
		191 =	95	,,	96	,,

Exp. 57 (♀ H., with 3 different mates)—

Brood 1 numbered	8 =	3 Black and	5 Red.
,, 2	,,	22 = 11	,,	11	,,
,, 3	,,	30 = 16	,,	14	,,
,, 4	,,	33 = 20	,,	13	,,
,, 5	,,	21 = 11	,,	10	,,
,, 6	,,	32 = 13	,,	19	,,
,, 7	,,	20 = 8	,,	12	,,
,, 8	,,	38 = 20	,,	18	,,
,, 9	,,	24 = 13	,,	11	,,
		228 = 115	,,	113	,,

For examples of the preponderance of one colour Exps. 60, 61, 71, and 95 will serve ; 60 is a ♂ H. and 71 a ♀ H., both had 4 broods each, with 117 and 118 young respectively.

In Exp. 60—

Brood 1 numbered 11 =   7 Black and   4 Red.
,,   2   ,,   28 = 12   ,,   16   ,,
,,   3   ,,   47 = 28   ,,   19   ,,
,,   4   ,,   31 = 16   ,,   15   ,,
                117 = 63   ,,   54   ,,

In Exp. 71—

Brood 1 numbered 12 =   6 Black and   6 Red.
,,   2   ,,   24 = 17   ,,   7   ,,
,,   3   ,,   41 = 22   ,,   19   ,,
,,   4   ,,   41 = 18   ,,   23   ,,
                118 = 63   ,,   55   ,,

In Exp. 61 the Black are in excess.

Brood 1 numbered   8 =   4 Black and   4 Red.
,,   2   ,,   21 = 12   ,,   9   ,,
,,   3   ,,   29 = 18   ,,   11   ,,
,,   4   ,,   15 = 11   ,,   4   ,,
                73 = 45   ,,   28   ,,

In Exp. 95 the Red preponderate (cf. Exp. 51).

Brood 1 numbered 15 =   7 Black and   8 Red.
,,   2   ,,   14 =   5   ,,   9   ,,
,,   3   ,,   24 = 11   ,,   13   ,,
,,   4   ,,   33 = 15   ,,   18   ,,
,,   5   ,,   27 = 15   ,,   12   ,,
,,   6   ,,   33 = 15   ,,   18   ,,
                146 = 68   ,,   78   ,,

For illustrations of broods unevenly divided the first broods in Exps. 32 and 72 may be given.

Exp 32.   Brood 1 with 23 = 10 Black and 13 Red.
        ,,   2   ,,   27 = 15   ,,   12   ,,
                   50 = 25   ,,   25   ,,

Exp. 72.   Brood 1 with   9 =   7 Black and   2 Red.
        ,,   2   ,,   33 = 16   ,,   17   ,,
        ,,   3   ,,   27 = 11   ,,   16   ,,
                   69 = 34   ,,   35   ,,

The H. ♀ of Exp. 75 had two broods of 21—in one case 13 Black and 8 Red, in the other 13 Red and 8 Black.

The number of young in a brood varies with the individual, but the numbers in the broods of a single pair do not vary much as a rule ; to take an example, Exp. 99 had seven broods as follows : 11, 15, 13, 10, 11, 15, 11.

Exp. 35 is an interesting one, showing the varying proportions of Black and Red with different mates. This female was mated with four males with the following results : with male *a*, one brood of 13 young, 3 Black, 10 Red ; with male *b*, one brood of 10, 8 Black, 2 Red ; with male *c*, two broods of 28 and 27, with 12 Black and 16 Red, and 11 Black and 16 Red respectively ; and with male *d*, two broods of 11 and 23, with 6 Black and 5 Red, and 14 Black and 9 Red respectively.

Many of the F_2 animals had died by the time these experiments were finished, only a few remained to be mated together. Two matings of P. × P. were made, the other P. animals being paired with H. mates.

P. × P.	Exp.	83*a*	5 broods	133 Black-eyed young.	♂ died.
,,	,,	83*b*	2 ,,	61 ,, ,,	♀ died.
P. × H.	,,	84	1 brood	Eggs thrown off.	♂ died.
P. × H.	,,	110*b*	1 ,,	6 Black-eyed young.	♂ eaten.
P. × H.	,,	118	2 broods	48 ,, ,,	♂ died.
P. × H.	,,	119	1 brood	3 ,, ,,	♂ died.
H. × P.	,,	102	1 ,,	43 ,, ,,	♂ died.
H. × P.	,,	105*a*	3 broods	85 ,, ,,	♂ died.
H.F_3 × P.F_2	,,	105*b*	4 ,,	113 ,, ,,	♂ eaten.
H. × P.	,,	107	—	,,	♀ died.
H.F_3 × P.F_2	,,	115	1 brood	5 ,, ,,	♂ died.
H. × P.	,,	117	—	—	♂ died.
Total .	.	In 21 broods	497 Black-eyed young.		

The matings of H. × H. are as follows :—

H. × H.	Exp.	86	2 broods	60 young	=	46 Black	14 Red.		♀ eaten.
H. × H.	,,	103	1 brood	22 ,,	=	16 ,,	6 ,,		
and another brood									
(♂ unhealthy)				1 ,,	=	1 ,,	—		♂ died.
H. × H.	Exp.	106*a*	1 brood	52 ,,	=	48 ,,	4 ,,		♂ died.
,,	,,	106*b*	—		=	—	—		♀ died.
H. × H.	,,	109	4 broods	62 ,,	=	43 ,,	19 ,,		♂ died.
H. × H.	,,	110*a*	1 brood	38 ,,	=	30 ,,	8 ,,		♂ died.
H. × H.	,,	112	2 broods	40 ,,	=	29 ,,	11 ,,		Both died.
H. × H.	,,	116	1 brood	11 ,,	=	7 ,,	4 ,,		♂ died.
Total .		In 12 broods	286 young		=	220 Black	66 Red.		

The proportions of Black to Red in these H. × H. experiments are about right if Exp. 106a is not counted.

The H. male in this experiment had been previously mated with a Red female, and had had one brood of 9 young, 1 Black and 8 Red—a preponderance of Red.

The H. female had also been previously mated with a Red male, and had had 84 young in 3 broods, 32 Black to 52 Red, a preponderance of Red. When mated together the one brood of 52 was the result, 48 Black to 4 Red—a preponderance of Black. (The Red male with which the H. female mated was tried with another H. female which had already had 30 young, 16 Black and 14 Red—with the result, one brood of 18 young hatched, 13 Black and 5 Red.)

A great many of the F_3 animals from these experiments were mated in order to see if the results would repeat those already obtained in the P. F_1 and F_2 generations. They were examined regularly, but only a few records were kept, the fact that in all cases they bred true being considered sufficient evidence of accordance with the Mendelian law.

SEX.

All the broods were kept in separate bowls to come to maturity, in the hope of finding the number of males and females hatched, and if the number varied in the different crosses. Owing to unfavourable conditions, bacteria, etc., it was found impossible to get good results. The broods, therefore, are taken in which over fifty per cent of the young came to maturity, and the numbers are given below, together with the broods in which less than fifty per cent survived, and the number of broods which failed entirely.

As a rule, all or nearly all the animals in the small broods survived, probably because they were stronger, as they were certainly larger than the others on hatching. Almost all the very large broods failed in spite of repeated efforts to save them by separating them into several bowls so as to avoid overcrowding, etc.

Of the broods that failed entirely 5 were in the P. × R. cross, 11 in the R. × P., 29 in the H. × R., and 23 in the R. × H., 68 in all.

Broods in which 50 % and over survived to maturity.

Black and Red Crosses. ♂ ♀	Number of Broods.	Number Hatched.	Number Survived.	Black				Red			
				Males.	Females.	Hatched.	Survived.	Males.	Females.	Hatched.	Survived.
P. × R.	10	106	83	50	33						
R. × P.	25	299	240	129	111						
H. × R.	43	551	387	95	101	282	196	90	101	269	191
R. × H.	37	510	351	92	95	269	187	72	92	241	164

Broods in which less than 50 % survived.

Black and Red Crosses. ♂ ♀	Number of Broods.	Number Hatched.	Number Survived.	Black				Red			
				Males.	Females.	Hatched.	Survived.	Males.	Females.	Hatched.	Survived.
P. × R.	10	142	31	16	15						
R. × P.	26	492	86	45	41						
H. × R.	43	889	174	46	43	438	89	36	49	451	85
R. × H.	40	860	176	44	36	432	80	55	41	428	96
Black Crosses.											
P. × P.	7	194	79	40	39						
P. × H.	5	57	28	10	18						
H. × P.	9	169	40	17	23						
H. × H.	13	286	30	7	15	220	22	6	2	66	8

RECORDS OF ABNORMAL EYES: "NO-WHITE," "PART-WHITE," AND "ALL-WHITE."

Attempts at breeding the animals together to ascertain if the " no-white," " part-white," and " all-white " variations follow the Mendelian lines of inheritance have so far not succeeded, although these abnormalities seem to run in certain families and not in others. For example, in the F_1 Hybrids (p. 31) a great number of cases occurred in Families A and K, only one case in M, and none in the other families.

Some instances may be given in illustration of the proportions and degree per brood of the " *no-white* " variation. In K family at least six normal-eyed females transmitted this strain, some more than others, and the proportion of " no-white "-eyed in their broods was much higher than in A family. These females mated in the brood-bowl and were removed to extrude their young, and then returned to the bowl to mate again. During the month of June, 1915, 20 broods were extruded by the different K females (some of them having two broods each in the month), and

in 10 of the broods "no-white"-eyed individuals were found, as follows :—

14 young :   11 Black, 3 Red ; amongst them 2 Black "no-white."

9	,,	8	,,	1	,,		,,	4	,,		,,
19	,,	15	,,	4	,,		,,	3	,,		,,
								2 Red			,,
3	,,	3	,,	0	,,		,,	1 Black			,,
15	,,	11	,,	4	,,		,,	6	,,		,,
28	,,	23	,,	5	,,		,,	1	,,		,,
								1 Red			,,
30 (2 broods	23	,,	7	,,		,,	5 Black			,,
together)								2 Red			,,
17 young :	14	,,	3	,,		,,	4 Black			,,
15	,,	14	,,	1	,,		,,	5	,,		,,

In the A family 7 animals out of the 93 black-eyed (p. 34) produced some "no-white"-eyed young, 1 male and 2 females from Af_2, 1 male and 1 female from Df_2, 1 male from Ef_2, and 1 male from Ff_2. The details are as follows :—

In Exp. 28. Brood III. 1 Black "no-white" on one side, and 1 Red "no-white" both sides. The Black was a female, the Red died before maturity. The ♂ of this experiment mated with the ♀ in Exp. 27 and had 1 Black abnormal ♀ in Brood III.

,,   59.   ,,   I.   2 "no-white" Black—both died.

  ,,   II.   1   ,,   ,,   preserved.

  ,,   III. 2   ,,   ,,   one died. The other was a female "no-white" on right side.

  ,,   60.   ,,   II.   1 "no-white" Red male, one side only.

  ,,   IV.   Contained 31 young, the eyes in all with very imperfect and broken reticulation.

,,   66.   ,,   VI.   1 "no-white" Black, female, left side.

,,   93. One brood of 12 young. 1 "no-white" Black, died. All the others with the reticulation imperfect. One brood of 7 young, 5 with imperfect reticulation. One brood of 32 young, all with imperfect reticulation.

,,   112. The male was from Af_2, the female from Df_2.

Brood I. 38 young. 1 "no-white" Black, died. Many with reticulation imperfect. Several Red, very pale colour.

  ,,   II.   2 young. 1 Black "no-white" both sides—died.

Another instance is that of Exp. 99 (p. 38), a Pure Black male from Bf$_2$ mated with a Recessive female, both with normal eyes. All their young, 86 in number, were also normal. In the F$_2$ generation the " no-white " and the " part-white " strains appeared in the offspring of a pair from Brood 7. This pair had three broods, the first brood of 6 died young. Of the second brood, 21 in all, 13 Black and 8 Red, only 7 survived, 3 Black males, one with the left eye affected (in this case 2 or 3 of the ommatidia formed a little cluster apart from the ommateum). 4 Red survived, two normal and two " part-white " as figured (Fig. 7). (In the first brood from these Reds 3 out of the 4 young (F$_4$) had normal eyes, the fourth had eyes like the male figured.) The third brood numbered 30, 20 Black and 10 Red, of these 6 survived, 4 Black and 2 Red, only one normal-eyed amongst them, a Black. Two of the other Blacks were " no-white " on both sides, and the remaining one was normal on the right side, but had a small cluster of ommatidia apart on the left side. Of the two Reds, one was " no-white " on the left side, the other had the white reticulation partly lacking, i.e. partly " no-white."

Many cases have occurred in which the white pigment (instead of being diminished or lacking) is present in excess. This appears to be always accompanied by a diminution of the coloured pigment of the retinular cells, the red, e.g., being hardly perceptible, even with a strong lens showing only as a very pale pink tint, instead of the vivid blood-red of the normal red eye. This variation has been noticed especially in the later generations of the inbred Recessives, and it is possible that another generation or two of inbreeding may produce the " *all-white* " eye.

Only a few " *all-whites* " have been recorded so far (Nov. 19, 1915). Two, a male hatched April 2, 1915, and a female hatched April 14, have appeared in the Pure Red Stock amongst the young from Brood 4, Exp. 5, Recessives (p. 27) (descendants of the fourth brood of female A of the original experiments, p. 22). The female came to maturity but died without mating. The male (Fig. 8) was mated with female B (Figs. 9 and 10), referred to below (a Hybrid with degenerate " white " eyes), and proved pure Red—the 5 young being normal-eyed, 2 Black and 3 Red. It died in moulting, November 19, 1915, without mating again. Two other females from the same brood as the " all-white " female extruded their young in the brood-bowl, 6 in number, all with very pale pink, almost " white " eyes.

A curious instance of the " all-white " accompanied by degeneration of the eye was noted in the forty-second brood of M family, F$_1$ Hybrids (p. 31). This brood was extruded on June 1, 1915, and numbered 12 young, 7 Black, 1 Red, and 4 " all-white " eyes. These four proved to be 1 male and 3 females. The male mated with one of the females, eggs were

laid but thrown off, then the male died and was eaten. A Pure Black male was put in, mated with one of the females, but ate it after mating.

By September 26 only the two females B and C were left. The " all-white " male from the Pure Red Stock with unpigmented perfectly formed eyes (Fig. 8) was put with them and mated at once with female B (Figs. 9 and 10), eggs were laid, and 5 young were extruded, on October 16, all with *normal* eyes, 2 Black and 3 Red. This result proved beyond doubt that female B was a true Hybrid and the male a true Recessive.

The second female, C, was left with the same male, but as no mating had taken place by October 28, a Red male was added, mated, and the eggs were laid on November 4.

The figures given of the eyes and eye-colours are all taken from living animals, for the colours alter so rapidly after death, that notes made on the colour in dead or preserved specimens are not of the slightest value. For instance, the white pigment disappears within an hour or two of death, and the red also fades out completely, though much more gradually.

GENERAL NOTES.

Breeding different generations together.—Eight experiments were made with males of the F_3 generation and females of the F_2: one with R. × H.; two with H. × R.; two with H. × H.; and three with H. × P. In the first, the male was rather small, mated three times, and carried the female for 7, 6, and 6 days respectively with no results; female disappeared. In 2nd Exp. the female was eaten; 3rd Exp., one brood of 26 young was hatched, 11 Black and 15 Red, the male died; 4th Exp., one brood of 6 young; 5th Exp., eggs were laid, not hatched, male died; 6th Exp., same male as in the second experiment, one brood of 5 young, male died; 7th Exp., female laid eggs but died before they hatched; 8th Exp., four broods of 36, 17, 30, 30; male eaten. The results are not satisfactory, probably because of the difference in size. The females were large, and the males had only just reached maturity. When the animals are about the same size there is nothing to distinguish their matings from those of animals of the same generation.

Fertility.—A great variation in fertility has been noticed, not only in individuals, but often in all the members of any one brood.

Some instances may be given in illustration from broods of the F_1 generation of the Recessives. As an example of infertility Brood 1 of Exp. 9, p. 27, may be taken. Ten young were hatched, and most of them reached maturity, but after six months' breeding they all perished without leaving a single descendant. Brood after brood of eggs were laid, but not a single young one was hatched.

Another brood, Exp. 5, Brood 4, kept under the same conditions as the one just mentioned and breeding during the same time had 132 young. In the following four months, March to July, 1915, 91 young were hatched.

The next brood of the same experiment, Exp. 5, Brood 5, shows a curious variation. There were the same number of individuals as in the last, the same conditions, etc. After six months' breeding only 2 young were hatched from all the eggs laid, but in the following three months, April to July, 1915, 90 young were hatched.

For instances of fertility and infertility in individuals some of the F_2 animals may be taken. Sometimes an animal will mate several times with no results; the most striking case of this was the H. female of Exp. 39 (p. 36). Mated with a Black male, eggs were laid on September 12, 1914, carried for six days and then thrown off; eggs again on September 25 and again thrown off before hatching. The male was taken away, and another Black male put in: eggs laid on October 9 and thrown off; eggs again on October 23 and again thrown off. Then the female was left for a period without a male. On November 29 the male was put back, and eggs were laid, a large number, thrown off some days later; eggs laid on December 14, a large number, thrown off; eggs laid on January 3, 1915, all there on January 12, but on the 14th they were all thrown off except two, these were carried a day or two longer but not hatched. The male was taken away, and a Red male put in, which died on January 26 without any mating taking place. Then two more Red males were added —one disappeared on February 8. The female laid eggs, very few, these were thrown off on February 11. The male was again changed. On February 17 eggs were laid, and from these 4 young were hatched on March 8. Eggs were laid on March 10 and 12 young hatched on April 3. A fresh brood laid on April 3, hatched out on April 23, 19 young. The male disappeared and another was put in. Eggs laid on June 1, very few in number. On June 9 the male ate the female. The seven males used in this experiment, 2 Black and 5 Red, were all healthy animals, which had already fertilised the eggs of other females.

Numbers in Broods.—As a rule it is found that an exceptionally large brood of young is followed by a very small brood, or by the omission of one period of sexual activity, but in several cases the animals had a series of large broods, the highest numbers recorded in two succeeding broods being: In Exp. 11 (R. ♀ mated with H. ♂), 42 in the brood and (mated directly after with another H. ♂, Exp. 20) 44 in the next; in Exp. 51 (H. ♀ × R. ♂), 40 and (mated then with H. ♂, Exp. 106) 52, the largest number in a brood yet recorded; Exps. 60, 68, and 104 (H. ♂ × R. ♀) had 47 and 31, 30 and 48, and 40 and 43 respectively, and Exps. 70 and

71 (P. ♀ × R. ♂, and H. ♀ × R. ♂) had 43 and 23, and 41 and 41 respectively, all except Exp. 70 being Hybrid Black and Recessive matings.

Different rate of development.—There is often a marked difference in the rate of development of individuals in the same brood, and also of broods from the same pair. For example, in Exp. 85 (p. 38) some members of a brood hatched on January 6, 1915, were mature in March, the others not till June. Many instances like this were noted.

In Exp. 99, Brood V took four months to reach maturity ; Brood VI, seven months ; while Brood VII was mature in two months, and the animals were then much larger than many of the broods hatched three months earlier.

It was found that Bacteria greatly retarded growth ; in one case a female took eight months to become mature, and was then only about half the normal size.

SUMMARY.

1. Twenty-one thousand, five hundred and fourteen (21,514) amphipods of the species *Gammarus chevreuxi* Sexton have been examined for eye-colour, 21,302 referred to in this paper, and 212 in other experiments, not included.

2. The normal eye-colour of this species is black, with a superficial reticulation of opaque white pigment.

3. The pigmentation of the eye is very variable within limits. Eyes have been observed either partially or entirely lacking in the coloured pigment of the retinular cells, or with either a partial or entire lack, or else an excess of the opaque white pigment.

4. The red strain appears to have arisen as a " sport " in the second generation of offspring of the first animals captured. No red-eyed animals have yet been found in natural conditions, although many thousands have been brought in from time to time and examined. Those counted for the purpose while the work for this paper was in progress numbered 8697, but this figure does not include the many thousands previously observed. Experiments have been made repeatedly with a view of getting the Red strain again from the Pure Black, but with no success.

5. The Red eye-colour is not a sex-limited character ; about as many males as females come to maturity. 4248 red-eyed animals have been examined, 4175 referred to in the paper, and 73 in control experiments.

6. The inheritance of the coloured pigment of the eye follows the Mendelian law—Black is dominant and Red recessive. The dominants are divided into Pure Black and Impure or Hybrid Black.

7. The Pure Dominants and the Recessives breed true through all generations.

8. The crosses which have been made and the young hatched from them are as follows :—

Pure Black × *Recessive.*—3779 black-eyed young ; 3746 in paper, 33 in control experiments.

Hybrid Black × *Recessive.*—4255 young, of which 2176 were black-eyed and 2079 red-eyed. Those referred to in the paper numbered 4189, 2138 Black and 2051 Red, the others came from other experiments in the F_4 generation—not included.

Pure Black × *Pure Black.*—All black-eyed young, 1715 in number.

Pure Black × *Hybrid Black.*—All black-eyed young, 379 in number.

Hybrid Black × *Hybrid Black.*—4393 young, of which 3327 were black-eyed and 1066 red-eyed. Those referred to in the paper numbered 4302, 3259 Black and 1043 Red—the other 91, being from the F_4 experiments, not included here.

9. The absence or diminution of the white pigment seems peculiar to some broods. The " *no-white* " eye appeared in the second generation of offspring of Pure Black animals brought in from the ditches. The individuals affected in this way are more difficult to rear than the others, and, so far, attempts to breed them have not been successful.

10. The absence of the coloured pigment and degeneration of the eye occurred also in the F_2 generation—in this case from Hybrid Black animals.

11. The absence of the coloured pigment in perfectly formed eyes, the " *all-white* " eye, occurred in the Recessives. A great diminution of the red pigment has also been observed, particularly in the F_4 generation of the inbred Recessives.

12. The absence of the coloured pigment in part of the eye, the " *part-white* " eye, was observed in the first generation of offspring of Pure Blacks brought in from the ditches. It has been noted several times in both black and red eyes of specimens bred in the Laboratory, but only once in fresh-captured material. This case was a male, with one eye affected.

13. About as many males as females survive to maturity.

14. The breeding together of animals from different generations gives the same results as regards proportions of colours as the breeding together in the same generation.

EXPLANATION OF PLATE I.

FIG. 1.—Pure Black eye. Female from Brood 1 of Exp. 118 (p. 41). Extruded June 9.
        Mated with Red male, first brood hatched Aug. 26 numbering 14 ; five more
        broods, 19, 31, 24, 41, and 36 respectively, all black-eyed. Figured Oct. 29,
        1915, a few hours before moulting. × 58.

FIG. 2.—Hybrid Black eye. Female from Brood 7 of Exp. 105b (p. 41). Extruded April
        29, figured Nov. 24, 1915. Mated with H. male, one brood of 13, 10 Black
        and 3 Red. × 58.

FIG. 3.—Red eye. Large male from Recessive stock. Figured Nov. 5, 1915, two days
        before moulting ; examined after moulting but no increase of ommatidia
        seen. × 58.

FIG. 4.—Right eye of young Hybrid from H. × R. cross. Extruded Oct. 22, figured
        Oct. 25, 1915 ; the white pigment was then much more solid in appearance
        than when newly hatched. × 75.

FIG. 5.—Right eye of young Red from Recessive stock. Extruded Oct. 21, 1915, and
        figured three hours after extrusion. × 75.

FIG. 6.—" No-white " eye. Young male from the second generation of Pure Blacks
        (p. 25). Figured Nov. 23, 1915. × 58.

FIG. 7.—" Part-white " eye. Male. F_2 generation from P. × R. cross (see p. 45). Ex-
        truded June 15. Figured Nov. 2, 1915. × 58.

FIG. 8.—" All-white " eye. Male from inbred Recessive stock (see p. 45). Extruded
        April 2, died in moulting and figured Nov. 19, 1915. × 58.

FIG. 9.—" All-white " degenerate eye, right side. Female B. F_2 generation from
        P. × R. cross (see p. 46). Extruded June 1, figured Nov. 16, 1915. × 58.

FIG. 10.—" All-white " degenerate eye, left side, from Female B. Figured Nov. 16. × 58.
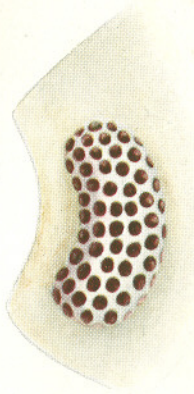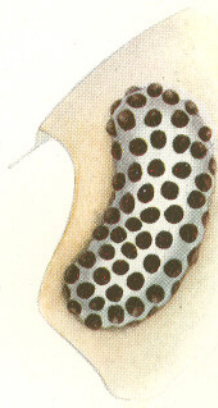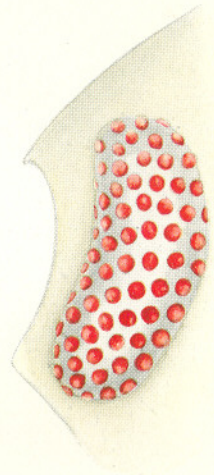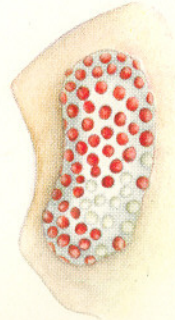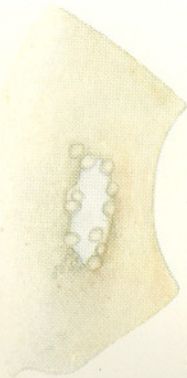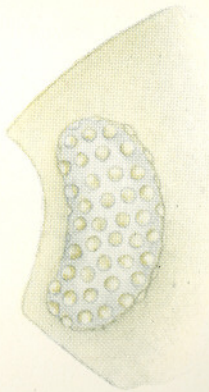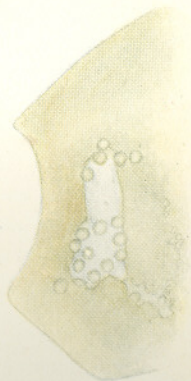
Notes on the Life History of *Anaphia petiolata* (Kröyer).

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With Figures 1 to 3 in the Text.

IN the early summer of 1915 it was noticed that many medusæ brought in with the tow-nettings contained larval Pycnogonids in the manubrium and at the junction of manubrium and stomach. The medusæ specially noticed to contain them were *Obelia* sp., *Cosmetira pilosella*, *Turris pileata*, *Stomotoca dinema* and *Phialidium hemisphericum*. By far the greater number were in *Obelia*, although many were in *Phialidium hemisphericum* and *Cosmetira pilosella*. They were extremely abundant in June, after that became scarcer, and finally disappeared by October. On examination they were seen to be larval stages of *Anaphia petiolata**** (Kröyer), a Pycnogonid common in Plymouth Sound. The older larvæ sometimes were seen to cast their skins, so that the species could be easily recognised, although the fourth pair of walking legs were not fully developed. This is evidently the species described by Dogiel (1913) as *Anoplodactylus pygmæus*, the life history of which he traces from its first entry into the *Obelia* hydroid to the older stages when it is ready to leave its host. The form he refers to as *Anoplodactylus petiolatus* occurring in cysts in *Coryne* with *Phoxichilidium femoratum* must be some other species, as his figures prove clearly that it differs from *A. pygmæus*, and also the colour is totally different (a bright pink, while the present form is a pale yellow). Dogiel believes he has proved that *Anoplodactylus petiolatus* and *A. pygmæus* are different species from the difference in their life histories, and it is evident that he is dealing with two different species, but his *A. petiolatus* cannot be the same as our form, which is certainly identical with his *A. pygmæus*, and shows that Sars (1891) and Norman (1894) were right in regarding *A. pygmæus* as the young form of *A. petiolatus* (Kröyer).

* This is a synonym of *Anoplodactylus petiolatus* (Kröyer). See Norman, 1908, p. 202.

Dogiel's account of the larval stages of *A. pygmæus*, together with the present discovery of the older larvæ in medusæ, shows a most interesting life history. According to him the very young larva hatches out of the egg (which contains very little yolk), leaves the protection of the father, and crawls on to the *Obelia* hydroid. In this early stage it has three appendages, the first the chelæ, the second and third with long thread-like ends which are used for attachment to the father directly after hatching. It immediately begins to burrow into one of the hydroid polyps, and once settled down there undergoes a metamorphosis, the second and third appendages atrophy, and three pair of walking legs develop. After several moults older larvæ appear, which are like the adults, except for the incompleteness of the last pair of walking legs, and these leave the hydroid and begin to live a free existence.

The stages found in the medusæ correspond to the larval stages after the second and third appendages have atrophied. The youngest stage seen corresponds with Dogiel's Stage IV with the three pair of walking legs indicated and the chelæ well stretched out in front, which are used for clinging firmly to the host. Dogiel has called attention to the fact that many larvæ do not succeed in entering the polyps, and have to undergo their development on and not in the hydroid, and now we find still another alternative for the larva. A large proportion of them, instead of entering a polyp, must in some way manage to enter a medusa. How they do this it is not possible at present to say. Possibly they cling to a medusa just as it is escaping from the colony, or perhaps they may get into a gonotheca before the liberation of the medusæ. One young larva in just the same stage as the youngest from a medusa was found amongst a colony of *Obelia* from Laminaria collected below the Laboratory. The occurrence of the same larva in various medusæ shows that it does not strictly keep to one species or genus of hydroid, although *Obelia* seems to be the favourite host.

The discovery that larval Pycnogonids are carried about by medusæ must have an important bearing on their means of dispersal, those individuals which are in the medusæ having much greater chances of life than those in the crowded area where the hydroid colony is situated. Pycnogonids swim feebly, and have not much in themselves to help in their distribution (see Calman, 1915, p. 6), but in the parasitic habits we have an important means of dispersal. Already H. Merton (1906) has found a species of nymphon (*N. parasiticum*) living parasitically on the nudibranch *Tethys leporina* in the Mediterranean. H. Prell (1909) has found nymphon on Lucernaria (in this case eating the tentacles), now we find larval forms being carried about in medusæ. It is interesting to note that a young specimen of *Endeis spinosus* (Montagu) was twice found

in the tow-nettings from outside the Breakwater, Plymouth, extended flat on the top of the bell of an *Obelia* medusa, and clinging to it. So beautifully was it balanced that the medusa could swim perfectly, although weighted by the Pycnogonid.

If medusæ and Pycnogonids are left together in a vessel, e.g. *Anaphia petiolata* or *Endeis spinosus*, it is nearly always found that the Pycnogonids are attracted towards the medusæ and cling to them. The only movement made by the young larvæ when taken from the medusæ is a strong waving of the chelæ, and if these come in contact with a medusa they cling tightly to it.
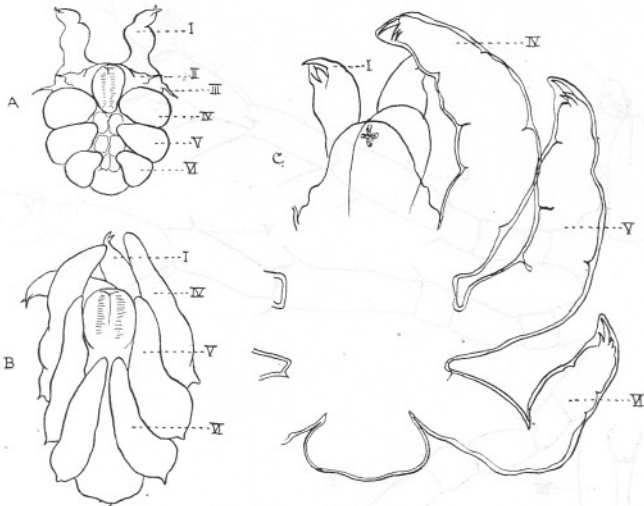
Fig. 1.—Larval stages of *Anaphia petiolatus* (Kröyer). × 60. A. Youngest stage in *Obelia* medusa ; B. Later stage ; C. Still later stage, the legs having been separated with needles. I–VI. The appendages. Ventral view.

The larva at all stages is of a pale yellow colour, and has its legs so folded that they pack into the smallest possible space. As many as four were found in one medusa, but usually there is only one. It grows rapidly, and the body elongates considerably together with a great lengthening of the legs. In the youngest stage found (Fig. 1, A) the legs (IV–VI) were short, roundish stumps, the alimentary canal extending into them and well into the chelæ. The chelæ were powerfully developed with strong claws ; remains of the second and third larval appendages were seen as small hair-like protuberances. These, however, are often very difficult to see, and the drawing shows an exceptionally clear specimen. These appendages, although dwindling, persist until the larva has grown to nearly twice the size ; in this differing from Dogiel's observations, who describes them as disappearing almost at once.

As the legs elongate a short spine is apparent at the angle of folding, but these soon disappear (Fig. 1, B). When considerably larger the larva resembles the adult, although still packed up tight. If the legs be unfolded the body is seen to be broad with the cephalic segment distinct, proboscis fairly long, the claws of the legs showing through the skin, and the last pair of legs and caudal segment appearing as a broad hind piece (Fig. 1, C). Yellow eyes have now appeared. This is the last larval
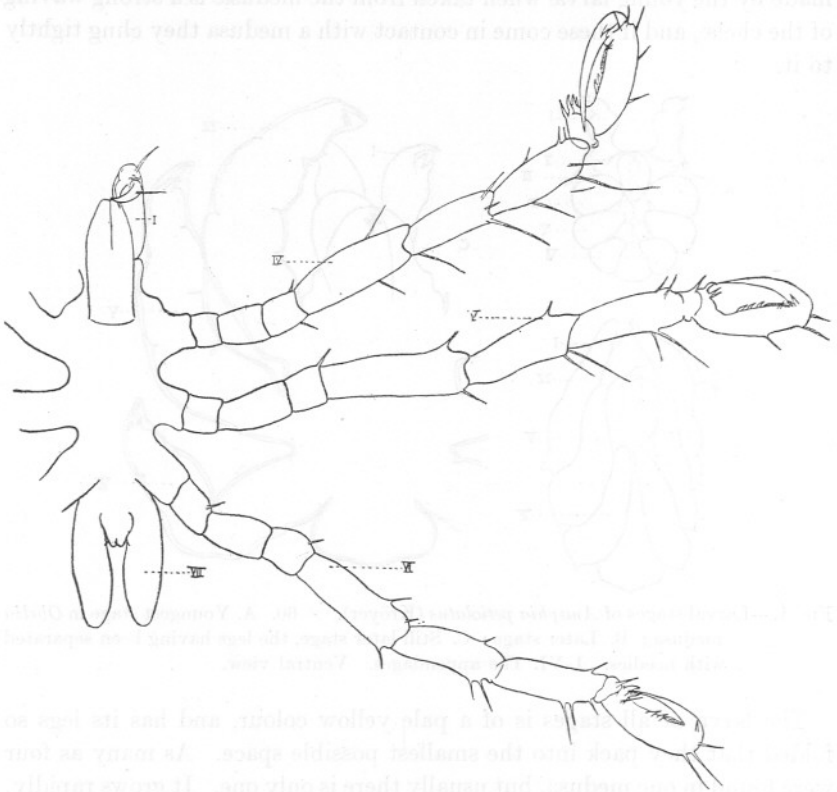
Fig. 2.—Young *Anaphia petiolata* (Kröyer) soon after emergence from the last larval skin. Lettering as before. × 47.

stage, which shows the young *Anaphia* through the skin, and this form can often be seen with the young *Anaphia* emerging from it. This is in all essentials like the adult, but much smaller, and with the last pair of legs appearing as two stumps with a very short caudal segment in between them. When quite newly hatched it measures about 0·70 mm. from the anterior end of the cephalic segment to the posterior end of the caudal segment (Fig. 2). The cephalic segment is very short, in fact the whole animal is exactly like the figures and descriptions of *Anoplo-*

dactylus pygmœus (Hoek, 1881 ; Hodge, 1864). By comparing these young forms with older undoubted specimens of *Anaphia petiolata* (Kröyer), they correspond exactly with the exception of the length of the cephalic segment, which grows with the animal just as Canon Norman suggests (1894). The growth, however, appears to take place after the
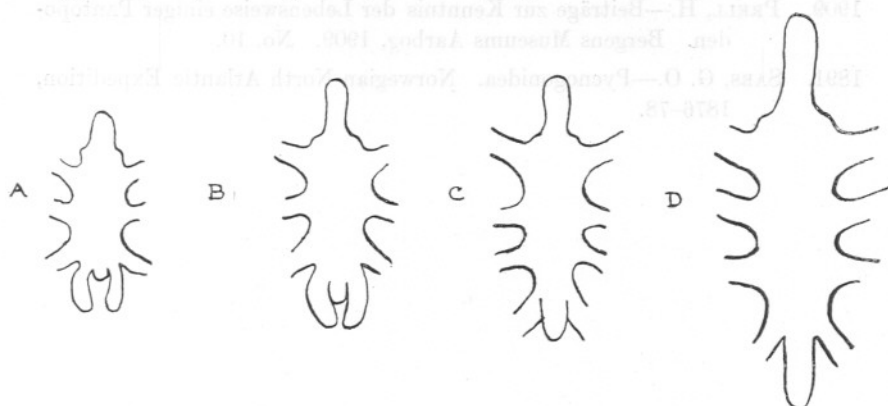
FIG. 3.—Diagram to show growth of cephalic segment. A. Length 0·70 mm., young *Anaphia petiolata* directly after emergence from the last larval skin ; B. Length 0·90 mm., later stage ; C. Length 1·04 mm., later stage in which all legs are developed ; D. Length 1·56 mm., nearly full grown.

moult in which the walking legs are complete, that is to say when the body and legs are fully formed, for a series of measurements show that there is very little difference in the length of the cephalic segment of the young form after it has sloughed its last larval skin and the young form with completely formed legs (see Fig. 3). The increase in length takes place afterwards.

LITERATURE.

1915. CALMAN, W. T.—Pycnogonida. British Antarctic (" Terra Nova ") Expedition. 1910.

1913. DOGIEL, V.—Embryologische Studien an Pantopoden. Zeitschrift für Wissenschaftliche Zoologie, Bd. 107, pp. 575–741.

1864. HODGE, G.—List of the British Pycnogonoidea with Descriptions of Several New Species. Annals and Magazine of Natural History. Feb., 1864.

1881. HOEK, P. P. C.—Nouvelles Etudes sur les Pycnogonides. Archives de Zoologie Expérimentale et Générale, pp. 445–542.

1906. MERTON, H.—Eine auf Tethys leporina parasitisch lebende Pantopodenlarve (Nymphon parasiticum, n. sp.). Mittheilungen aus der Zoologischen Station zu Neapel, Bd. 18, pp. 136–41.

1894. NORMAN, CANON A. M.—A Month on the Trondhjem Fiord. Annals
        and Magazine of Natural History, Ser. 6, Vol. XIII. Feb., 1894.

1908. Ibid.—The Podosomata (=Pycnogonida) of the Temperate Atlantic
        and Arctic Oceans. Journal of the Linnean Society, Zoology,
        Vol. XXX, pp. 198–238.

1909. PRELL, H.—Beiträge zur Kenntnis der Lebensweise einiger Pantopo-
        den. Bergens Museums Aarbog, 1909. No. 10.

1891. SARS, G. O.—Pycnogonidea. Norwegian North Atlantic Expedition,
        1876–78.

Medusæ as Hosts for Larval Trematodes.

By

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With Figure 1 in the Text.

THE larval form (late cercaria stage) of *Pharyngora bacillaris* (Molin) has been recorded by Nicoll (1910) from Plymouth as occurring free in the coarse-meshed tow-nettings in August. The adult is a common parasite of the mackerel, and the above is the only record of its larval stage.

Whilst examining tow-nettings at Plymouth in 1915 it was found that certain medusæ were at times abundantly infected with a trematode which proved to be the larval form of *Pharyngora bacillaris*. As it also occurred free, although almost certainly having originally come from the medusæ, it is obviously the form recorded by Nicoll, who expected the host to be a crustacean and unsuccessfully examined copepods in order to find it.

The medusæ found to contain the trematode were *Obelia sp.*, *Cosmetira pilosella*, and *Turris pileata*. *Cosmetira pilosella* was the commonest host in the early summer when Pharyngora was most abundant, but in the later summer Obelia was found to contain it frequently, Cosmetira not occurring at those times in the tow-nettings. *Phialidium hemisphericum* was also a host in the later summer and autumn. Even in December it still occurred, though very rarely. A ctenophore may also serve as host for this trematode, as it is occasionally found clinging to the inside of the stomach of *Pleurobrachia pileus*.

The parasite is generally to be found clinging to the manubrium or stomach wall of its host, but sometimes it occurs underneath the umbrella wall, so that it looks as if it were on the top, the wall being so transparent ; on further examination, however, it is seen to be underneath. It seems to be undoubtedly a case of parasitism as so many of the medusæ were infected, sometimes every specimen in a haul, and, with the exception of an occasional ctenophore, none of the other animals in the same haul contained them or had them clinging to them.

From these observations it seems that there is no encysted stage in this species, the period passed in the medusa serving the same purpose. Probably this period is very short, the mackerel swallowing the host soon after the entry of the parasite, and for this reason an encysted stage is not necessary.

Nothing is at present known of the early stages in the life history of Pharyngora, although it is to be inferred that a mollusk is the first host.
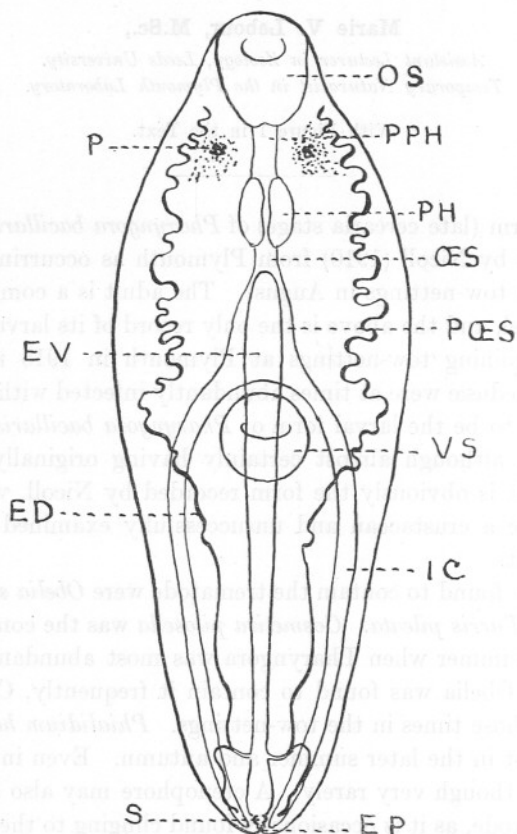
Fig. 1.—*Pharyngora bacillaris.* × 120. ED, excretory duct ; EP, excretory pore ; EV, excretory vesicle ; IC, intestinal cæcum ; ŒS, œsophagus ; OS, oral sucker ; PH, pharynx ; PPH, prepharynx ; PŒS, pseudo-œsophagus ; VS, ventral sucker.

The larval worm is very like the adult, but without reproductive organs (see Fig. 1), and bears a close resemblance to Nicoll's figure (Plate XXIX, Fig. 5). The body is covered with minute spines ; the curiously shaped oval sucker is conspicuous ; ventral sucker, prepharynx, pharynx, œsophagus, pseudo-œsophagus, and intestinal cæca all agree with the

adult form. The body in this stage, however, is crowded with gland cells along the sides reaching from the pharynx to well behind the ventral sucker. The pigment spots anteriorly are very well developed. The excretory vesicle is long and narrow, just as Nicoll describes it, its ducts in the larval form showing particularly clearly. At the hind end is a strong sphincter guarding the opening posteriorly ; in front of this the main excretory branches are given off which send one branch backwards and a much convoluted branch forwards. The flame cells are particularly well seen in the living larval forms. As Nicoll's description does not enter into the details of the excretory system a figure of the larva is given, showing the main points.

REFERENCE.

1910. NICOLL.—On the Entozoa of Fishes from the Firth of Clyde. Parasitology, Vol. III, No. 3.

Notes on the Œcology of *Cirratulus* (*Audouinia*) *tentaculatus* (**Montagu**).

By

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With Figures 1 to 7 in the Text.

Cirratulus tentaculatus is found inhabiting the wet, sandy, somewhat foul mud of the Aberystwyth shore, chiefly in the Laminarian zone, although it also occurs in rock pools higher up the shore in which there is sufficient depth of sand containing the necessary organic matter. The presence of the worm in its natural habitat is indicated by a group of delicate, elongate, rosy or yellow coloured filaments of tentacular appearance which protrude from the sand into the pools left by the receding tide. These filaments nearly always display a certain amount of movement, either waving gently from side to side or curling slightly from the tips. The amount of motion and also the colour of the filaments will depend on the degree of freshness of the water in the pool, and this, of course, will, in its turn, be related to the state of the tide.

Specimens are not easy to collect owing to the marked propensity the animal exhibits for lying with its body beneath stones or pieces of rock embedded in the mud. In rock pools or crevices where there is but little depth of sand and the animal lies with its body more or less parallel to the surface collection is almost impossible. This response to stimuli of contact and pressure, or, as M. Georges Bohn has it, this " thygmotactism," is very marked, and, in the aquarium, when specimens are placed in a vessel containing sand and a few stones, the animals will roam about till some portion, at any rate, of their bodies is undergoing pressure from those stones.

Thus, in addition to the occurrence of sandy mud of rich organic content, the worm would seem to require the presence of a certain amount of rock or loose stones. Both these requirements are well met on the portion of the Aberystwyth shore opposite the College. Here a large reef of rock runs out to sea in such a manner as to form a barrier to the prevailing wind and thus to aid in the deposition of organic matter, of which no doubt a certain proportion is contributed by the Harbour sewer lying to southward, decaying fragments of algæ, etc.

When withdrawn from the mud Cirratulus presents an exceedingly limp and bedraggled appearance. The body appears to possess, when in this partially extended condition, absolutely no turgidity. This is in agreement with the animal's marked thygmotactism, the necessary tension being secured in the natural habitat by the pressure of stones.

A detailed account of the external characters is no longer necessary, owing to the recent appearance of Vol. 3 of Prof. McIntosh's memoir on British Marine Annelids, containing the Cirratulidæ (1). It is sufficient to say that the species *tentaculatus* is distinguished by the occurrence of lateral filaments on segments anterior to the fifth chætigerous segment behind which the paired fascicles of filaments arise.

Considerable doubt seems to exist as to the analogy of the lateral filaments with those of the paired tufts. Prof. McIntosh quotes Claparède as distinguishing (in *C. chrysoderma*) between tentacles and branchiæ in such forms by the fact that the former have only one blood-vessel, whilst the latter have two. In *Audouinia filigera*, on the contrary, every filament is branchial in structure. De St. Joseph (2) distinguishes between Cirratulus, in which the tentacles appear at the same time as the branchiæ, and Audouinia, in which the segments bearing the tentacles are preceded by a variable number of segments with lateral branchiæ, and remarks that in neither case do the tentacular filaments and lateral branchiæ differ materially in external appearance. Cunningham and Ramage (3), on the other hand, describe a groove along the so-called tentacles and find it to contain only a single blood-vessel, whereas in the branchiæ two blood-vessels are present.

J. Bounhiol (4), in an ingenious paper on Respiration in Polychætes, denies any respiratory function to either kind of filaments ; he says if a specimen of either *Cirratulus cirratus* or *C. tentaculatus* be placed in a glass vessel the floor of which is covered with sand, the animal is soon seen to make active use of the tentacular filaments to remove the sand grains, draw them towards itself and more or less cover itself with them. These filaments have been placed by anatomists in two categories, according to whether they contain a simple vascular cæcum or a complete vascular circuit. The first are called tentacular filaments, the others gills. But the animal uses both kinds indiscriminately as prehensile organs. It has also been shown by experiment that the respiratory rôle of these so-called gills is very feeble, and merely corresponds to an increase of the body surface. " La définition anatomique des branchies de Cirratulidæ n'est donc pas confirmée par l'expérimentation physiologique. Ce sont de simples organes prehensiles, tout comme les filaments prehensiles dont on avait cru pouvoir les distinguer."

The experiments of M. Bounhiol on Cirratulus in his examination of the

filaments as respiratory organs were faulty as they made no allowance for
the animal's natural habitat. The rôle played by the filaments is essen-
tially respiratory; further, close observation has shown that the prehensile
function, so readily admitted by most authors, is non-existent. Careful
study of the animal's habits shows that there is absolutely no need for
such a function, whereas there is every need for that of respiration. What
leads the majority of observers to suppose a prehensile function is un-
doubtedly the perpetual curling motion of the filaments in the pools. A
differentiation of function between the lateral filaments and those in the
paired fascicles is undoubtedly suggested by their behaviour when the
animal is withdrawn from the mud. The filaments in the clusters im-
mediately contract, their colour becoming quite yellow, while the remain-
ing lateral filaments are still more or less distended by the contained blood,
and are, of course, red in colour. These superficial differences, however,
do not necessarily prove any difference in function, and this notwithstand-
ing the disparity in structure referred to by Bounhiol. [It has been sug-
gested that the fascicles of filaments are prostomial tentacles which have
shifted backwards, Meyer (12)]. The worm is essentially and in all except
perfectly abnormal conditions a burrower, and consequently permanently
subject to pressure. When all pressure is relaxed and the animal bathed on
all sides by water it is only natural that, with respiration taking place over
the whole body surface, numbers of filaments should be left idle, and it
would be particularly the filaments lying in front of the heart-body which
would be affected. In further response to the relieved pressure the animal
contracts and curls up, the anterior part of the body is forced beneath the
coils and the prostomium is protruded as far as possible, and the charac-
teristic actions of burrowing are performed, that is to say, the anterior
region is pumped turgid with fluid and waves of muscular contraction
pass along the body from behind forwards. At the same time the mucous
investment, with the sand adhering from the burrow, is gradually shed
and becomes caught in the gill filaments, and an inextricable tangle is the
result. Prof. McIntosh notes that the animal appears to be less comfort-
able in pure sea water, and thinks the mud to be the most fitting medium,
since it keeps the filaments apart. Undoubtedly, mud is a more fitting
medium, but not, I think, for this latter reason. If a number of flat stones
be laid upon the bottom of the vessel, the worm, a few hours later, will be
found ensconced beneath them and numbers of filaments will stretch in
all directions, without any trace of entanglement, showing that what the
animal chiefly lacks is pressure.

The appearance of the gill filaments when the worm is in its natural
habitat is sufficiently familiar, but the manner in which they attained
that position, in view of their extreme delicacy, is rather remarkable. If

the worm be withdrawn from the mud on the floor of the pool and left on the surface, it will immediately coil up and commence to burrow again in the manner already noticed. Owing to the downward and forward move- ment the gill filaments will tend to stream backwards, and, as the worm progresses, being extremely elastic, their distal portions will remain at the surface, the filaments stretching till the animal has found its proper level. The portions of the filaments remaining in contact with the water will thus be available for aeration of the contained blood.

The question now arises as to how the animal would react should the filaments become buried beneath several inches of mud, as must often happen.

In order to answer this question a specimen of Cirratulus was placed at the bottom of a glass vessel 5 inches high by $2\frac{1}{4}$ inches in diameter, covered with mud to the height of two inches, and the remainder of the vessel filled with water. Four hours later a number of filaments were projecting at the surface. The following day, when about 20–30 filaments were pro- jecting, another $2\frac{1}{2}$ inches of mud were added. Two hours later one fila- ment had been protruded. This time, by a lucky chance, the anterior end of the worm was in contact with the glass close to the top of the first layer of mud, and its behaviour could thus be observed. The body of the worm itself was practically stationary, some of the filaments of the anterior fascicles were yellow and motionless, but numbers which were gorged with blood showed remarkable activity, and were gradually yet speedily forcing their way upward through sand and mud to the surface, exactly as if they were so many individual worms. The extensility and muscular activity of the filaments is therefore enormous, the length of some of them from their junction with the body wall to the tips exceeding three inches.

The whole forms a remarkable adaptation to an underground habitat. The majority of species of Polychætes inhabiting the same environment are either of small size and able to respire through the body wall generally, or they are obliged to mount to the surface to avoid asphyxiation. Cirra- tulus is able to live permanently surrounded by the sandy mud where it finds its food supply (reference to which will be made later), and by re- maining constantly underground is well protected from enemies. The large numbers in which Cirratulus occurs is sufficient proof of its success.

We have seen that when the body of the worm is undergoing pressure the filaments are stimulated to great activity by the pressure of blood in their vessels, and on seeking an explanation of this phenomenon, we can- not help being struck by the fact that in the Cirratulidæ, the heart-body, the function of which has aroused so much curiosity, reaches its greatest development.

The structure and function of the heart-body, in this and in other

groups where it occurs, has been discussed by L. J. Picton (5) and, several years previously, by J. T. Cunningham (6). Although the former writer is chiefly concerned with the composition of the granules contained in the cells forming the body, and of their reaction to various stains, his object being principally to examine its claims as an excretory or blood-controlling organ, he nevertheless gives a certain amount of attention to its possible mechanical function. He quotes the suggestion of Schaeppi (7) in the case of Ophelia and of Steen in that of *Terebellides Stroemii* to the effect that the organ has a valvular function. Schaeppi considers this is brought about by the swelling of the organ at systole owing to the pressure of blood in its meshes. The most telling evidence in favour of a mechanical action is that afforded by *Cirratulus chrysoderma*. Picton says that in this species, which is transparent, the heart-body at the point of its greatest development almost entirely blocks, at systole, the lumen of the heart, the action of which as a blood-propelling organ must be considerably modified.

It seems certain from what has been noted of the habits of Cirratulus that it depends to a great extent amid its somewhat foul surroundings, for its supply of oxygen, on the long filaments. There is, therefore, every necessity, in view of their delicate nature, for maintaining them turgid. Otherwise, they would be extremely liable to breakage and laceration. This difficulty would be met by the heart-body acting as a valve and preventing the blood from being regurgitated. It is certainly remarkable that in Arenicola, to which genus the above arguments apply with almost equal force, the heart-body is also strongly developed. J. H. Ashworth (8) also suggests a valvular function in this latter, and the fact that the organ does not appear till after the pelagic larval and post-larval stages are complete is not without significance. Some such arrangement would be a small compensation for the drawbacks to which Arenicola, with its delicate branched gills, must undoubtedly be exposed, through its sandy environment.

External processes with respiratory properties are a common feature in Polychætes, but that does not necessarily imply the same need for a heart-body, with the function described, in all. According to Picton a heart-body is found in the following groups : Spionidæ, Cirratulidæ, Terebellidæ, Ampharetidæ, Amphictenidæ, Chlorhæmidæ, Sternaspidæ, and Hermellidæ. He omits the Arenicolidæ, and states that in Magelona the organ is merely larval and transitory. As regards the Spionidæ, I am unable to find any confirmation as to its occurrence in this group. Possibly owing to a revision of the nomenclature the Cirratulidæ have been included twice in this list, under different headings.

M. Georges Bohn (9) shows how among Annelids adaptation to life in the sand is pushed further in some groups than in others, and divides the Poly-

chætes, after excluding the Errantia, into three classes, according to the degree in which they have become adapted to a subterranean existence. In connection with this it is interesting to note that it is only in his third group, i.e. among those in which the burrowing habit is the rule, that the heart-body is present, and that all possess delicate respiratory filaments. Bounhiol, to whose paper reference has already been made, belittles the value of these processes for respiration, but the point is that they are not merely of value as gills pure and simple, but are often the seat of abundant cilia which ensure the circulation of water round the body itself. Thus in tubicolous forms serious damage to the processes is as dangerous as in Cirratulidæ or Arenicolidæ. In the Sabellidæ, which do not possess a heart-body, aeration of the body in the tube is obtained by the perpetual protrusion and retraction of the branchial crown, and here the branchiæ or tentacles are no longer soft and delicate, but are supported by an undoubted skeleton, whereas in the closely allied Hermellidæ, e.g. Sabellaria, where a heart-body is present, the " tentacles " and neuropodial processes are again of the delicate type.

GROUPS POSSESSING A HEART-BODY.

Family	Habits.	Type of branchiæ.
Cirratulidæ.	Permanent burrowers; with exception of one boring form.	Gills soft, delicate, and filamentous, capable of great elongation.
Terebellidæ.	Forms building tubes of sand or mud.	Gills, situated at anterior end, branched in most species, but all soft and delicate.
Ampharetidæ. } Amphictenidæ. }	Tubicolous.	Gills, situated at anterior end, delicate and filiform, capable of extension, e.g. *Pectinaria belgica.*
Arenicolidæ.	Permanent burrowers.	Gills branched and delicate.
Chlorhæmidæ.	Burrowers or inhabitants of tubes in mud.	Gills delicate and filiform.
Sternaspidæ.	Burrowers.	Gills delicate and thread-like.
Hermellidæ.	Tubicolous.	Filaments at anterior end are apparently not much used for respiration, but true branchial processes are present on the sides of the body. These are delicate, unbranched and covered with cilia.

The above table shows considerable similarity in the nature of the gills and habitat among the species of those families which possess a heart-body. The majority are burrowers, permanently subjected to pressure, and even in the tubicolous forms, seeing that they must often become sanded up (for instance, by wave shock when the tide is rising), the possession of a heart-body cannot but be advantageous in preventing re-gurgitation of the blood to the dorsal vessel, keeping the branchial processes turgid, and generally counteracting the effects of varying pressure. As a proof of this we note that the greatest development of the heart-body occurs in just those groups where burrowing habit and branchial development are carried to their greatest extent.

It is perhaps advisable to point out here that any mechanical function which is suggested on behalf of the heart-body is only regarded as secondary. There seems hardly any doubt that in the heart-body we are dealing with a structure the original function of which was almost, if not entirely, organic.

It may be urged that, according to this theory, one might reasonably expect to find the development of a heart-body in those other groups of M. Bohn's where the burrowing, free-swimming, and crawling habits are combined, e.g. in the Aphroditidæ, Phyllodocidæ, Nephthydidæ, Glyceridæ, Eunicidæ, Ariciidæ. In these groups, however, apart from the fact that, owing to their semi-active habits, the danger of asphyxiation is considerably reduced, the branchial processes themselves are in most cases effectively protected by the great development of the parapodia and chætæ. This is excellently exemplified by the condition in Nephthys, where the sickle-shaped gill is situated between the strongly developed lobes of the parapodia and their lengthy chætæ.

As we pass to the consideration of forms with more and more pre-dominantly burrowing habit we note the concurrent reduction in size of the chætæ, for, useful as they undoubtedly are in swimming and crawling, they can only be a hindrance to progress in and through sand. The bristles acquire more and more the character of short hooks, enabling the animal to grasp the side of its burrow, and, if the gills are to be retained, a new method of protection must be adopted.

METHOD OF FEEDING.—I will now examine the specialised method of feeding in Cirratulus in more detail. Unlike its congener in the same habitat, Arenicola, Cirratulus does not live by passing sand through the gut ; selection of the nutritive organic particles is made outside the body. The excreta are green in colour, and the worm's diet would seem to consist of algal spores, fragments of decaying algæ, diatoms, and general organic debris. In preparing the worm for sectionising no special precautions were taken to ensure the emptying of the gut, and the razor did not suffer.

The best proof of the microscopic nature of the animal's food is the ciliated condition of the gut. It remains to be seen by what means the animal is able to exercise selection.

On the ventral side of the peristomium a deep groove leads back to the mouth and is continuous with the dorsal surface of the gut. On the walls of the pharynx immediately behind the mouth opening are situated a pair of flaps. These flaps are dorso-lateral in position and project each with its free edge standing out ventrally towards the median line (see Figs. 1–7).

FIG. 1.—Transverse section through the anterior portion of the peristomium, showing the ventral groove.
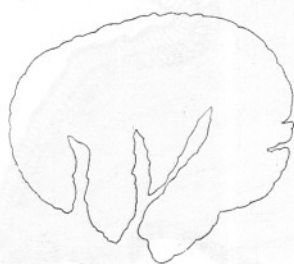
FIG. 2.—Transverse section behind Fig. 1, showing the development of the sensory flaps.
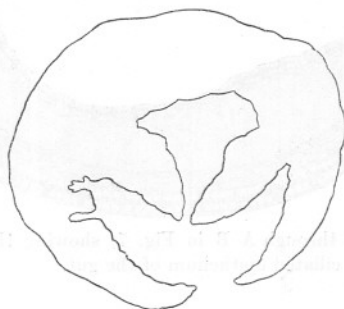
FIG. 3.—Section through the peristomium, somewhat anterior to the line AB in Fig. 7.

The two free edges are closely apposed and thus practically separate a groove above them from the remainder of the vestibule beneath. The epithelium of this groove and of the surfaces of the flaps which face inwards, including the free edges, is ciliated and rich in sensory elements, and is most markedly distinguishable from the general epidermis and from the lining of the vestibule, the floor of which projects forwards and seems glandular. The ciliated epithelium of the gut has already been noticed. The animal would thus seem to feed by a kind of suction; the sensitive edges of the flaps being closely apposed would effectively prohibit the entrance of any but the smallest food particles, and these latter would be wafted backwards by the cilia of the gut epithelium.
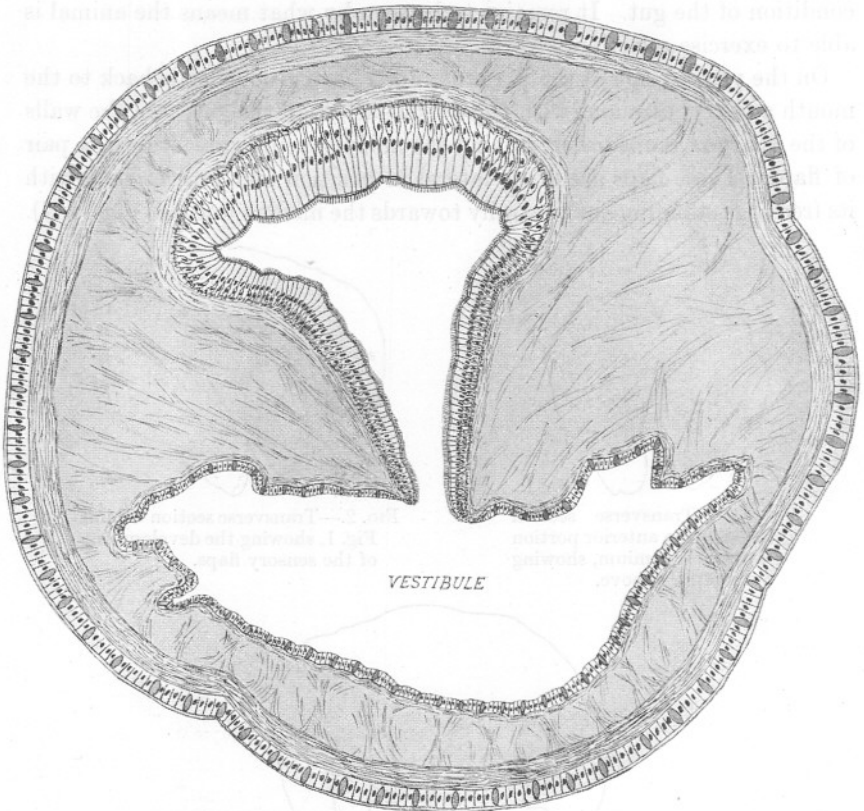
FIG. 4.—Transverse section through A–B in Fig. 7, showing the sensory lips and the ciliated epithelium of the gut.
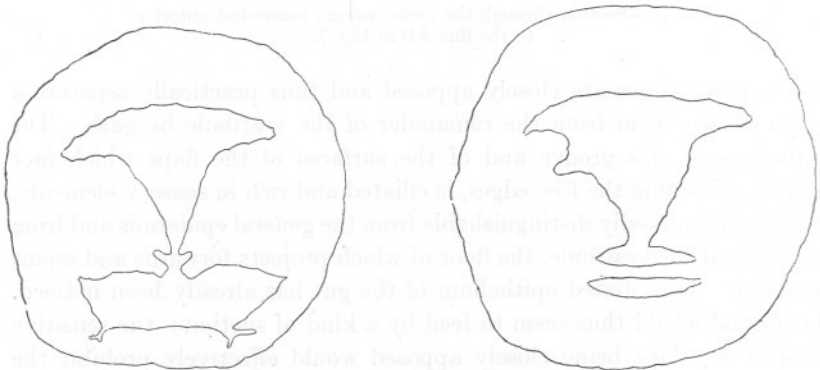
FIGS. 5 and 6.—Sections showing the gradual disappearance of the vestibules and the fusion of the sensory flaps with the sides of the pharynx.

In view of such a method of feeding, the idea of a food-catching function on the part of the filaments must be rejected. Moreover, as the mouth of the worm in its burrow is situated some distance beneath the surface and the filaments are waving in the water above, how is any such function practicable ?

I am convinced that it is only under direst necessity that Cirratulus quits its burrow, and then it is certainly not to swim about actively, as M. Bounhiol suggests, but merely to crawl sluggishly on the surface of the
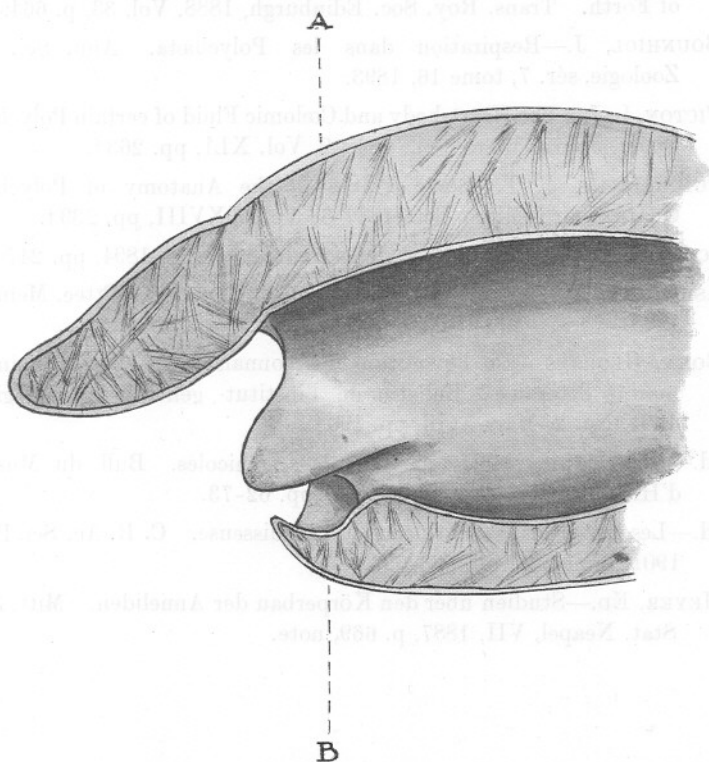
Fig. 7.—Diagrammatic median longitudinal section through the anterior end of Cirratulus.

mud. If by an accession of clean water the symptoms of asphyxia are removed, the worm will immediately recommence burrowing.

Nor are the filaments used to collect sand particles. Sand particles adhere to the mucus exuded by the body of the worm, and by so doing probably prevent the walls of the burrow from caving in. They thus allow the animal greater freedom of movement, but there is certainly nothing that can be dignified by the name of a tube.

In conclusion, I wish to thank Mr. F. S. Wright for his able execution of the drawings for half-tone blocks for this paper.

BIBLIOGRAPHY.

1. McIntosh, W. C.—British Marine Annelids. Ray Society, 1915. Vol. III, Part 1, pp. 242 f. Cirratulus tentaculatus.

2. de St. Joseph.—Les Annélides Polychétes des côtes de Dinard. Ann. Sci. Nat. Zoologie, sér. 7, tome 17, 1894, pp. 1 f.

3. Cunningham, J. T., and Ramage.—Polychæta Sedentaria of the Firth of Forth. Trans. Roy. Soc. Edinburgh, 1888, Vol. 33, p. 664.

4. Bounhiol, J.—Respiration dans les Polychæta. Ann. Sci. Nat. Zoologie, sér. 7, tome 16, 1893.

5. Picton, L. J.—The Heart-body and Cœlomic Fluid of certain Polychæta. Quart. Journ. Micro. Sci., 1898-9, Vol. XLI, pp. 263 f.

6. Cunningham, J. T.—Some Points in the Anatomy of Polychæta. Quart. Journ. Micro. Sci., 1887-8, Vol. XXVIII, pp. 239 f.

7. Schaeppi.—Ophelia radiata. Jenaische Zeitschrift, 1894, pp. 247-293.

8. Ashworth, J. H.—Arenicola. Liverpool Mar. Biol. Cttee. Memoirs, 1903.

9. Bohn, Georges.—De l'évolution des connaissances chez les animaux marins littoraux. Bulletin de l'institut general psychologique, 1904, No. 2, Mars-Avril, pp. 190 f.

10. Id.—Observations biologiques sur les Arenicoles. Bull. du Museum d'Histoire Naturelle, 1903, No. 2, pp. 62-73.

11. Id.—Les intoxications marins et la vie fouisseuse. C. R. Ac. Sci. Paris, 1901, tome 133, pp. 593-596.

12. Meyer, Ed.—Studien über den Körperbau der Anneliden. Mitt. Zool. Stat. Neapel, VII, 1887, p. 669, note.

An Account of the Researches on Races of Herrings

Carried out by the Marine Biological Association at Plymouth, 1914–15.

By

J. H. Orton, D.Sc.,

Naturalist at the Plymouth Laboratory.

With Figs. 1 to 6 in the Text.

CONTENTS.

[The following Tables record the measurement and enumeration of a number of characters in certain samples of Herrings taken in the neighbourhood of Plymouth. The work was carried out as part of a general scheme for studying the question of the existence of local races of herrings around the British Coasts, which was organised by the Board of Agriculture and Fisheries. In consequence of the war there is no immediate prospect of the figures being analysed and compared with similar figures relating to fish obtained in other localities. It has therefore been thought

advisable to place them on record as they stand, so that they may be available for other workers at any time. The short explanatory statement of the methods employed was prepared by Dr. Orton, who had charge of most of the work, to accompany the figures when they were sent to the Board of Agriculture and Fisheries, and was not written by him with a view to publication. The drawings have been made by Mrs. Sexton.—E. J. ALLEN.]

THE INVESTIGATIONS MADE.

IN accordance with the general scheme of the Board of Agriculture and Fisheries two samples of herrings each of more than 500 specimens have been examined. In the season of 1914–15 we were able to examine in such numbers only the herrings spawning near Plymouth, i.e. in the locality of Bigbury Bay. In December, 1914, a sample of 550 herrings of the shoal spawning in this area was examined in all the characters recommended by the Board, and in January, 1915, a further sample of 525 fish from the same locality was investigated similarly.

In early December, 1914, a small sample of herrings from Cawsand Bay was examined for the purpose of practice and also for comparison with fish from the spawning grounds.

Along with the investigations mentioned above are submitted particulars of a sample of 84 herrings taken in the Channel and examined by Mr. R. S. Clark in July, 1914.

THE CHARACTERS STUDIED.

The following is the scheme of the characters studied, as authorised by the Board of Agriculture and Fisheries :—

All measurements* are to be made with the special apparatus supplied by the Board. The fish should be placed upon the board in such a way that the snout is pressed against the end board sufficiently hard to keep the mouth shut and the body of the fish should be at right angles to the end board. The measurements are to be in all cases the shortest distance from the end board to each point specified. They are to be in the order given below, and tabulated in this order on the forms supplied. A diagram of the herring is appended (Fig. 1), showing the measurements to be taken.

The measurements required are as follows :—

From the end board to

(1) Nearest point of bony orbit.

(2) Hinder edge of operculum.

* Measurements are all given in centimetres.

(3) Anterior end of dorsal fin.

(4) Base of pelvic fins.

(5) Posterior end of dorsal fin.

(6) Anterior end of anal fin.

(7) Posterior edge of hindmost scale.*

(8) Distal end of mid-caudal ray.

(9) Distal end of longest ray in dorsal fluke of caudal fin, when fluke is placed so that its dorsal margin lies parallel to line of measurement (i.e. line on board upon which snout and mid-caudal ray should lie).

These measurements made, the following are counted :—

(10) Number of keeled scales on median ventral line in front of base of pelvic fins. [This character was found unreliable and was omitted.]
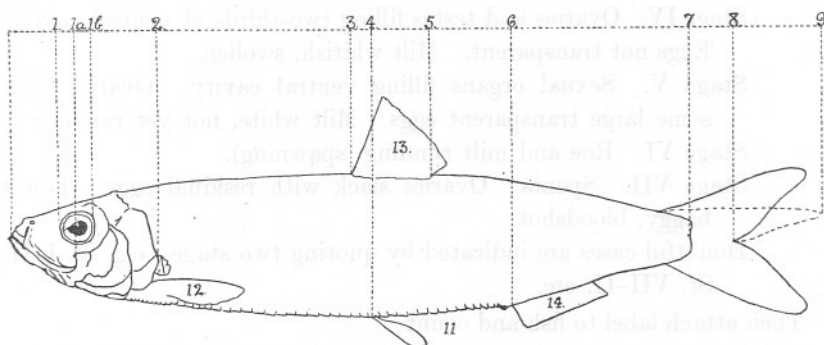
FIG. 1.—Diagram of Herring, showing the measurements, etc., taken by Dr. Orton, copied from the figure supplied by the Board of Agriculture and Fisheries.

(11) Number of keeled scales between base of pelvics and anus.

(12) Number of rays in right pectoral fin.

(13) Number of rays in dorsal fin.

(14) Number of rays in anal fin.

Then take

(15) Weight of fish in apparatus supplied † to nearest 10 grms.

Then

Take scales ‡ from neighbourhood of pectoral fins and preserve in envelopes to be examined by Hjort's method.

Then open fish and take

(16) Sex and degree of maturity (Hjort's scale).

* See p. 83.

† Each fish was weighed singly to the nearest gram on an ordinary balance in our work.

‡ The scales were forwarded to the Board for examination. The pyloric cæca of eac fish were also preserved (see p. 86).

State of sexual organs is classified in 7 stages (Publications de Circonstance, No. 53, p. 35).

Stage I. Virgin individuals. Very small sexual organs close under vertebral column. ♀ wine-coloured torpedo-shaped ovaries about 2–3 cm. long and 2–3 mm. thick. Eggs invisible to naked eye. ♂ whitish or greyish-brown knife-shaped testes 2–3 cm. long and 2–3 mm. broad.

Stage II. Maturing virgins or recovering spents. Ovaries somewhat longer than half the length of ventral cavity, about 1 cm. diam. Eggs small but visible to naked eye. Milt whitish, somewhat bloodshot, same size as ovaries, but still thin and knife-shaped.

Stage III. Sexual organs more swollen, occupying about half of ventral cavity.

Stage IV. Ovaries and testes filling two-thirds of ventral cavity. Eggs not transparent. Milt whitish, swollen.

Stage V. Sexual organs filling ventral cavity. Ovaries with some large transparent eggs. Milt white, not yet running.

Stage VI. Roe and milt running (spawning).

Stage VII. Spents. Ovaries slack with residual eggs. Testes baggy, bloodshot.

Doubtful cases are indicated by quoting two stages, e.g. St. I–II, St. VII–II, etc.

Then attach label to fish and count

(17) Serial number of first vertebra having complete hæmal arch.*

(18) Total number of vertebræ.

METHOD OF WORK.

The measurements and weighings of the fish were first made and the counting of the scales and fin-rays accomplished in a second series of operations, and finally the skeletons were prepared in a third stage.

It was found possible to take the weight and measurements of only 250 fish in the first sample and 300 fish in the second sample within 24 hours of the landing of the fish, but weights and measurements of the whole samples of 550 and 525 respectively were completed within less than 36 hours of the landing of the fish. The fish not examined on the first day were kept in an ice chamber until required and remained in good preservation. It may here be noted that both the larger samples were obtained from steam-drifters, on which boats it appears that the fish are subjected to rougher handling than on sailing drifters. Some fish

* The figures given in Tables II, III, and IV denote the number of vertebræ with perfect and imperfect hæmal arches. For details see pp. 80–82.

were damaged with respect to one or more of the characters required, and were rejected ; apart from these damaged fish there was no other selection effected.

Both larger samples were samples from a large haul of fish and were taken at random from the catch.

The method of work in detail was as follows :—

1st series of operations.

The fish were first weighed singly and a sample of the scales taken from the region under the pectoral fin and put in a previously numbered envelope. A light metal label attached to a small safety pin was then stuck into the fish, which was passed on to be measured, the weight of the fish in the meantime being called out to the recorder. The measurements 1 to 9 were then taken—being called out and recorded successively. The sex and condition of the gonad were next determined and recorded and the fish finally labelled—by pinning the label to the skull through the orbit—and put into an ice-chest tray. Four persons were concerned in this operation—one to weigh and take scales, one to record, one to hand the fish on and assist mechanically with the measuring, and one to measure and take condition of gonad and sex. It was found that weighing and taking scales could be done on the whole rather more quickly than taking measurements and sex. In this way from about 34 to 44 fish could be examined in one hour's continuous work. The time within which a given number of fish were examined was noted and is given in the account of the examination of the different samples.

2nd series of operations : Counting.

In the large samples the counting of the keeled scales and fin rays (Characters 11 to 14) began on the third day of the investigation and was finished on the fourth. When four workers were available each counted the same fin—or the scales—in all the fish, and handed each fish on to his or her neighbour in turn. In the early stages of the work each worker called out the count to be recorded, and later each worker kept a record to check the count called out, but in the whole of the second sample, each worker simply recorded his or her own work. When the Characters 11 to 14 had been recorded the alimentary canal was taken out and labelled with the number of the fish, and preserved for the future examination of the pyloric cæca.

3rd stage : Preparing skeletons.

It was found better to place the fish in cold water, to bring the water to the boil, and allow to boil only two minutes than to boil for ten minutes.

Not more than upwards to about 50 fish were boiled at a time, and a shallow tray which just fits into the fish kettle was used for containing the fish during boiling, one tray being used for boiling while the boiled fish in another tray were being cleaned.

It was found that with one worker cleaning the fish roughly, another worker could clean up to 30 skeletons in an hour after a little practice. The skeletons of the whole sample in each case were prepared in two working days by one worker cleaning them roughly and two others cleaning them finally. All the skeletons have been kept with their own label for future reference and comparison with others. It was found important not to clean the skeletons too well in the region in front of the anterior complete hæmal arches, and to cut the vertebral artery at an early stage in the cleaning operation. The prepared skeletons were kept in shallow wooden trays.

DISTRIBUTION OF WORK AMONG THE WORKERS.

The work in the different stages was accomplished with the help of workers who gave their services at different times. The responsibility for the method and form of the work was undertaken by Dr. Orton, but the assistance rendered by the team of helpers can best be shown in tabular form as follows :—

Weighing and taking scales . . . Mr. A. J. Smith.

Recording . . . . . Miss Clark, Mrs. Matthews, Dr. Allen.

Measuring characters 1 to 9 and recording sex and condition of gonad . . Dr. Orton.

Counting rays in pectoral fin . . . Mr. A. J. Smith, Dr. Orton.

Counting rays in dorsal fin . . Dr. Allen, Mr. Crawshay, Dr. Orton.

Counting rays in anal fin . . . Mrs. Orton, Mrs. Matthews, Dr. Allen, Dr. Orton.

Counting keeled scales between pelvic and anal fins . . . . Dr. Orton.

Preparing skeletons . . . Dr. Orton, Mr. Smith.

Counting vertebræ . . . Dr. Orton.

Checking counting of vertebræ . . Mrs. Orton, Mrs. Matthews, Dr. Allen.

Mr. William Searle assisted in handling and labelling the fish and labelled the gut with attached pyloric cæca for further examination.

It may be mentioned that a fair amount of practice in measuring, weighing, recording, and counting was done by Dr. Orton, Mr. Smith, Miss Clark, and Mrs. Orton before the large samples were investigated.

DESCRIPTION OF THE WORKING OF THE SEPARATE SAMPLES.

Four samples of herrings have been investigated fully, two smal samples and two large ones. For the sake of convenience they have been numbered in chronological order.

Sample   I.   84 herrings 9 miles S. of Looe, July 15, 1914.

      ,,   II.   32   ,,   from Cawsand Bay, Dec. 9, 1914.

      ,,   III.   550   ,,   from 6 miles W. by S. of Start Point, Dec. 15, 1914.

      ,,   IV.   525   ,,   from about 8 miles W.S.W. to about 3 miles S.S.W. of Start Point, Jan. 6, 1915.

Sample I.

Particulars of this sample are given on the recording sheets. Characters 13 and 14 are given as totals. This sample, being a batch of summer herrings from the Plymouth district, should be specially interesting in comparison with the winter spawning herring ; it was examined by Mr. R. S. Clark, with the assistance of Mr. E. Ford and Mr. F. M. Gossen.

Sample II.

This sample of 32 fish from a total catch of from 250 to 300 was taken on December 9, 1914, from drift nets moored in Cawsand Bay. The fish were in excellent condition and were weighed and measured during the morning of December 9.

In this sample two additional characters to those recommended by the Board were investigated, namely, (a) the position of the posterior border of the maxilla in relation to the position of the eye, and (b) the number of pyloric cæca. The former necessitated two additional measurements, which were numbered "1a" and "1b." 1a is the shortest distance between a line tangent to the posterior border of the maxilla taken at right angles to the long axis of the fish, and a line tangent to the tip of the lower jaw at right angles to the long axis of the fish.

1b is the shortest distance between a tangent to the posterior border of the orbit taken at right angles to the long axis of the fish, and a similar tangent to the tip of the lower jaw.

To obtain the number of pyloric cæca the gut of each fish was taken out and preserved with a label attached bearing the same serial number as the fish.

The number of fin rays is given in each case as a total, but during the examination of the fin rays it was observed that an attempt might be

made to analyse the fin rays in the dorsal and anal fins. The analysis of the vertebræ in this sample is the same as in the larger Samples III and IV (see pp. 80 and 82).

Sample III.

This was a sample of 550 fish examined from a catch of 22 cran, i.e. about 20,000 herrings. The fish were caught in herring drift nets by the steam-drifter *Diadem*, Lowestoft, near Bigbury Bay, with Start Point bearing about E. by N. 6 miles. The sample was taken at random from the catch, and consisted of fish of various sizes, but mostly in a condition approaching ripeness. Fish which were damaged were not investigated ; otherwise there was no selection.

In the circumstances under which the research was carried out it was possible to examine only 250 fish in measurements, weight and condition of gonad on the first day, that is within 12 hours of the landing of the fish. The fish not examined the first day were kept in ice, and were found to be in excellent preservation on the second day, when the remainder of the sample, namely 300 fish, was examined for measurements, weight and condition of gonad. The whole sample was examined within 35 hours of the landing of the fish, and a record of time was taken as the examination of each lot of 50 fish was completed. These records are given with those for Sample IV in tabular form on page 79.

Sample IV.

In this sample 525 fish out of a catch of 56 cran, i.e. about 50,500 herrings, were examined. The catch was taken by the steam-drifter *G.M.V.* 1062, Lowestoft, in herring drift nets near Bigbury Bay, between a region 8 miles W.S.W. of Start Point and a position about 3 miles S.S.W. of Start Point. The fish were caught during the night of January 5–6, 1915, and landed about 10 a.m., January 6. Work was begun on the sample during the same morning, and 300 fish examined for weight, measurements and condition of gonad in the course of the day. The completion of the examination of the whole sample was effected within $33\frac{1}{2}$ hours of the landing of the fish.

The fish were mostly in a condition almost ready for spawning, some few being spent. In this sample there were a good many damaged fish, and to obtain 525 fish from a sample of 600 it was necessary to reject about 40 to 50 fish, most of which were too badly damaged about the head to be measured. The damage to these specimens had undoubtedly chiefly occurred in unmeshing them. No selection of specimens occurred other than that of damaged ones.

The times at which successive batches were examined for weight,

measurements and condition of gonad are shown with those for Sample III in the following table :—

Total fish examined.	Sample III.		Hours from landing.	Sample IV.		Hours from landing.
			Hr. min.			Hr. min.
50	12.40 P.M.	Dec. 15	2.10	12. 2 P.M.	Jan. 6	2. 2
100	4.30 ,,	,,	6. 0	2.58 ,,	,,	4.58
150	7.30 ,,	,,	9. 0	4.40 ,,	,,	6.40
200	8.55 ,,	,,	10.25	7.20 ,,	,,	9.20
250	10.13 ,,	,,	11.43	8.47 ,,	,,	10.47
300	11.55 A.M.	Dec. 16	25.25	10. 4 ,,	,,	12. 4
350	1. 5 P.M.	,,	26.35	11.49 A.M.	Jan. 7	25.49
400	4.35 ,,	,,	30. 5	2.45 P.M.	,,	28.45
450	7.20 ,,	,,	32.50	4.30 ,,	,,	30.30
500	8.30 ,,	,,	34. 0	7. 0 ,,	,,	33. 0
550 or 525	9.40 ,,	,,	35.10	7.35 ,,	,,	33.35

EXPLANATION OF RECORDS OF CHARACTERS 1A AND 1B IN SAMPLES II AND III.

In Sample III two characters in addition to those recommended by the Board were examined in a few fish. These characters are 1a and 1b. Character 1a, as in Sample II, is the shortest distance between a tangent to the posterior border of the maxilla taken at right angles to the long axis of the fish, and a tangent to the tip of the lower jaw at right angles to the long axis of the fish. Character 1b is the shortest distance between a tangent to the posterior border of the orbit taken at right angles to the long axis of the fish, and a similar tangent to the tip of the lower jaw.

It was found, however, that the taking of those measurements would decrease the number of fish examined within the shortest time recommended for the Characters 1 to 9, hence it was decided at an early stage to discontinue to take the additional ones.

EXPLANATION OF RECORDS OF CHARACTERS 13, 14, AND 17 IN SAMPLE III.

With regard to Characters 13, 14 and 17 on the sheets an attempt has been made in the case of the fins (13 and 14) to analyse them, and in the case of the vertebræ with hæmal arches to give additional information. The records for these characters are given in the general form of $a+b$.

In Sample III the dorsal and anal fins (13 and 14) were analysed in the following manner : in each case the fin-rays in the anterior portion of the fin equal to or less than two-thirds the height of the longest rays were

counted separately from the fin-rays posterior to them ; thus the records take the form of $a+b$, the sum of which gives the total number of rays in the fin. A cursory examination of the records indicates that $2+17$ is the commonest form for the dorsal fin and $2+15$ the commonest form for the anal fin (Figs. 4 and 5).

In the case of Character 17, which is stated in the scheme to be the
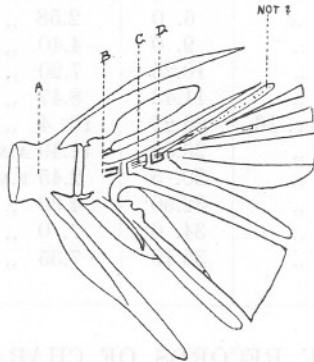
FIG. 2.—Diagram of Tail-bones of Herring, from Williamson. A is the last vertebra counted in the present work. B is regarded by Williamson as the last vertebra. Not ? = Notochord ?

" serial number of first vertebra having complete hæmal arch," the records have been made in the form of $(a+b)$ where b=the total number of vertebræ with complete hæmal arch—not, however, counting the
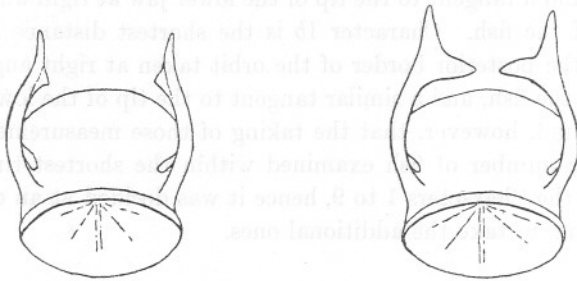
FIG. 3.—Vertebræ, showing incomplete but "well-developed" hæmal arch.

terminal vertebra-like ossicle regarded by Williamson as the " last vertebra " (see Fisheries, Scotland, Sci. Invest., 1914, I (April, 1914) Fig. 7, B, p. 21). Williamson's figure is here reproduced as Fig. 2.

In this character (17), a=the number of vertebræ having an incomplete, but " well-developed " arch, and an arch was considered " well developed " if the hæmal processes were almost as large as those of the first complete arch, and if these processes possessed even the smallest trace of an internal cross-piece (see Figure 3). It should be mentioned that all inter-

mediate stages are met with between a trace of an internal cross-piece and a complete arch. It is not improbable that in the living animal these arches are closed by a cartilaginous cross-piece. Cursory examination of the records indicates that in a majority of skeletons the sum of the number of vertebræ with complete hæmal arch and the number with well-developed (i.e. potentially complete ?) arches is 33 ; or it might be said that the commonest number of vertebræ with potentialities for complete hæmal arches is 33 ; the greatest number of such vertebræ appears to be 35.

EXPLANATION OF CHARACTERS 13, 14, AND 17 IN SAMPLE IV.

In Number IV Sample it was thought that more information could be obtained by analysing the dorsal and anal fin (Characters 13 and 14) in a slightly different way from that adopted in Sample III.

Thus in Sample IV all the anterior fin-rays of the dorsal fin which were distinctly shorter than the longest fin-ray were counted separately from the following and recorded in the general form of $a+b$, where a is the
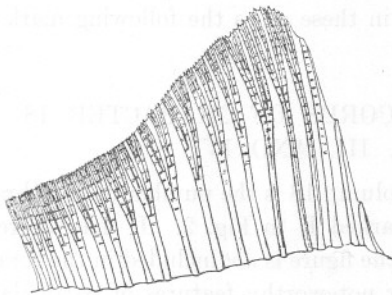
FIG. 4.—Dorsal Fin. In Sample III the above would be recorded as 2+17 ; in Sample IV as 3+16.
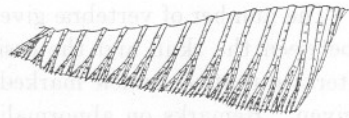
FIG. 5.—Anal Fin. In Sample III the above would be recorded as 2+15 ; in Sample IV as 3+14.

number of the smaller anterior rays and b the number of rays posterior to these. In this way it is possible to reconstruct a fin to represent the commonest form which by cursory examination of the records is seen to be one having 3+16 rays. A drawing of the type of ray is shown in Fig. 4.

In the case of the anal fin (Character 14) the fin was analysed in the following manner : all the anterior fin-rays which were not subdivided at the tip or splayed out in any way were counted and recorded separately as " a " from those in which the rays were splayed out—recorded as " b." The commonest form of fin is seen from the records to be one recorded as 3+14. This type of fin is shown in Fig. 5.

Character 17 in Sample IV is also recorded in a manner slightly different

from that in Sample III. In this sample (IV) it was decided to include under " well-developed " open hæmal arches those in which the hæmal processes were relatively stout to those of the first closed arch, but which processes did not necessarily possess the trace of a cross-piece on their internal faces. This change of recording has resulted in only a slight difference in the records, but in a few cases the number of vertebræ
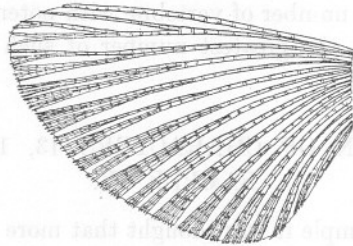
FIG. 6.—Pectoral Fin. 17 rays.

recorded in the " a " category is higher than in corresponding skeletons in Sample III.

It should be mentioned that in some skeletons the hæmal processes of the vertebræ anterior to the first vertebra with complete arch were missing, having been cleaned away ; in these cases the following mark †️ is placed alongside the record.

EXPLANATION OF THE RECORDS OF CHARACTER 18 IN SAMPLES II, III, AND IV.

The number of vertebræ given in column 18 is the number of vertebræ between the skull and the ossicle marked B in Fig. 2. It may be re-iterated that the ossicle marked B in the figure is *not* included in the total given. Remarks on abnormalities or noteworthy features of particular skeletons are connected by an asterisk to explanations in the Appendix to the Tables. It may be noted that in several skeletons two or more vertebræ have apparently become fused together ; as, however, such fused vertebræ show uniformly only two articulations, they have in each case been counted as one vertebra, although it is most probable that most of these abnormal vertebræ are equivalent to two or more normal ones. Each case is discussed in the Appendix to the Tables.

EXPLANATION OF RECORDS OF CHARACTERS 1 TO 9, 11, 12, 15, AND 16 IN SAMPLES III AND IV.

Characters 11 and 12 call for little comment.

In counting the keeled scales between the pelvic fin and anus (11) the adjacent scales were cleaned well away before beginning to count. In

this way the insertions of the keeled scales could be made out and their total number established with certainty. Practically no difficulty was experienced in counting the rays in the pectoral fin (12). It was noticed, however, that in fins with a large number of rays the increase in the number appeared to be accounted for by additions of small rays near the posterior border. No attempt was made to analyse this fin as in the case of the dorsal and anal fins, but it is possible that useful information might be obtained by attempting such an analysis.

The weight of the fish (15) was taken separately and to the nearest gram.

In recording the condition of the gonad (16) it was found necessary to use combinations of the numerals representing different stages, which require explaining.

In the records occur such combinations as IV–VI and VI–IV. A record such as IV–VI is put down to represent fish in which the gonad appeared to be about ripe, although it did not fill the body cavity entirely. These records, however, refer mostly to males, in which the approach to and incidence of ripeness of the gonad are not easy to differentiate. In the case of records such as VI–III or VI–IV, these indicate that the gonad is definitely ripe, but has become reduced by spawning (or compression in some cases) to the size in the stage indicated by the second numeral; thus VI–IV indicates gonad reduced to the size of half the volume of the abdominal cavity. The numeral VII was reserved for fish which were spent or practically spent. By distinguishing spawning fish in this way it is possible to correlate to some extent the weight with the size of the fish.

With regard to Characters 1 to 9 all measurements were taken with the instrument supplied by the Board of Agriculture and Fisheries. An attempt was made to measure Character 1 to the nearest ·2 of a millimetre in Samples III and IV.

Character 2 was measured to the nearest ·5 mm. in Sample III and to ·2 mm. in Sample IV.

Characters 3 to 9 were measured to the nearest ·5 mm. in both Samples III and IV.

DEFINITION OF CHARACTER 7.

Characters 1 to 9 are those recommended by the Board except No. 7. Character 7 is defined in the Scheme as " from the end-board, etc. . . . to the posterior edge of the hindmost scale." In preliminary investigations, however, it was found that posterior scales were either rubbed loose or missing in about one-third of the specimens examined. It was therefore

decided to use some other fixed point of more constant position. The point chosen is in all probability the one shown in the figure of the Herring supplied by the Board. It is the point from which the perpendicular 7 arises, and marks the origin of the median caudal rays from the muscular part of the tail. The muscular part of the tail is covered by an epidermis of metallic appearance, and is in nearly all cases sharply marked off from what may be regarded as the tail fin proper where this kind of epidermis is absent. The caudal fin-rays are slightly embedded in the fleshy part of the tail. Thus the point chosen for measurement may be stated shortly to be the *origin of the mid-caudal rays from the fleshy part of the tail*.

The origin of these rays is, however, a concave line, as indeed is shown in the Board's figure, and the point actually measured is the line at right angles to the long axis of the fish which forms a tangent to the posterior border of the fleshy part of the tail. This line is apparently the same as the perpendicular No. 7 shown in the Board's figure.

There were only a few fish in which this point was at all difficult to determine and these were among Sample IV. It is of course well known that the posterior scales extend over the mid-caudal fin-rays.

ACCURACY OF MEASUREMENTS.

Before the large samples were examined a batch of 33 fish was examined twice, in order to obtain some determination of the error in measuring under the conditions in which the samples would be examined. The fish measured were not in good condition, so that it is probable that the errors observed in this case would be the maximum error, especially as more practice in measuring was obtained afterwards. In this experiment the average difference in the two sets of readings was less than 1 mm. in all measurements except 4 and 6, in which the average difference was 1·3 mm. and 1·1 mm. respectively. These 33 fish were examined in 47 and 45 minutes respectively, i.e. about the rate of 44 per hour, about the maximum rate for the large samples. After this experiment assistance was obtained in making measurements for Characters 3, 4, 5, and 6, and there can be no doubt that the accuracy of the measurements was thereby increased. In all measurements therefore it may be confidently stated that they are correct on the average to one millimetre, and in the case of 1 the average error is probably not more than ·5 mm. It is believed that only isolated *errors of measurement* occur of as much as 3 mm., but errors would increase in frequency towards zero.

It is, however, possible that occasional *errors of observation* may occur of as much as 5 mm. where the ·5 cm. line on the scale has been read as a

whole cm. division line, for one or two cases of this kind were actually observed in time to prevent this error. It is probably very difficult to exclude completely *occasional* lapses of this nature in examining large numbers of fish at the high rate of speed required.

It is unfortunate in some respects that the experimental sample mentioned above was not a fresh sample exactly comparable with a research sample, and it would probably be better in future work to re-examine a batch of the research sample in order to determine the error of measurement.

An experiment was carried out to determine how accurately the instrument would measure. A number of slips of paper (30) were ruled with lines parallel to one end, which was placed against and was parallel with the " end-board " of the instrument. The points measured on the ruled lines were similar to those measured on herrings, so that in measuring them it was necessary to move the instrument about in approximately the same way as when measuring the research herrings. The slips of paper represented in fact paper herrings. These 30 slips were measured twice at a rate greater than the maximum rate at which the research samples of herrings were examined. Characters 1 and 2 were read to ·2 mm., and Characters 3 to 9 to the nearest ·5 mm., just as in the research sample. The average difference between the first and second measurements of Characters 1 and 2 was less than ·1 mm., and in only 4 cases was the difference as much as ·3 mm. The average difference between all the measurements of Characters 1 and 2 and the actual distance—as measured by a 15-cm. ivory rule divided to fifths of a millimetre—was also less than ·1 mm., and in only 5 cases were there differences of ·3 mm.

The average difference between first and second measurements of Characters 3 to 9 was less than ·1 mm., and in only one case was the difference more than ·5 mm. The difference was exactly ·5 mm. in 30 cases, and in 159 pairs of measurements the results were exactly the same. In all the measurements of Characters 3 to 9 the average difference from the actual distance measured was about ·13 mm.

In a large number of measurements, however, it is considered that the instrument may be taken as reading accurately *on the average*, since the plus and minus variations would tend to balance each other, although ranging between plus and minus the maximum error mentioned above. The average algebraical error of all the measurements taken in the paper-herring sample mentioned above was less than + ·03 mm. in Characters 1 and 2, and + ·04 mm. in Characters 3 to 9.

REMARKS ON ADDITIONAL CHARACTERS TO THOSE RECOMMENDED BY THE BOARD.

In Sample II two additional characters to those recommended by the Board were examined, namely, the relation of the posterior border of the maxilla to the orbit, and the number of pyloric cæca. In the large sample it was found impracticable to examine the former character in addition to the Board's characters, owing to the exigencies of time, but the pyloric cæca of all the fish in Samples III and IV have been preserved with their proper number, and can be examined and recorded at leisure.

The examination of these characters is considered of equal importance to those recommended by the Board, since they are characters in which *Clupea harengus* differs from allied species.

Table I. Herring Race Investigations.

Position . . 9 miles S. of Looe ; Plymouth.
Date . . July 15/14. (Nets shot July 14/14.)
Vessel . . Motor Drifter (Looe Boat) " John Wesley."
Net . . Drift net.

Number examined . . 84.
Quantity of fish caught . 1000 (total catch).
Date examined . . July 15/14.
Examined by . . R. S. Clark.

The characters are briefly : Length in centimetres from snout to (**1**) eye, (**2**) operculum edge, (**3**) front of dorsal fin, (**4**) pelvic, (**5**) back of dorsal, (**6**) front of anal, (**7**) root of tail, (**8**) end of mid-caudal, (**9**) end of longest caudal ray. Number of (**11**) keeled scales (pelvics to anus), (**12**) rays in pectoral, (**13**) rays in dorsal, (**14**) rays in anal, (**15**) weight in grams, (**16**) sex and maturity.

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16
1	1·3	4·2	10·2	10·5	12·5	14·8	19·7	20·3	22·6	15	16	19	19	107	♀ i
2	1·4	4·4	10·9	11·1	13·2	15·8	20·9	21·7	24	14	16	18	18	123	♂ i–ii
3	1·3	4·1	10	10·4	12·6	15	19·7	20·5	22·5	14	17	19	18	104	♀ i
4	1·2	3·7	9·6	10·1	11·8	14·9	19·4	20·3	22·3	15	18 ?	18	17	91	♀ i
5	1·3	4·3	10·1	10·6	12·6	15·1	20·3	21·1	23·3	15	16	20	17	129	♀ i–ii
6	1·4	4·5	11·6	12·2	14·3	17·3	22·7	23·8	26·1	15	16	20	18	151	♀ i
7	1·3	4·2	10·3	10·4	12·7	15·5	20·3	21·3	23·6	14	17	19	16	120	♀ i
8	1·3	4·3	11·1	11·6	13·9	16·7	22	22·8	25·2	15	17	19	17	146	♀ i
9	1·3	4·2	10·4	11	12·8	15·6	20·1	21·3	23·5	15	17	20	18	112	♀ i
10	1·2	4	9·8	10·4	12·8	14·5	19·6	20·3	22·3	14	16	19	17	100	♂ i
11	1·3	4	10·3	10·9	12·8	15·4	20·4	21·4	23·5	15	16	19	18	118	♂ i
12	1·2	4·3	10·6	11·2	13·2	15·8	20·8	21·8	24·2	15	17	19	18	121	♀ i
13	1·2	4	10·3	10·5	12·8	15·4	20	21	23·1	15	16	19	18	112	♀ i
14	1·2	4	10·1	10·3	12·4	15·0	19·6	20·2	22·2	15	15	19	17	101	♂ i–ii
15	1·2	4·1	10·3	10·6	12·7	15·1	20·1	20·7	23·1	15	16	19	17	116	♀ i–ii
16	1·2	4·1	10·1	10·8	12·9	15·3	20·2	21·2	23·5	14	15	19	19	122	♀ i
17	1·2	3·9	9·7	9·9	12	14·5	18·8	19·6	21·6	15	17	19	18	82	♀ i
18	1·3	4·3	10·5	10·8	13·4	15·5	20·9	21·6	24·1	15	17	19	18	126	♂ i–ii
19	1·3	4·2	10·5	11	12·9	16·1	21	21·8	24·1	15	17	18	18	126	♀ i–ii
20	1·2	3·9	9·4	10·1	11·9	14·5	18·8	19·8	22	15	16	19	18	90	♀ i
21	1·3	4·2	10·1	10·7	12·6	15	19·8	20·8	23·1	14	17	19	19	118	♀ i–ii
22	1·3	4·1	10·2	10·7	12·7	15·3	20	20·7	23	16	17	20	17	100	♀ i
23	1·3	4·5	11·1	11·6	13·7	16·7	21·5	22·6	25·1	15	16	19	19	138	♀ i–ii
24	1·2	4	9·9	10·3	12·3	14·9	19·7	20·4	22·7	14	17	19	18	111	♀ i
25	1·2	4·2	9·8	10·7	12·5	15·1	20·1	21	22·3	14	17	19	18	114	♂ i
26	1·2	3·8	10	10·6	12·3	15	19·8	20·8	22·6	15	15	17	16	102	♂ i
27	1·2	4·2	10·2	10·8	12·8	15·9	20·6	21·5	23·8	14	16	19	17	128	♀ i
28	1·3	4·3	10·3	11	12·7	15·4	20	21·0	23·3	14	16	18	16	121	♀ i
29	1·2	4·1	9·8	10·5	12·4	15	19·9	20·6	22·7	15	17	18	18	107	♀ i–ii
30	1·2	4·1	10	10·3	12·4	15	19·7	20·7	23	15	16	19	17	100	♀ i–ii
31	1·2	4·2	10·1	10·6	12·7	15·1	19·9	20·7	22·8	14	17	19	18	114	♀ i–ii
32	1·1	4	9·6	10·4	12·2	14·3	19·3	20	22·2	15	17	19	18	114	♂ i
33	1·1	4	10·1	10·3	12·4	14·7	19·4	20·1	22·4	14	17	19	19	105	♂ i
34	1·2	4·1	10·1	10·8	12·6	15·1	20·2	20·9	23·1	15	17	19	18	113	♂ i–ii
35	1·2	4·2	10·3	10·7	12·7	15·2	20·2	21·1	23·3						
36	1·2	4	9·3	10	11·9	14·1	18·7	19·4	21·7	15	17	19	18	92	♀ i–ii
37	1·2	4	9·8	10·6	12·6	15·1	19·7	20·6	22·9	15	16	19	17	114	♂ i–ii

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16
38	1·2	4·3	11·3	11·9	14·1	17·3	22·2	23·1	25·4	16	17	19	18	154	♂ ii
39	1·3	4·3	10·8	11·6	13·6	16·5	21·9	22·7	25·1	15	18	20	17	140	♂ i–ii
40	1·2	4·1	10	10·7	12·5	15	19·9	20·7	22·8	14	15	20	18	112	♀ i
41	1·2	4·2	10·1	10·6	12·8	15·1	20·2	21	23·3	14	17	19	19	113	♀ i–ii
42	1·2	4·3	9·9	10·6	12·4	15·2	20·2	21	23·1	14	17	19	16 ?	115	♂ i
43	1·2	4·3	10·1	10·7	12·9	15·4	20·7	21·5	23·8	14	17	19	17	122	♂ i
44	1·2	4·2	9·8	10·3	12·3	13·8	19·2	20·2	22·2	15	17	19	17	93	♀
45	1·2	4·2	9·9	10·5	12·4	15·1	19·4	20·3	22·4	14	18	19	18	104	♀
46	1·3	4·3	10	10·6	12·7	15·3	20	21	23·3	15	19	19	19	113	♂ i
47	1·2	4·2	10·3	10·7	12·8	15	20·1	21·1	23·4	15	17	19	19 ?	118	♀ i
48	1·3	4·5	10·8	11·3	13·5	16·3	21·5	22·3	24·9	14	17	20	17	155	♂ ii
49	1·3	4·4	10·4	11·2	13	15·5	20·7	21·5	23·8	14	17	19	16	127	♂ i–ii
50	1·2	4·3	10·7	11·3	13·5	15·8	21·3	22·1	24·4	15	17	19	18	130	♀ i
51	1·2	4·4	10·4	10·9	13·0	15·3	20·5	21·1	23·6	14	18	19	17	126	♀ i–ii
52	1·2	4·1	9·7	10·4	12·3	15·2	19·9	20·6	22·9	15	17	20	18	109	♂ i–ii
53	1·2	4·3	10·4	11·3	12·9	16·2	20·6	21·6	24·0	14	16	19	16	117	♂ i
54	1·2	4·2	10·5	11·3	13·2	15·5	20·5	21·2	23·5	14	17	19	16	121	♂ i
55	1·2	4·4	10·2	10·9	12·5	15·2	20·2	21	23·2	15	17	20	17	116	♂ i
56	1·2	4·1	9·7	10·4	12·1	14·8	19·6	20·3	22·4	14	17	19	17	105	♂ i
57	1·3	4·4	10·7	11·4	13·3	16·2	21·4	22·1	24·5	15	17	18	18	138	♂ i
58	1·3	4·6	11·4	11·8	14·1	16·8	21·9	22·7	25·3	15	17	19	17	154	♀ i–ii
59	1·2	4·1	9·5	10·6	12	14·5	19·3	20·2	22·3	15	17	20	19	108	♀ i–ii
60	1·3	4·4	10·6	11·2	13·4	16	21·5	22·3	24·7	14	17	19	18	141	♀ i–ii
61	1·1	4·1	9·5	10·2	12·1	14·4	19·3	20	22·2	15	17	20	17	102	♂ i
62	1·2	4	9·9	10·5	12·3	15	19·6	20·5	22·7	15	16	19	19	100	♂ i
63	1·2	4	10	10·5	12·2	15·3	19·9	20·6	22·7	14	15	19	17	115	♀ i–ii
64	1·2	4·1	9·7	10·6	12·2	15·1	19·7	20·4	22·6	16	16	18	16	113	♂ i
65	1·2	4·3	9·5	10·1	12	14·4	19·3	20	22·1	14	16	20	18	99	♂ i–ii
66	1·2	4	10·3	11·1	13	15·8	20·6	21·4	23·7	15	17	20	18	113	♀ i
67	1·2	4·1	9·6	10·0	12	14	18·9	19·7	21·8	13	17	18	18	99	♀ i
68	1·2	4·2	9·9	10·6	12·5	15	19·6	20·5	22·8	14	17	19	17	109	♀ i
69	1·1	4·1	9·3	9·9	11·8	14	18·8	19·4	21·5	15	15	19	18	85	♂ i
70	1·1	4	9·5	10·1	12·2	14·4	19·3	19·9	22·2	14	15	20	17	99	♂ i
71	1·3	4·3	10·1	10·9	12·6	15·2	20·2	21	23·3	14	16	19	18	119	♀ i
72	1·2	3·9	9·5	10·2	11·8	14·5	19·1	19·9	21·9	15	17	19	18	98	♂ i–ii
73	1·1	4·1	9·7	10·5	12·1	14·5	19·4	20	22·2	15	16	18	16	101	♂ i
74	1·3	4·5	10·5	11·4	13·3	16·1	21·2	22	24·3	15	17	19	17	137	♂ i–ii
75	1·2	4·1	9·8	10·1	12·2	14·7	19·7	20·3	22·8	15	17	19	18	103	♂ i
76	1·2	4·2	9·7	10·7	12·3	14·7	19·5	20·3	22·3	14	16	20	18	98	♂ i
77	1·1	3·9	9·4	10·2	11·9	14·2	19·1	19·7	21·9	14	16	19	18	91	♂ i–ii
78	1·2	3·9	9·9	10·3	12·3	14·5	19·5	20·2	22·4	14	16	18	18	102	♂ i–ii
79	1·2	4·2	10·2	11·1	13	15·4	20·4	21·2	23·5	14	16	19	18	125	♂ i–ii
80	1·2	4·1	10·2	10·6	12·8	15·4	20·2	21	23·4	15	17	19	17	113	♀ i–ii
81	1·2	4·1	10·0	10·6	12·7	15·2	20·3	20·9	23·3	15	16	19	17	123	♀ i–ii
82	1·2	3·9	9·9	10·5	12·3	15·1	20·2	20·9	23	15	16 + 1	19	18	110	♀ i
83	1·2	4·1	9·8	10·6	12·3	14·7	19·7	20·3	22·7	15	16	19	17	113	♂ i
84	1·2	4·3	10·4	11·3	12·9	15·5	20·4	21·3	23·8	15	17	20	18	119	♂ i–ii

Table II. Herring Race Investigations.

The characters are briefly : Length in centimetres from snout to (**1**) eye, (**2**) operculum edge, (**3**) front of dorsal fin, (**4**) pelvic, (**5**) back of dorsal, (**6**) front of anal, (**7**) root of tail, (**8**) end of mid-caudal, (**9**) end of longest caudal ray. Number of (**11**) keeled scales (pelvics to anus), (**12**) rays in pectoral, (**13**) rays in dorsal, (**14**) rays in anal, (**15**) weight in grams, (**16**) sex and maturity, (**17**) vertebræ with hæmal arch, (**18**) total vertebræ.

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	Pyloric cæca.	11	12	13	14	15	16	17	18	No. of fish.
1	1·28	1·86	2·3	4·1	9·8	10·35	12·1	14·5	19·05	20·1	22·3	22	15	17	18	17	79	♂ iv–vi	0+32	55	1
2	1·53	2·1	2·6	4·55	11·45	11·85	14·25	17·15	22·4	23·4	26·25	18	16	17	18	18	149	♀ iv–v	1+31	55	2
3	1·5	1·9	2·55	4·4	10·2	10·65	12·7	15·1	19·8	20·9	23·25	25	15	18	18	17	94	♂ v–vi	0+32	55	3
4	1·6	2·3	2·7	4·95	11·45	12·3	14·2	17·05	22·5	23·65	26·35	20	15	17	18	17	114	♂ ii	1+32	55	4
5	1·4	1·9	2·4	4·45	11·3	11·8	13·9	16·8	21·65	22·7	25·45	17	15	16	19	16	123	♀ iv–v	0+32	55	5
6	1·53	2·0	2·6	4·6	11·15	11·7	13·55	16·5	21·4	22·4	25·1	20	16	17	18	16	106	♀ v	2+31	56	6
7	1·45	2·15	2·6	4·7	11·3	11·8	13·9	16·5	21·9	23·0	25·6	19	14	17	18	18	126	♀ iv–v	1+32	55	7
8	1·33	1·46	2·34	4··2	10·1	10·8	12·55	15·1	19·7	20·8	23·1	18	15	17	19	14	96	♂ v–vi	1+32	56	8
9	1·46	2·0	2·53	4·35	9·95	10·5	12·4	14·45	19·35	20·35	22·85	19	14	17	19	17	91	♂ v–vi	0+32	55	9
10	1·2	1·74	2·2	4·1	10·1	10·8	12·2	15·2	19·75	20·8	22·96	23	15	17	17	15	93	♂ v–vi	2+31	55	10
11	1·4	1·95	2·5	4·4	11·5	12·4	13·2	16·05	21·15	22·15	24·65	20	15	17	20	19	114	♀ iv–v	1+32	56	11
12	1·46	2·15	2·6	4·8	11·5	12·4	14·1	17·3	22·3	23·4	26·1	23	15	16	20	16	106	♂ ii	1+32	56	12
13	1·28	1·73	2·28	4·13	9·65	10·26	12·2	14·25	19·05	20·0	22·4	18	15	18	21	17	83	♀ iii–iv	1+33	57	13
14	1·4	2·0	2·5	4·4	10·1	11·1	12·9	15·2	19·85	20·9	23·4	18	14	18	19	16	100	♂ v	1+32	56	14
15	1·25	1·75	2·25	4·05	9·6	10·3	11·05	14·0	18·55	19·4	?	21	14	16	20	17	78	♂ v–vi	1+31	55	15
16	1·8	2·45	3·1	5·45	12·25	13·15	15·2	18·45	23·95	25·3	28·2	21	15	17	19	17	125	♂ ii	1+33	55	16
17	1·45	2·0	2·5	4·5	10·3	11·45	12·85	15·8	20·7	21·7	24·4	20	15	16	18	1+16	106	♂ v–vi	1+32	55	17
18	1·53	2·05	2·6	4·7	11·0	11·7	13·85	16·05	21·5	22·6	25·2	20	14	17	20	17	114	♂ ii	1+32	56	18
19	1·35	1·77	2·35	4·15	10·3	10·95	12·9	15·85	20·6	21·7	24·25	22	15	16	20	1+17	101	♂ iv–v	1+33	56	19
20	1·5	2·15	2·63	4·8	11·15	11·7	13·8	16·85	21·8	22·95	25·55	19	15	17	19	1+16	119	♂ iii	1+32	55	20
21	1·45	2·0	2·5	4·4	10·95	11·65	13·3	16·2	21·35	22·5	25·0	22	14	16	18	1+16	111	♂ v–vi	1+32	56	21
22	1·42	1·92	2·46	4·3	10·45	11·4	12·8	15·95	20·65	21·65	24·2	20	15	17	18	15	107	♀ iv–v	1+32	56	22
23	1·35	1·9	2·36	4·1	9·3	10·1	11·8	14·2	18·65	19·6	21·9	18	15	17	18	16	78	♀ ii–iii	0+33	56	23
24	1·4	2·0	2·4	4·5	10·7	11·6	13·15	16·2	21·4	22·5	24·95	16	14	17	18	1+16	108	♂ iv–vi	1+33	56	24
25	1·46	2·0	2·45	4·4	10·5	11·1	12·8	15·5	20·5	21·5	24·0	19	15	17	19	1+16	106	♂ v	2+31	56	25
26	1·4	2·0	2·45	4·4	10·05	11·1	12·6	15·3	20·3	21·45	23·8	21	16	16	19	17	103	♂ iv–vi	2+31*	56	26
27	1·3	1·8	2·3	4·3	10·46	11·25	12·8	15·7	20·5	21·4	24·0	21	14	16	19	1+16	81	♂ i–ii	2+31	55	27
28	1·23	1·75	2·2	4·0	9·7	10·55	12·0	14·4	18·85	19·85	22·05	21	14	17	19	2+14	84	♀ iii–iv	2+31	55	28
29	1·5	1·8	2·55	4·4	10·2	10·9	12·75	15·2	19·95	21·1	23·3	22	14	16	18	1+14	94	♂ v	1+32	56	29
30	1·48	2·0	2·53	4·5	10·2	10·25	12·5	15·5	20·1	21·1	23·5	19	15	17	19	1+14	88	♂ v	1+31	55	30
31	1·4	1·88	2·35	4·2	9·5	10·3	11·85	14·3	18·9	19·9	22·3	25	15	17	19	2+14	72	♀ iii	1+32	55	31
32	1·4	2·05	2·45	4·58	11·3	11·7	14·2	16·7	21·85	23·0	25·5	25	16	17	19	2+15	126	♂ iv–v	0+33	56	32

* One vertebra with 2 neural and 2 ventral arches.

Table III. Herring Race Investigations.

HAUL. SAMPLE III.

Position . . Start Pt. E. by N. 6 miles.	Number examined . . 550.
Date . . Dec. 15/14. Landed at 10.30 a.m.	Quantity of fish caught . 22 crans (about 20,000).
Vessel . . Steam Drifter " Diadem," Lowestoft.	Date examined . . Dec. 15/14.
Net . . Drift.	Examined by . . . J. H. Orton.

The characters are briefly : Length in centimetres from snout to (1) eye, (2) operculum edge, (3) front of dorsal fin, (4) pelvic, (5) back of dorsal, (6) front of anal, (7) root of tail, (8) end of mid-caudal, (9) end of longest caudal ray. Number of (11) keeled scales (pelvics to anus), (12) rays in pectoral, (13) rays in dorsal, (14) rays in anal, (15) weight in grams, (16) sex and maturity, (17) vertebræ with hæmal arch, (18) total vertebræ. * For explanation of signs see Appendix to Tables.

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
1	1·5	2·1	2·6	4·8	12·35	13·1	15·55	18·16	23·9	25·2	27·95	15	18	3+17	3+15	156	♂ v	1+32	56
2	1·63	2·36	2·9	5·2	12·45	12·8	15·45	18·2	23·3	24·55	27·6	15	18	3+17	2+15	182	♀ iv–v	0+33	56
3	1·7	2·45	3·05	5·35	12·55	13·65	15·55	18·6	24·4	25·75	28·65	15	16	3+16	2+16	181	♂ v	0+32*	56
4	1·4	2·0	2·5	4·7	11·6	12·55	14·15	17·8	22·85	23·9	26·7	16	16	2+17	2+15	132	♂ iv–v	1+32	56
5	1·47	1·95	2·53	4·6	11·25	12·1	14·0	16·9	22·1	23·3	26·1	14	16	2+17	2+15	141	♂ iv	1+33	56
6	1·8	2·34	3·0	5·25	12·75	13·9	15·8	19·1	24·75	26·0	29·0	14	17	2+17	2+15	205	♀ iv	2+31	56
7	1·5	2·0	2·6	4·6	11·4	12·1	14·0	16·9	21·9	23·1	25·8	14	16	2+17	2+17	156	♂ v	1+32	56
8	1·55	2·2	2·75	5·0	12·0	13·0	14·9	18·1	23·4	24·5	27·4	15	17	2+17	2+16	178	♀ v	2+31	56
9	1·6	2·1	2·75	4·7	11·65	12·6	14·7	18·15	23·0	24·15	27·1	15	16	3+17	2+16	166	♀ iv–v	0+32*	56
10	1·6	2·1	2·78	5·0	11·9	12·85	14·85	18·15	23·25	24·45	27·3	14	18	2+17	2+16	162	♂ iv–v	1+32	55
11	1·55			4·8	11·9	12·9	14·5	17·7	22·6	23·6	26·55	14	16	3+16	2+15	146	♀ iv	0+32	56
12	1·5			4·6	11·4	11·95	13·95	16·8	22·1	23·1	25·8	14	16	2+17	2+16	139	♂ v	0+33	56
13	1·53			4·7	11·4	12·55	14·25	17·6	22·65	23·7	26·3	15	16	3+17	3+15	162	♂ v	0+33	56
14	1·5			4·7	11·4	12·0	14·0	16·9	21·9	23·0	25·8	14	18	3+17	2+16	142	♀ iv	0+32	55
15	1·5			4·8	11·75	12·05	14·4	17·3	22·3	23·4	25·9	15	17	2+17	2+18	148	♂ iv–v	1+32	56
16	1·52			4·7	11·5	12·05	14·3	17·05	22·0	23·2	25·7	14	16	2+17	2+14	159	♂ v	1+32	56
17	1·5			4·8	12·3	12·55	15·2	18·0	23·0	24·25	26·9	16	16	2+17	3+16	172	♀ iv–v	1+32	55
18	1·5			4·7	11·15	11·75	14·9	16·6	21·7	22·8	25·2	15	17	3+16	2+15	117	♂ iii–iv	1+32	55
19	1·56			4·7	11·5	12·5	14·0	17·3	22·0	23·3	25·8	14	17	2+16	2+15	152	♀ iii–iv	2+31	56
20	1·5			4·6	11·25	12·15	13·8	16·9	21·85	23·0	25·6	15	17	2+17	2+15	114	♂ iii	†1+32	56
21	1·6			4·9	11·95	12·35	14·85	17·4	22·6	23·7	26·6	13	16	3+17	2+16	152	♀ iv–v	1+32	56
22	1·46			4·6	12·15	12·65	14·9	17·45	22·8	24·0	26·45	13	17	2+17	3+16	158	♀ iv–v	2+31	56
23	1·47			4·6	11·2	12·4	13·95	17·3	22·0	23·25	25·8	15	16	3+17	3+15	135	♀ iv	0+33	56
24	1·43			4·46	11·3	11·9	14·1	16·7	21·8	22·95	25·65	13	16	3+16	2+16	140	♀ iv	1+32	55
25	1·53			4·66	11·65	12·6	14·45	17·4	22·2	23·35	26·15	15	16	3+16	3+14	166	♂ v	1+32	56
26	1·35			4·2	10·25	10·6	12·5	15·05	19·3	20·4	22·7	14	17	3+17	2+16	95	♀ ii –iii	1+31	55
27	1·6			5·2	12·4	13·05	15·3	18·5	23·9	25·2	27·9	15	16	2+16	2+17	165	♂ v	1+33	57
28	1·4			4·25	10·35	10·85	12·55	15·3	20·05	21·1	23·6	15	17	2+16	2+14	104	♂ iii	0+32	56

29	1·47			4·8	11·7	12·7	14·35	17·15	22·3	23·55	26·2	14	16	2+17	2+15	139	♀ v–vi	1+32	56
30	1·43			4·5	10·6	11·4	13·4	15·8	20·8	21·9	24·3	14	16	2+17	3+15	113	♀ iii–iv	2+31	55
31	1·7			5·0	12·1	12·9	14·8	18·2	23·3	24·5	27·0	15	16	2+16	1+15	122	♀ vi	1+32	56
32	1·55			4·7	11·5	12·4	14·35	17·2	22·2	23·3	26·2	15	17	2+17	2+14	120	♂ iii	1+31	54
33	1·4			4·4	10·1	11·3	12·75	15·5	20·3	21·3	23·9	15	17	3+16	2+16	93	♂ iii	1+33	56
34	1·43			4·58	11·7	12·35	14·2	17·45	22·45	23·7	26·3	15	17	3+16	3+13	124	♀ iv	0+32*	55
35	1·68			5·15	12·45	13·6	15·15	19·1	24·6	25·8	28·7	15	16	2+17	2+14	183	♀ iv–v	1+31	56
36	1·3			4·1	10·05	11·0	12·4	15·4	19·85	20·9	23·35	15	16	2+16	2+15	90	♂ iv	0+33	56
37	1·42			4·3	10·45	11·5	12·9	16·0	20·45	21·65	24·1	15	18	2+17	3+14	120	♀ v–vi	2+32	56
38	1·27			4·2	10·3	11·3	12·9	15·9	20·5	21·5	23·85	14	16	2+17	2+16	105	♀ iv	0+32	55
39	1·3			4·2	9·8	10·6	12·05	14·85	19·6	20·6	22·8	14	16	2+17	2+16	95	♂ iv	1+33	57
40	1·4			4·4	11·1	11·8	13·7	16·8	21·7	22·85	25·55	15	17	3+17	3+16	137	♂ iv	1+32	56
41	1·4			4·3	10·6	11·3	13·0	15·95	20·6	21·7	24·2	13	17	3+15	2+15	115	♂ iv–v	1+31	55
42	1·5			4·45	10·85	11·45	13·3	16·3	21·05	22·05	24·6	14	16	2+17	2+16	106	♂ iii	2+31	56
43	1·6			5·1	12·55	13·75	15·9	19·1	24·55	25·9	28·7	15	17	2+17	3+16	186	♀ v	1+32	56
44	1·25			4·0	9·45	10·3	11·9	14·65	19·1	20·15	22·4	15	16	3+16	2+16	185	♀ vi–iii	†0+32	55
45	1·5			4·4	10·75	11·3	13·2	15·95	20·9	22·0	24·4	15	17	2+17	2+17	115	♀ iv–v	0+33	56
46	1·43			4·5	10·8	11·7	13·3	16·4	21·3	22·35	24·8	15	17	3+17	2+15	99	♀ ii–iii	1+32	56
47	1·6			4·9	12·15	13·2	15·05	18·45	23·6	24·8	27·45	15	16	2+16	1+14	165	♀ v	0+32	56
48	1·5			4·8	11·7	12·2	14·7	17·6	22·8	23·95	26·55	17	17	3+17	2+13	144	♀ iv	1+32	56
49	1·48			4·8	12·3	12·8	15·0	18·2	23·0	24·2	26·8	14	17	3+16	2+16	142	♀ iv–v	1+31	56
50	1·6			5·1	12·6	13·6	15·75	19·05	24·9	26·2	29·1	14	16	3+16	2+16	193	♀ v	1+33	57
51	1·43	2·06	2·58	4·6	11·1	11·5	13·55	16·2	21·35	22·5	25·2	16	17	2+16	2+16	123	♂ iv	0+33	56
52	1·6	2·2	2·8	5·05	11·9	12·8	14·9	17·9	23·1	24·2	27·05	15	18	2+17	2+14	157	♂ iv–v	1+32	56
53	1·4	2·0	2·43	4·45	11·3	11·9	14·0	17·25	22·4	23·5	26·2	15	17	3+16	2+15	147	♂ iv	0+32	55
54	1·5	2·1	2·65	4·65	11·95	12·6	14·5	17·75	23·0	24·2	26·7	15	16	2+16	2+14	163	♂ v	1+33	56
55	1·32	1·86	2·3	4·25	10·2	11·1	12·5	15·45	20·0	21·05	23·6	15	16	2+17	2+14	94	♀ vi	0+32	55
56	1·5	1·96	2·6	4·6	11·0	11·7	13·8	16·5	21·5	22·7	25·25	14	17	2+18	2+16	126	♂ iv–v	1+32	56
57	1·3	1·86	2·32	4·3	10·3	11·1	13·05	16·0	20·9	22·0	24·5	16	18	2+17	2+15	122	♀ iii–iv	0+33	56
58	1·3	1·84	2·4	4·1	9·75	10·05	11·9	14·4	18·7	19·75	21·95	15	18	2+17	3+16	81	♂ ii–iii	1+32	55
59	1·5	2·05	2·6	4·7	11·9	12·35	14·7	17·4	22·7	23·9	26·55	14	16	2+17	2+17	149	♂ v	0+33	57
60	1·4	2·05	2·55	4·55	11·3	11·8	14·0	16·5	21·8	22·9	25·45	15	18	3+17	2+17	141	♂ v	0+33	56
61	1·6			5·0	12·25	12·9	15·2	18·1	23·2	24·45	27·2	15	17	3+17	2+14	153	♂ v	2+31	56
62	1·45			4·7	11·15	12·35	13·8	16·9	21·9	23·0	25·6	14	16	2+17	2+15	128	♂ v	0+32	56
63	1·65			5·05	12·5	13·35	15·6	18·5	24·0	25·25	28·2	14	18	3+16	3+16	180	♀ v	1+32	56
64	1·3			4·3	10·8	11·45	13·3	15·85	20·7	21·9	24·4	15	17	2+16	2+14	116	♂ v	0+32	55
65	1·5			4·75	11·7	12·5	14·45	17·6	22·55	23·7	26·4	15	17	2+17	2+15	135	♂ v	1+32	56
66	1·55			4·75	11·45	12·35	14·15	17·2	21·85	23·1	25·9	14	17	2+17	3+15	121	♀ v	2+31	55
67	1·45			4·45	10·8	11·1	13·1	16·15	20·75	21·9	24·4	15	16	2+16	2+16	116	♀ iii–iv	2+31	56
68	1·36			4·35	10·3	11·15	12·8	15·3	20·25	21·3	23·7	15	16	2+17	2+15	94	♂ iii–iv	1+31	56
69	1·55			4·8	11·4	11·9	14·0	16·55	21·55	22·8	25·2	14	18	2+17	2+15	129	♂ v	0+32	55
70	1·45			4·35	10·4	10·8	12·95	15·45	20·1	21·1	23·7	15	16	3+17	3+15	108	♂ v	1+32	56

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
71	1·47			4·75	11·75	12·7	14·7	17·4	22·8	23·8	26·6	14	18	2+17	2+18	151	♂ v	2+33	57
72	1·5			4·75	11·7	12·2	14·4	17·55	22·2	23·4	26·05	15	16	2+16	2+14	147	♂ v	1+32	56
73	1·62			5·05	12·3	13·5	15·4	18·4	23·8	25·05	28·1	15	16	2+17	1+16	177	♂ v–vi	1+33	56
74	1·48			4·6	10·95	11·5	13·6	16·6	21·3	22·45	25·1	15	18	3+17	3+15	127	♀ iv–v	1+31	56
75	1·45			4·75	11·9	12·9	14·65	17·9	23·25	24·5	27·1	14	18	2+16	2+15	165	♀ v	0+32	55
76	1·6			5·15	13·15	13·85	16·15	19·5	24·6	25·8	28·5	15	16	3+16	3+14	171	♀ v	1+33	56
77	1·45			4·6	11·05	12·0	13·7	16·9	21·9	22·95	25·5	15	17	1+17	3+14	124	♀ iv–v	2+32	56
78	1·6			4·95	12·75	13·5	15·75	19·1	24·4	25·6	28·35	16	17	2+17	2+16	176	♂ iv–v	0+32	56
79	1·36			4·3	10·25	10·9	12·85	15·45	19·95	21·0	23·35	16	17	2+17	2+16	109	♂ iv	3+30	56
80	1·6			5·2	12·1	13·0	14·8	17·85	23·35	24·5	27·3	13	16	3+16	2+15	150	♂ v	1+32	56
81	1·5			4·65	11·45	11·85	14·1	16·9	21·9	23·05	25·7	15	16	2+17	2+16	129	♀ iv–v	0+32	56
82	1·48			4·65	11·0	11·8	13·75	16·5	21·45	22·6	25·2	15	17	3+16	2+14	124	♀ vi	1+31	55
83	1·45			4·45	10·75	11·35	13·4	16·2	21·0	22·2	24·4	15	17	2+16	2+15	125	♀ v–vi	1+32	55
84	1·37			4·3	10·6	11·45	13·2	16·25	21·15	22·3	24·8	15	17	3+16	2+16	95	♀ vi–iii	1+32	55
85	1·4			4·4	10·2	10·9	12·8	15·1	19·85	20·95	23·35	14	17	2+15	1+16	99	♀ iii	1+32	56
86	1·35			4·25	10·35	11·05	12·9	15·45	20·4	21·5	24·0	14	17	2+18	3+16	101	♀ vi–iv	0+32	55
87	1·38			4·3	10·55	11·25	13·0	15·7	20·5	21·65	24·0	15	16	2+16	2+16	114	♂ iv–v	1+32	57
88	1·55			5·0	12·2	13·1	15·15	18·15	23·5	24·75	27·55	15	17	2+17	2+15	164	♂ v	0+33	56
89	1·37			4·5	10·8	11·7	13·5	16·1	20·65	21·75	24·35	14	16	2+16	2+15	114	♀ v–vi	2+31	55
90	1·35			4·3	10·4	11·1	13·0	15·5	20·05	21·1	23·4	14	17	2+16	2+16	97	♀ iv	1+32	55
91	1·3			4·35	10·7	11·2	13·1	15·75	20·85	22·0	24·45	15	16	3+15	3+15	111	♂ iv	0+33	56
92	1·42			4·63	11·6	12·2	14·3	17·6	22·4	23·6	26·1	15	15	2+16	2+14	153	♂ iv	1+33	56
93	1·4			4·38	10·8	11·45	13·3	16·4	21·2	22·3	24·75	14	17	2+16	2+15	119	♂ v–vi	3+31	56
94	1·4			4·4	10·85	11·9	13·5	16·6	21·55	22·6	25·1	15	17	2+17	2+14	119	♀ iv	†1+32	56
95	1·7			5·2	12·4	13·8	15·55	19·1	24·3	25·65	28·2*	14	17	2+17	2+17	199	♂ v	2+30	55
96	1·3			4·25	10·05	10·9	12·45	15·35	20·1	21·25	23·55	14	17	2+16	2+17	98	♂ iii–iv	1+33	56
97	1·52			4·9	11·95	12·65	14·6	18·2	22·9	24·15	26·85	16	17	2+16	2+14	142	♂ iv	0+32	55
98	1·4			4·4	10·45	10·9	12·7	15·2	20·2	21·25	23·9	13	17	2+17	2+16	97	♀ vi–iv	0+31*	54
99	1·4			4·45	11·15	11·7	14·15	17·1	21·9	23·0	25·6	15	17	2+17	2+14	133	♀ v–vi	1+32	56
100	1·45			4·65	11·6	12·0	14·3	17·4	22·1	23·2	25·75	15	16	2+16	2+14	127	♂ iv–v	0+32	56
101	1·4	1·85	2·45	4·3	10·8	11·3	13·4	15·8	20·85	22·0	24·4	15	16	2+17	2+15	101	♀ vi	2+31	56
102	1·34	1·8	2·4	4·35	10·2	10·95	12·75	15·3	20·1	21·1	23·5	15	17	1+17	2+15	98	♂ v	1+32	57
103	1·35	1·92	2·43	4·4	10·15	10·75	12·4	15·1	20·0	21·1	23·5	14	16	1+17	2+16	85	♂ iv	0+33	56
104	1·73	2·3	2·96	5·3	12·4	13·3	15·6	18·8	24·2	25·55	28·5	15	17	2+17	2+15	171	♂ v	2+32	57
105	1·64	2·15	2·88	5·0	12·3	13·25	15·4	18·3	23·65	25·0	27·7	14	16	2+17	2+15	162	♂ v	1+32	56
106	1·55	2·13	2·7	4·75	11·45	12·05	14·25	17·05	21·8	22·9	25·7	14	17	2+17	2+16	163	♀ iv–v	2+31	55
107	1·42	1·95	2·43	4·55	11·1	11·75	13·7	16·6	21·7	22·75	25·4	15	17	2+17	1+15	156	♂ v	1+32	56
108	1·52	1·96	2·6	4·7	11·7	12·8	14·4	18·05	23·1	24·3	27·0	14	16	3+16	1+15	144	♀ iv–v	1+31	55
109	1·56	2·08	2·74	4·8	11·7	12·4	14·6	17·3	22·5	23·65	26·5	14	17	2+16	3+15	147	♂ v	1+31	55

110	1·7	2·2	3·0	5·05	12·2	13·2	15·1	18·2	23·4	24·7	27·5	15	16	2+16	3+14	156	♂ v	2+30	55
111	1·54			4·5	11·2	11·8	14·2	16·6	21·6	22·75	25·35	14	16	3+17	3+14	131	♀ iii–iv	1+31	55
112	1·4			4·25	10·45	11·7	12·9	16·2	21·0	22·2	24·65	14	17	2+16	1+16	114	♀ vi	2+32	56
113	1·5			4·6	11·05	12·1	13·7	16·5	21·5	22·65	25·05	14	15	2+17	2+15	120	♀ iv–v	1+32	55
114	1·58			4·74	11·2	12·15	14·25	17·05	22·4	23·55	26·3	15	17	2+18	1+17	143	♂ iii–iv	1+32	56
115	1·4			4·65	11·1	11·8	13·9	16·6	21·5	22·6	25·3	15	18	3+16	2+14	116	♂ iv–v	0+32	55
116	1·6			4·9	11·7	12·8	14·8	17·7	22·9	24·05	26·9	15	16	2+17	2+15	159	♂ v	1+32	55
117	1·58			5·1	12·75	14·0	15·9	19·15	24·65	25·95	28·85	14	18	2+17	2+16	213	♂ v	2+32	56
118	1·45			4·65	11·4	12·25	14·5	17·15	22·2	23·2	26·05	14	17	2+18	2+15	122	♂ v	†0+33	56
119	1·5			4·85	12·2	13·0	15·15	18·5	23·8	25·0	27·8	15	17	2+17	2+16	172	♂ v	0+33	56
120	1·63			5·1	12·8	13·4|	15·7	19·05	24·25	25·45	28·3	14	17	2+16	2+15	176	♀ iv–v	0+32	55
121	1·4			4·65	11·05	11·55	13·7	16·35	21·3	22·45	24·95	14	18	2+17	3+14	120	♂ iv	1+33	56
122	1·33			4·5	11·0	11·8	13·6	16·8	21·65	22·75	25·5	16	16	2+16	1+13	117	♀ iv–v	0+33	55
123	1·46			4·76	11·3	11·7	13·85	16·55	21·8	22·85	25·5	14	17	2+17	2+14	128	♀ v	1+32	55
124	1·5			4·5	10·9	11·5	13·55	16·3	21·2	22·3	25·0	15	16	2+16	2+16	123	♂ iv–vi	1+31	55
125	1·5			4·55	11·4	12·15	14·1	17·1	22·1	23·25	25·9	15	17	3+17	3+16	121	♀ iv	1+33*	57
126	1·7			5·3	12·9	13·5	15·85	19·2	24·7	25·8	28·9	15	16	2+16	2+16	174	♂ v–vi	2+32	56
127	1·5			4·8	12·0	13·0	14·9	18·7	23·55	24·7	27·4	15	17	3+17	2+15	169	♂ v	0+33	56
128	1·4			4·47	11·5	12·4	14·2	17·4	22·5	23·6	26·3	15	16	2+17	2+14	144	♀ v	2+31	55
129	1·5			4·5	10·8	11·6	13·5	16·3	21·45	22·5	24·95	15	17	2+17	2+15	120	♀ vi	0+32	55
130	1·6			5·1	12·4	12·9	15·5	18·45	23·8	25·05	28·05	15	17	2+18	2+16	189	♂ v–vi	1+32	56
131	1·4			4·5	10·9	11·3	13·6	16·1	21·15	22·25	24·8	15	17	2+17	2+16	114	♂ iv–v	0+34	56
132	1·55			4·75	11·4	11·9	14·05	16·8	21·7	22·85	25·6	15	17	2+17	2+15	131	♀ iv–v	2+31	55
133	1·38			4·35	10·55	11·4	12·95	15·75	20·65	21·7	24·2	14	17	2+16	2+16	112	♀ iv–v	†0+33	55
134	1·65			4·8	11·2	12·3	14·25	17·2	22·7	23·9	26·7	14	16	2+17	2+16	168	♀ v	0+32	55
135	1·4			4·5	10·65	11·4	13·2	16·2	21·1	22·1	24·7	15	18	3+16	2+15	124	♀ iv	1+33	57
136	1·6			5·15	12·0	12·8	14·9	17·8	23·0	24·25	27·05	14	16	2+16	2+15	132	♂ iii	1+31	54
137	1·5			4·7	11·4	12·25	14·1	17·15	22·05	23·25	25·95	14	16	2+16	1+15	137	♀ v	2+32	57
138	1·7			5·0	12·4	13·3	15·3	18·4	23·75	25·1	27·9	15	17	3+17	2+16	172	♂ v	1+32	56
139	1·5			4·7	11·4	11·8	14·2	16·7	21·85	23·0	25·65	15	17	2+17	2+15	134	♂ iii–iv	2+30*	56
140	1·7			5·1	12·0	13·5	14·9	18·5	23·5	24·7	27·55	15	17	3+16	2+15	170	♀ v	1+32	56
141	1·5			4·5	10·7	11·6	13·3	15·8	20·9	21·95	24·55	15	16	2+16	3+15	115	♀ iv–v	1+31	56
142	1·4			4·5	10·85	11·6	13·7	16·5	21·5	22·5	24·9	14	17	2+17	2+17	119	♂ iv	0+32	56
143	1·5			4·86	11·6	12·4	14·35	17·5	22·75	23·95	26·65	14	17	2+17	2+16	157	♀ vi	†0+34	56
144	1·55			4·65	11·7	12·1	14·55	17·8	23·0	24·15	26·9	15	17	2+16	3+15	144	♀ vi–iv	0+32	56
145	1·5			4·7	11·55	12·45	14·3	17·5	22·8	24·0	26·75	14	16	2+16	3+15	146	♂ v	2+30	55
146	1·47			4·6	11·0	11·7	13·65	16·6	21·35	22·95	25·65	15	16	2+17	2+16	123	♂ iv	0+33	56
147	1·44			4·73	11·5	11·75	14·3	16·9	22·05	23·1	25·8	15	16	2+17	2+15	132	♂ iv	†0+32	56
148	1·5			4·7	11·55	12·7	14·25	17·8	22·85	24·1	26·6	15	16	2+18	2+15	130	♂ ii	1+32	56
149	1·5			4·6	11·55	12·2	14·3	17·45	22·75	23·9	26·55	15	16	3+16	2+16	159	♀ v	1+32	56
150	1·5			4·7	12·1	13·0	14·9	18·1	23·5	24·7	27·5	15	17	3+16	2+16	164	♀ iv–v	1+32	56
151	1·35			4·3	10·3	11·3	12·7	15·5	20·45	21·55	24·0	14	16	2+16	2+15	103	♂ iii	0+34	57

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No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
152	1·24			4·15	9·95	11·1	12·4	15·3	20·0	21·0	23·5	15	17	2+17	3+15	103	♂ iii–iv	1+32	56
153	1·45			4·45	10·6	11·8	13·55	16·5	21·5	22·6	25·3	14	17	3+17	2+15	127	♀ iv–v	1+32	56
154	1·43			4·6	11·55	12·3	14·45	17·6	22·8	23·9	26·7	15	16	2+16	2+16	152	♀ v	1+32	56
155	1·4			4·85	11·8	12·5	14·65	17·65	22·95	24·2	26·95	15	17	3+16	2+17	171	♀ iv–v	1+32	56
156	1·65			5·05	12·4	12·9	15·25	18·4	23·55	24·8	27·8	15	16	2+17	2+15	171	♀ v	1+32	56
157	1·47			4·7	11·35	11·7	14·15	16·7	22·1	23·2	25·75	16	17	2+17	2+14	119	♂ iii	*1+0+32	57
158	1·5			4·6	11·0	12·15	13·65	16·7	21·75	22·8	25·4	14	17	2+16	2+15	117	♂ iv	0+32	55
159	1·63			4·9	11·6	12·45	14·65	17·6	22·8	23·95	26·85	14	15	2+17	2+16	137	♂ iii	1+32	56
160	1·5			4·55	10·8	11·75	13·4	16·35	21·3	22·45	25·05	15	17	2+18	2+16	107	♀ vi–iv	2+31	55
161	1·4			4·4	11·05	11·7	13·5	17·0	21·4	22·6	25·3	15	16	2+16	3+14	138	♂ v	1+31	*?
162	1·44			4·6	11·35	12·35	14·25	17·7	22·55	23·75	26·3	14	16	2+16	2+16	157	♀ iv–v	1+32	56
163	1·43			4·35	10·8	11·65	13·25	16·3	21·05	22·2	24·6	14	16	2+16	2+14	113	♂ iii–iv	1+32	56
164	1·33			4·5	10·8	11·45	13·9	16·5	21·45	22·55	25·25	15	16	2+17	2+16	134	♂ v–vi	1+32	55
165	1·72			5·05	12·75	13·05	15·5	18·65	24·0	25·3	28·2	15	17	2+16	3+15	185	♀ v	1+32	56
166	1·35			4·5	11·0	10·9	13·4	16·2	21·4	22·45	25·1	16	17	2+16	2+16	121	♀ vi	2+33	56
167	1·36			4·14	9·8	10·75	12·3	14·8	19·35	20·4	22·9	‡—+11	17	2+16	2+16	88	♂ v	1+31	55
168	1·55			4·55	11·0	11·45	13·6	16·5	21·4	22·5	25·0	15	17	2+16	2+16	110	♂ iv–v	0+33	56
169	1·43			4·55	11·05	11·45	13·9	16·65	21·6	22·75	25·6	15	17	2+17	2+16	138	♀ v	1+32	56
170	1·6			4·65	11·5	12·4	14·1	17·3	22·5	23·7	26·4	15	16	2+16	2+14	156	♀ vi	1+32	56
171	1·4			4·5	11·25	12·05	14·0	17·2	22·2	23·35	25·9	16	18	2+16	2+14	146	♂ iv–v	1+33	56
172	1·4			4·35	10·35	11·1	12·85	15·8	20·5	21·65	23·8	15	17	2+17	2+15	108	♀ iv–v	†0+33	56
173	1·4			4·4	10·3	10·9	12·85	15·45	20·25	21·25	23·8	15	16	2+18	2+14	94	♀ vi–iv	1+32	56
174	1·45			4·6	11·3	12·0	13·85	17·1	22·3	23·4	26·05	16	16	2+16	3+13	128	♀ vi	1+33	56
175	1·46			4·6	11·4	11·9	14·1	16·75	21·65	22·75	25·4	14	17	3+16	2+16	154	♀ v	1+31	55
176	1·5			4·75	11·45	11·9	14·25	17·15	22·4	23·55	26·2	15	16	2+17	2+16	131	♀ iv–v	1+31	55
177	1·4			4·25	10·15	11·05	12·7	15·7	20·15	21·25	23·7	16	15	2+17	2+15	107	♂ v	0+32	56
178	1·5			4·65	11·5	12·0	14·15	16·5	22·0	23·15	25·65	14	16	2+17	2+17	111	♀ vii	1+32	56
179	1·48			4·7	11·1	12·15	13·85	16·6	21·75	22·95	25·7	15	17	3+16	2+15	129	♀ iv–v	0+31	56
180	1·6			5·1	12·3	13·1	15·4	18·7	23·9	25·2	27·9	15	18	2+17	2+15	154	♂ v–vi	1+32	56
181	1·5			4·85	11·85	12·65	14·75	17·55	22·55	23·7	26·3	15	15	2+17	2+15	140	♀ v	1+32	56
182	1·4			4·6	10·6	11·2	13·1	16·05	20·6	21·7	24·15	16	16	2+17	2+15	94	♂ iii	2+31	56
183	1·4			4·5	11·1	11·9	13·85	16·75	21·85	22·95	25·4	15	17	3+16	2+15	122	♀ vi–iii	0+32	55
184	1·8			5·3	12·85	13·8	15·9	18·8	24·35	25·65	28·5	14	18	3+17	3+16	163	♀ v	1+32	56
185	1·65			5·1	12·05	13·3	14·95	18·1	23·25	24·4	27·3	14	17	3+16	2+15	158	♂ v–vi	0+31	55
186	1·38			4·33	9·8	10·45	12·2	14·8	19·45	20·45	22·8	15	17	2+16	2+16	90	♂ v–vi	0+33	56
187	1·5			4·6	11·0	12·3	13·5	16·85	21·8	22·95	25·7	15	17	3+16	3+16	126	♂ iv–v	1+32	56
188	1·3			4·0	9·85	10·95	12·15	15·2	19·55	20·55	22·95	15	18	3+16	2+16	97	♂ iii–iv	†0+32	55
189	1·4			4·45	10·55	11·15	13·15	15·9	20·85	21·95	24·4	15	16	2+17	2+15	101	♂ iv	1+32	56

‡ Space devoid of scales.

190	1·46	4·4	10·4	11·35	13·05	15·8	20·55	21·5	23·45*	15	17	2+17	2+15	100	♀ iv–v	1+32	56
191	1·54	4·65	11·65	12·25	14·3	17·3	22·3	23·4	26·15	15	18	2+17	2+15	146	♂ v	1+32	56
192	1·46	4·6	11·0	12·3	14·1	17·25	22·3	23·5	26·15	15	16	3+17	3+15	155	♂ v–vi	1+32	56
193	1·55	4·75	11·15	12·1	13·9	16·5	21·95	23·05	25·7	13	17	3+17	2+16	136	♀ iii–iv	†0+33	57
194	1·35	4·5	11·0	11·6	13·6	16·4	21·15	22·25	24·7	15	18	2+16	2+15	116	♂ iv–v	0+33	56
195	1·3	4·15	9·95	10·8	12·45	15·05	19·55	20·6	23·0	14	16	3+17	1+16	94	♀ iv–v	3+30	55
196	1·33	4·2	10·8	11·45	13·4	16·5	21·3	22·35	25·0	14	16	2+17	2+15	124	♀ vi–iv	†1+32	56
197	1·35	4·3	10·2	10·95	12·7	15·25	20·05	21·05	23·6	13	17	3+17	2+15	102	♂ iv	0+31	55
198	1·43	4·4	10·5	11·4	13·2	15·9	20·7	21·85	24·4	16	17	3+16	1+16	106	♂ v–vi	1+32	56
199	1·48	4·9	12·15	12·8	15·15	18·0	23·1	24·2	26·8*	15	17	3+18	2+16	145	♂ iv–vi	†0+32	56
200	1·48	4·4	10·7	11·65	13·4	16·25	21·2	22·35	24·95	14	17	2+17	1+15	139	♀ iv–v	2+31	56
201	1·7	5·0	11·95	12·9	15·1	17·8	23·1	24·2	27·05	14	17	3+16	2+16	163	♂ v	0+32	55
202	1·45	4·4	10·7	11·35	13·4	16·15	20·9	22·1	24·6	16	17	2+18	2+16	112	♀ vi	1+33	56
203	1·48	4·65	11·15	12·15	13·65	17·15	22·0	23·05	25·8	15	16	2+15	2+15	142	♀ iv–v	1+33	56
204	1·44	4·7	11·0	11·6	13·5	16·5	21·55	22·7	25·2	14	16	3+17	3+15	117	♂ v	1+31	45
205	1·36	4·3	10·3	11·0	12·8	15·65	20·45	21·5	24·05	15	17	2+16	2+16	115	♂ iv–v	1+32	56
206	1·46	4·55	11·45	12·2	14·3	17·3	22·15	23·3	25·8	15	16	3+16	2+16	138	♀ vi	0+33	56
207	1·26	4·2	9·9	10·8	12·3	14·9	19·3	20·5	22·8	15	16	3+17	1+16	93	♂ v–vi	1+31	55
208	1·26	4·2	10·3	10·75	12·7	15·5	20·2	21·2	23·8	15	16	3+16	2+16	91	♂ iii–iv	0+32	56
209	1·5	4·7	11·95	12·6	14·8	17·7	22·9	24·05	26·8	14	17	3+16	2+15	154	♀ v	1+33	57
210	1·5	4·75	12·0	13·1	14·9	18·25	23·25	24·45	27·15	15	17	2+16	2+16	174	♂ v	0+34	57
211	1·36	4·4	10·5	11·5	13·3	16·1	20·9	22·05	24·55	14	16	3+17	2+15	116	♂ v–vi	†0+33	56
212	1·33	4·3	10·5	10·85	12·95	15·2	19·85	20·85	23·2	15	17	2+17	2+16	93	♂ iii	1+31	55
213	1·5	4·7	11·25	12·45	14·0	16·8	22·15	23·25	25·95	14	16	3+16	2+15	126	♀ v	1+32	56
214	1·4	4·4	10·25	10·95	12·8	15·2	19·9	20·95	23·55	15	17	3+17	2+17	91	♀ vi–iii	1+32	56
215	1·6	4·9	11·45	12·8	14·5	17·65	23·0	24·2	27·2	15	16	3+17	1+15	161	♀ vi	1+33	56
216	1·6	4·85	11·7	12·65	14·65	17·95	23·0	24·3	26·65	14	16	3+16	2+16	157	♀ v	1+31	55
217	1·75	5·35	13·2	14·6	16·6	19·9	25·8	27·15	30·2	14	17	3+17	1+16	200	♀ v	1+32	56
218	1·7	5·15	13·05	14·1	16·4	19·75	24·85	26·2	29·0	14	17	3+16	2+14	197	♀ v	1+31	55
219	1·65	5·15	12·55	13·45	15·2	18·2	23·9	25·2	27·85	14	17	3+16	2+16	169	♀ v	0+33	57
220	1·55	4·55	11·15	12·55	14·2	17·2	22·5	23·7	26·35	14	17	3+17	2+15	166	♂ v–vi	0+33	56
221	1·5	4·65	11·35	11·65	14·25	16·8	22·0	23·2	25·95	14	17	3+17	2+15	143	♀ v	2+32	56
222	1·45	4·45	10·8	11·45	13·5	16·1	21·3	22·4	25·0	15	17	3+16	2+14	119	♂ iii–iv	1+33	56
223	1·58	4·95	11·9	12·8	14·65	17·5	22·75	23·95	26·5	15	18	2+16	2+14	124	♂ iii–iv	1+32	56
224	1·46	4·5	10·5	11·0	13·0	15·75	20·45	21·55	24·15	15	17	2+17	2+15	116	♀ vi	1+31	55
225	1·4	4·5	11·1	12·0	14·05	17·15	22·3	23·4	26·0	14	16	3+17	0+15	143	♂ iv	2+31	55
226	1·3	4·36	10·85	11·45	13·5	15·9	21·15	22·35	24·9	14	17	2+17	3+16	121	♂ iv–v	1+31	55
227	1·66	5·0	11·65	12·35	14·55	17·4	22·65	23·85	26·8	14	16	3+16	1+16	167	♀ v	3+31	55
228	1·5	4·8	12·15	12·3	14·95	17·55	22·6	23·7	26·65	15	17	3+17	2+16	150	♂ v	1+32	56
229	1·4	4·45	10·9	11·65	13·55	16·55	21·35	22·45	25·05	14	17	2+17	2+15	123	♂ v	1+31	56
230	1·38	4·45	10·8	11·75	13·4	16·3	21·2	22·25	24·9	15	16	2+17	2+16	116	♂ v	1+32	56
231	1·48	4·6	11·2	11·9	13·8	16·8	21·65	22·75	25·3	15	17	2+17	2+15	118	♀ iii	1+32	56

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
232	1·5			4·9	12·1	12·25	15·0	17·65	22·75	23·95	26·6	14	16	3+16	2+16	154	♂ v	1+32	55
233	1·5			4·9	11·95	12·65	14·7	17·3	22·65	23·85	26·65	14	17	2+18	2+16	137	♀ v	1+33	56
234	1·4			4·55	11·0	11·75	13·7	16·5	21·75	22·9	25·4	1+15	17	2+16	2+15	123	♂ iv	0+31	55
235	1·38			4·35	10·15	10·6	12·7	15·15	19·8	20·9	23·4	14	16	2+17	2+16	95	♂ iv	1+31	55
236	1·44			4·45	10·95	11·7	13·55	16·5	21·4	22·45	24·95	15	17	2+16	0+16	124	♀ iv–v	†0+33	56
237	1·57			4·95	12·05	13·3	15·1	18·4	23·65	24·8	27·7	15	17	3+16	2+15	171	♂ v	2+31	55
238	1·6			5·1	12·5	12·95	15·5	18·3	23·7	25·1	27·9	14	17	3+16	2+16	157	♂ v	0+32	56
239	1·6			5·0	12·7	13·5	15·7	19·0	24·75	25·9	29·0	14	17	3+16	2+16	195	♀ iv–v	2+32	56
240	1·4			4·7	11·75	12·3	14·35	17·25	22·5	23·65	26·35	13	17	2+16	2+15	157	♀ v	†1+32	56
241	1·3			4·2	10·2	11·0	12·8	15·45	20·2	21·15	23·6	14	16	3+17	1+15	107	♂ iii–iv	†1+31*	54
242	1·44			4·83	11·95	12·8	14·7	18·0	23·0	24·15	26·85	15	16	2+16	1+16	156	♀ v	1+32	56
243	1·5			4·75	11·45	12·65	14·3	17·55	22·6	23·8	26·6	15	17	3+16	2+16	160	♂ iv–v	0+33*	56
244	1·65			4·95	11·85	12·6	14·9	17·6	22·95	24·15	26·9	15	17	3+17	1+16	149	♀ vi	2+31	55
245	1·53			4·95	12·5	13·3	15·65	18·45	23·8	25·0	27·85	14	18	2+17	2+15	145	♂ iii–iv	1+32	55
246	1·5			4·6	11·2	11·95	13·75	16·95	22·1	23·2	26·0	15	18	2+16	1+15	129	♂ iv	1+32	56
247	1·48			4·46	11·0	11·6	13·4	16·45	21·5	22·65	25·1	14	16	2+16	1+16	127	♀ vi	†1+32	56
248	1·4			4·35	10·45	11·6	13·15	15·9	20·7	21·75	24·2	15	17	2+17	2+16	109	♂ iv–v	1+31	55
249	1·4			4·5	11·1	12·0	13·95	16·5	21·5	22·55	25·0	14	17	3+17	1+15	126	♂ iv–v	0+32	55
250	1·58			5·0	11·55	12·5	14·6	17·4	22·8	23·95	26·8	13	17	2+18	2+16	156	♀ v	1+32	55
251	1·35			4·4	10·5	11·05	13·2	15·35	20·2	21·3	23·65	14	18	2+17	2+17	97	♀ vi–iii	0+32	56
252	1·35			4·45	11·35	11·5	13·9	16·55	21·35	22·55	25·05	15	16	2+16	2+15	127	♂ vi–iii	0+32	55
253	1·55			4·95	11·7	12·75	14·65	17·45	22·9	24·0	27·0	13	16	2+17	3+15	166	♀ v	†0+33	56
254	1·55			4·9	12·05	12·8	14·85	18·05	23·05	24·2	27·05	15	17	2+16	1+16	130	♂ ii	0+32	55
255	1·83			5·5	13·05	13·65	16·15	19·5	25·1	26·4	29·4	16	18	3+17	2+15	189	♀ v	2+30	56
256	1·45			4·5	11·0	11·95	13·85	17·0	21·95	23·0	25·6	14	16	3+17	3+15	132	♂ iv–vi	0+33	56
257	1·3			4·25	10·6	11·45	13·15	16·3	21·1	22·15	24·6	16	17	3+16	3+15	120	♂ iii–iv	0+33	56
258	1·4			4·7	11·55	12·4	14·35	17·4	22·5	23·7	26·3	15	16	3+17	2+15	137	♂ v	2+32	57
259	1·4			4·4	10·55	11·45	13·35	16·0	20·95	22·1	24·6	13	17	2+18	3+15	126	♂ v	2+32	56
260	1·7			4·25	12·85	13·65	15·65	19·0	24·15	25·45	28·2	15	16	2+16	2+14	181	♂ v	1+32	57
261	1·3			4·4	10·8	11·2	13·2	15·4	20·4	21·4	23·9	14	17	2+17	2+15	107	♂ iv–vi	1+32	55
262	1·55			4·7	11·05	12·0	13·8	16·6	21·8	22·9	25·75	15	16	3+16	2+15	139	♀ v	1+31	54
263	1·6			4·9	11·75	12·6	14·75	17·65	23·1	24·2	27·1	14	18	2+17	2+17	168	♂ v	1+33	57
264	1·35			4·5	10·5	11·2	13·15	15·5	20·8	21·9	24·6	15	16	3+17	2+16	108	♂ v	1+32	56
265	1·4			4·6	11·2	11·9	13·9	17·0	22·1	23·2	25·85	16	18	3+16	2+15	117	♀ vi–iii	1+33	56
266	1·45			4·65	11·15	11·95	13·85	16·4	21·45	22·65	25·25	14	16	3+16	2+17	118	♀ vi	0+32	55
267	1·35			4·4	10·8	11·4	13·55	16·4	21·25	22·45	24·95	15	17	2+17	2+16	116	♀ iv–v	0+[1+1+30]*	55
268	1·53			4·7	11·4	12·0	14·2	17·2	22·05	23·3	26·1	15	17	2+17	1+16	137	♀ iv–v	1+31	55
269	1·36			4·48	11·0	12·0	13·5	16·8	21·6	22·8	25·35	14	17	2+16	3+14	133	♂ v	0+33	56
270	1·35			4·35	11·05	11·5	13·5	16·3	21·25	22·25	24·75	16	16	3+16	2+15	113	♂ v–vi	†1+33	57

271	1·35	4·36	10·6	11·35	13·4	15·95	21·1	22·25	24·85	13	17	2+17	2+14	115	♂ iv–vi	0+32 56
272	1·55	4·85	11·95	13·1	15·0	18·1	23·4	24·7	27·35	15	16	3+17	2+15	166	♂ v	3+31 56
273	1·4	4·35	10·5	11·2	12·95	15·85	20·65	21·7	24·15	14	18	3+16	2+15	118	♂ v–vi	1+31 55
274	1·45	4·65	11·05	11·45	13·75	16·3	21·7	22·8	25·5	15	16	2+17	3+16	123	♂ v–vi	2+31 56
275	1·4	4·3	9·95	10·7	12·35	14·9	19·55	20·6	23·0	15	17	2+17	3+15	95	♀ iv–v	0+33 56
276	1·5	4·54	11·05	11·8	13·8	16·35	21·45	22·55	24·95	13	17	2+16	2+16	120	♂ v–vi	†0+32 55
277	1·43	4·55	11·25	11·85	14·1	16·9	21·7	22·9	25·3	15	18	3+16	2+15	123	♂ iv–v	1+32* 56
278	1·72	5·3	12·4	13·75	15·5	18·85	24·3	25·75	28·6	14	17	3+16	2+15	170	♀ v	1+31 55
279	1·4	4·5	11·35	11·7	14·2	16·95	21·95	23·05	25·75	15	17	2+17	2+15	123	♂ v	2+31 55
280	1·6	4·9	12·0	12·8	14·7	17·9	23·1	24·35	27·15	15	17	3+16	3+15	170	♂ v	1+31 55
281	1·53	4·7	11·3	11·95	13·85	16·6	21·5	22·6	25·3	13	17	2+16	3+15	128	♀ v–vi	1+31 55
282	1·3	4·1	10·5	11·45	13·15	16·15	20·9	22·1	24·5	14	16	2+17	3+15	115	♀ v–vi	0+32 56
283	1·38	4·42	10·85	11·4	13·35	16·15	21·25	22·35	24·85	15	15	2+16	3+15	103	♀ vi–iv	1+32 56
284	1·35	4·25	10·0	10·8	12·35	14·8	19·7	20·75	23·25	15	17	2+17	2+17	92	♂ iv–v	0+32 55
285	1·44	4·3	10·3	10·9	12·65	15·5	20·1	21·15	23·7	15	18	2+16	2+17	95	♂ iv–v	†0+32 56
286	1·4	4·4	10·45	11·1	13·1	15·35	20·5	21·55	24·0	9+0+5 16		3+16	3+16	102	♀ iii–iv	2+32 56
287	1·76	5·15	12·4	12·95	15·3	18·3	23·75	24·95	27·6	16	17	3+16	3+15	172	♂ v	2+31 56
288	1·5	4·55	11·05	11·6	13·55	16·45	21·35	22·45	25·1	16	18	2+15	2+15	119	♂ v	0+31* 56
289	1·48	4·65	11·45	12·1	14·2	16·9	22·2	23·4	25·95	14	18	3+17	2+15	130	♂ v	2+31 56
290	1·35	4·3	10·7	11·4	12·9	15·95	20·7	21·85	24·4	16	17	2+16	2+15	111	♀ v	†0+33 57
291	1·4	4·48	11·05	11·6	13·6	16·2	21·25	22·4	25·05	15	16	2+17	2+15	113	♀ vi	1+31* 56
292	1·55	4·85	11·95	12·75	14·95	18·05	23·2	24·4	27·2	1+14	16	2+18	2+15	160	♀ v	0+33 57
293	1·3	4·3	10·2	10·9	12·6	15·15	19·8	20·85	23·3	14	17	2+17	3+14	107	♂ iv–v	1+32 55
294	1·35	4·25	10·4	11·25	13·1	15·8	20·85	22·05	24·55	15	16	3+16	2+16	123	♂ v–vi	1+32 55
295	1·54	4·6	11·3	12·0	14·1	17·2	22·25	23·35	26·0	15	16	2+17	2+16	128	♀ iv–v	0+33 56
296	1·34	4·05	9·95	10·2	12·15	14·7	19·2	20·3	22·55	15	17	3+15	2+16	84	♂ iii–iv	2+31 56
297	1·5	4·85	11·75	12·8	14·6	17·5	22·65	23·75	26·45	16	18	2+17	2+14	133	♂ iv–vi	2+32 57
298	1·58	4·9	12·0	12·6	14·95	17·9	22·9	24·15	26·8	15	17	3+16	2+15	178	♂ v	2+32 56
299	1·5	4·65	11·45	12·45	14·45	17·2	22·45	23·7	26·35	14	17	3+17	2+15	125	♀ iv–v	1+32* 56
300	1·48	4·65	11·65	12·35	14·4	17·3	22·35	23·7	26·15	15	17	2+17	2+14	158	♂ v–vi	†0+31 55
301	1·48	4·55	11·1	11·65	13·6	16·95	21·8	22·95	25·7	16	16	2+16	3+15	136	♂ v–vi	2+31 55
302	1·4	4·2	10·5	11·1	12·95	15·85	20·3	21·5	24·0	15	17	3+16	2+15	114	♂ v	0+33 56
303	1·6	5·0	11·9	13·0	14·7	18·0	23·35	24·65	27·25	16	16	2+16	2+15	158	♀ vi	0+34 56
304	1·4	4·45	11·1	12·0	13·8	16·75	21·55	22·7	25·5	15	17	2+17	2+15	120	♂ iv–v	0+32 55
305	1·3	4·0	9·75	10·45	12·05	14·65	19·2	20·3	22·45	14	16	2+17	3+16	85	♀ vi–iii	1+32 56
306	1·5	4·9	12·35	12·8	15·15	18·2	23·6	25·0	27·6	15	17	2+16	2+16	176	♂ v	1+31 55
307	1·5	4·8	11·5	12·2	14·25	17·4	22·4	23·6	26·4	15	16	2+16	1+15	156	♀ v	0+32 56
308	1·4	4·4	10·45	11·15	13·1	16·0	20·8	21·9	24·5	14	17	3+17	1+15	117	♀ iii–iv	1+33 56
309	1·44	4·58	11·3	11·5	13·9	16·8	21·85	23·0	25·6	15	17	2+17	2+17	123	♀ v	0+32 55
310	1·4	4·48	10·95	11·45	13·9	15·8	21·2	22·39	24·95	14	17	3+17	2+16	128	♂ v	2+31* 55
311	1·3	4·3	10·2	11·0	12·75	15·55	20·2	21·3	23·6	15	18	2+17	2+16	93	♂ iv–v	†0+32 55
312	1·32	4·2	10·6	11·25	13·15	15·85	20·6	21·7	24·05	17	17	2+17	2+17	101	♂ iv–v	†0+32 56

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
313	1·34			4·55	10·95	11·7	13·6	16·65	21·7	22·8	25·5	16	17	2+16	2+15	125	♂ v	0+33	56
314	1·3			4·4	10·7	11·65	13·5	16·5	21·3	22·55	25·0	14	17	2+16	2+15	121	♂ v–vi	1+31	54
315	1·44			4·5	10·75	11·4	13·35	16·15	21·05	22·3	24·75	15	17	2+16	2+16	110	♂ iv–vi	†0+33	56
316	1·6			4·95	11·75	12·7	14·4	17·55	22·8	24·05	26·9	1+14	17	2+17	2+15	152	♀ vi	1+32*	56
317	1·5			4·7	11·9	12·6	14·75	17·75	22·8	24·0	26·65	15	16	2+17	3+15	136	♀ vii	†0+32	56
318	1·33			4·2	10·25	10·7	12·55	15·65	20·35	21·4	23·9	16	17	3+16	2+14	97	♂ iv–vi	1+32	56
319	1·48			4·7	11·2	12·2	13·75	17·25	21·15	23·3	25·9	16	18	2+17	2+15	128	♂ iv–vi	1+33	57
320	1·7			4·95	11·65	12·6	14·45	17·95	23·05	24·3	27·3	15	17	2+16	2+15	166	♂ v	0+32	56
321	1·26			4·15	10·3	10·8	13·0	15·25	19·8	20·9	23·3	14	16	2+16	1+15	95	♀ vi–iv	†0+33	56
322	1·52			4·8	11·4	12·5	14·2	17·15	22·3	23·45	25·95	14	17	3+17	1+16	129	♂ v	2+31	56
323	1·32			4·3	10·15	10·85	12·8	15·4	20·2	21·25	23·65	15	17	3+17	2+17	110	♂ iv–vi	†1+31	55
324	1·6			4·8	11·8	12·7	14·75	17·65	23·0	24·2	26·95	16	17	2+18	1+15	168	♂ v	†1+30	56
325	1·49			4·4	10·75	11·8	13·4	16·35	21·35	22·5	24·8	15	16	2+17	2+15	110	♂ iv–vi	1+32	55
326	1·66			5·2	12·65	13·7	15·55	18·65	24·35	25·7	28·5	14	16	2+17	2+16	165	♂ iv–v	0+33	56
327	1·6			5·0	12·3	13·5	15·3	18·55	24·25	25·5	28·6	15	18	2+17	2+16	177	♀ v	1+32	56
328	1·38			4·45	11·35	12·2	14·15	17·2	22·35	23·5	26·0	15	17	2+17	2+15	141	♂ v	1+33	56
329	1·48			4·5	10·85	12·25	13·5	16·6	21·75	22·95	25·7	14	16	2+16	1+17	134	♂ v	0+33	56
330	1·5			4·6	10·9	11·7	13·55	16·3	21·25	22·35	24·9	14	18	2+17	2+16	111	♀ vi	1+31	55
331	1·55			4·65	11·4	12·15	14·15	17·1	22·1	23·3	25·95	14	17	2+17	2+15	161	♀ iv–v	0+34	56
332	1·58			4·8	11·95	12·65	14·75	17·8	23·0	24·2	27·05	15	17	3+16	2+15	156	♀ v	2+32	56
333	1·6			4·85	11·1	12·5	13·65	16·85	22·05	23·15	25·95	15	17	3+16	2+14	124	♀ i–ii	2+31	56
334	1·43			4·55	10·7	11·4	13·5	16·05	21·0	22·2	24·95	15	17	2+18	2+15	114	♂ iv–v	2+31	55
335	1·36			4·32	11·05	11·7	13·75	16·6	21·4	22·5	25·1	15	17	2+17	2+16	138	♂ v	2+31	55
336	1·4			4·5	11·5	12·35	14·45	17·7	22·35	23·6	26·25	15	17	3+16	2+15	138	♂ v	0+31	55
337	1·38			4·45	11·1	11·65	13·95	16·9	21·75	23·05	25·65	14	17	2+17	2+15	151	♂ v	2+31	56
338	1·3			4·25	10·1	11·1	13·25	16·05	20·8	21·9	24·35	16	16	2+18	2+16	118	♂ iv–vi	0+32	56
339	1·4			4·55	11·6	12·45	14·4	17·7	22·7	23·95	26·75	14	17	2+17	2+15	152	♂ v	0+33	56
340	1·45			4·4	10·65	11·45	13·4	16·05	20·7	21·8	24·3	15	18	2+17	2+15	114	♂ iii–iv	1+32	56
341	1·5			4·55	10·65	11·4	13·4	15·85	21·95	22·1	24·65	13	17	3+17	2+17	104	♂ iii–iv	0+34	56
342	1·5			4·68	11·6	12·1	14·25	17·1	22·5	23·8	26·3	15	17	3+16	1+16	133	♂ v	2+32	56
343	1·4			4·5	10·95	11·95	13·7	16·75	21·85	23·0	25·7	16	17	2+17	2+16	118	♂ iv–vi	1+33	57
344	1·4			4·28	10·6	11·4	13·1	16·25	21·15	22·25	24·8	15	17	2+17	2+16	113	♂ iv–vi	1+34	57
345	1·5			4·65	11·65	12·2	14·35	17·15	22·35	23·5	26·55	15	16	2+16	2+14	158	♂ v	0+32	55
346	1·32			4·15	10·3	11·15	12·85	15·6	20·35	21·4	24·0	14	16	3+16	2+16	105	♂ iv–v	1+33	57
347	1·5			4·5	11·1	11·4	13·5	16·5	21·35	22·5	25·1	16	17	2+17	2+16	115	♂ iii–vi	1+33	56
348	1·38			4·32	10·75	11·15	13·3	16·1	20·95	22·05	24·7	14	16	2+16	2+15	114	♂ iv–v	†1+32	56
349	1·35			4·3	10·2	11·0	12·75	15·45	20·05	21·1	23·5	14	17	2+17	2+16	100	♂ iv–vi	2+32	56
350	1·33			4·15	10·1	10·65	12·5	15·35	19·9	21·1	23·45	14	16	3+15	3+15	103	♂ v	0+34	56
351	1·34			4·45	10·8	11·95	13·4	16·45	21·65	22·8	25·35	15	16	2+16	2+16	137	♂ v–vi	†0+34*	56

352	1·42		4·4	10·6	11·1	13·3	16·05	20·9	22·0	24·65	15	16	2+17	2+15	117	♂ v	2+31*	55
353	1·38		4·25	10·8	11·75	13·55	16·7	21·75	22·9	25·35	14	17	2+15	2+15	128	♂ v–vi	2+33	56
354	1·5		4·95	12·2	13·4	15·2	18·55	23·8	25·0	28·15	13	16	2+17	2+14	160	♀ v	1+31	55
355	1·35		4·3	10·6	11·35	13·4	16·25	20·95	22·1	24·75	16	17	2+17	2+15	126	♀ iv–v	1+30	55
356	1·43		4·6	11·05	11·7	13·6	16·45	21·4	22·65	25·15	14	17	2+17	2+17	113	♂ iv–vi	0+33	56
357	1·42		4·4	10·3	11·15	12·8	15·65	20·35	21·55	23·9	15	16	3+16	3+14	98	♂ iv	1+32	56
358	1·46		4·45	10·8	11·5	13·45	16·3	20·8	21·85	24·2	15	17	2+17	2+16	109	♀ iv	1+31	56
359	1·34		4·2	9·75	10·75	12·25	14·8	19·6	20·8	22·9	14	17	2+16	3+14	88	♂ iii–vi	†0+33	56
360	1·53		4·75	11·3	12·4	13·9	19·85	21·85	22·95	25·5	14	17	2+17	2+15	116	♂ iii	1+32	56
361	1·27		3·95	9·6	10·25	12·0	14·25	18·83	19·8	22·15	15	16	2+16	2+15	77	♀ iv	1+33	56
362	1·55		4·85	11·95	12·6	14·8	17·65	22·75	24·0	26·65	14	16	2+17	2+16	147	♂ iv–vi	1+32	56
363	1·3		4·2	10·35	11·05	12·75	15·4	19·95	21·05	23·45	16	16	3+16	3+14	84	♂ iii–iv	0+32	56
364	1·35		4·3	10·8	11·5	13·5	16·35	21·15	22·25	24·85	15	16	2+17	2+15	108	♀ iv–v	0+34	56
365	1·34		4·0	9·65	10·15	11·9	14·65	18·95	20·0	22·45	15	17	2+16	2+14	86	♀ ii–iii	†0+33	56
366	1·5		4·8	11·65	12·7	14·5	17·7	22·7	23·9	26·7	14	17	2+17	2+16	156	♀ v	2+31	56
367	1·33		4·2	9·8	11·1	12·5	15·0	19·7	20·6	22·6*	14	15	2+17	2+14	90	♂ iv–vi	2+31	56
368	1·45		4·35	9·95	10·75	12·2	15·1	19·5	20·55	22·8	15	17	2+15	2+15	88	♂ iii–iv	3+31	56
369	1·3		4·2	9·9	10·7	12·6	15·45	20·1	21·15	23·8	15	17	2+17	2+16	108	♂ iv–vi	1+32	56
370	1·4		4·53	11·1	12·2	13·75	17·15	22·05	23·2	25·9	16	17	2+17	2+14	131	♂ v	1+32	56
371	1·45		4·73	11·4	12·45	14·0	17·25	22·25	23·45	26·0	15	16	2+17	2+15	117	♀ iii–iv	0+31	56
372	1·46		4·6	11·4	12·4	14·1	17·0	22·1	23·25	25·85	14	17	2+16	3+14	127	♂ iv–v	0+33	55
373	1·3		4·23	10·15	11·0	12·85	15·35	20·45	21·55	24·15	14	17	2+17	2+17	102	♂ iii–iv	1+32	56
374	1·4		4·4	10·7	11·25	13·5	15·85	20·6	21·75	24·15	15	17	2+16	3+14	106	♂ v	1+32	56
375	1·36		4·53	11·05	11·75	13·95	16·55	21·7	22·85	25·15	15	16	2+17	3+16	120	♂ v	1+33	56
376	1·42		4·4	10·65	11·35	13·35	15·7	20·3	21·5	24·0	15	17	2+17	2+17	112	♀ iv–v	2+30	55
377	1·43		4·6	11·75	12·5	14·5	17·4	22·3	23·45	26·15	15	16	2+15	2+15	145	♀ iv–v	0+32	56
378	1·4		4·66	11·45	12·55	13·95	17·35	22·6	23·8	26·55	15	17	3+15	2+14	141	♀ v	0+33	56
379	1·3		4·16	10·05	10·8	12·35	15·0	19·35	25·0	22·75	15	16	3+16	2+15	95	♂ iv–vi	1+33	57
380	1·4		4·3	10·7	11·4	13·25	16·05	21·0	22·1	24·6	14	17	2+16	2+15	112	♂ iv–vi	1+32	55
381	1·32		4·16	10·05	10·55	12·3	14·8	19·3	20·3	22·6	15	17	2+16	2+14	85	♂ iv	2+32	56
382	1·4		4·3	10·45	11·45	13·15	16·05	20·7	21·8	24·15	15	18	2+17	3+15	106	♀ iii–iv	0+32	56
383	1·46		4·6	11·45	12·05	13·9	17·0	21·8	22·95	25·45	15	16	2+17	2+17	113	♂ iv	1+31	56
384	1·35		4·06	9·8	10·9	12·1	15·0	19·55	20·7	23·1	14	17	2+16	2+15	87	♂ iv	0+33	56
385	1·37		4·45	10·55	11·4	13·2	15·8	20·65	21·75	24·2	15	17	2+18	2+16	104	♂ v	1+32	56
386	1·4		4·33	10·05	10·9	12·6	15·3	20·0	21·05	23·5	15	17	2+16	2+16	91	♀ iii–iv	1+32	56
387	1·47		4·55	11·25	11·8	13·8	16·5	21·7	22·9	25·65	14	17	2+16	2+16	136	♀ v	1+32	56
388	1·53		4·62	12·15	12·7	14·75	17·9	22·85	24·1	26·8	15	16	3+16	2+15	138	♂ v	0+32	56
389	1·44		4·4	10·6	11·45	13·2	15·85	20·75	21·85	24·3	13	17	2+16	2+16	110	♀ iv–v	0+32	56
390	1·34		4·1	10·35	11·0	13·1	15·95	20·9	22·05	24·4	15	17	2+16	2+16	124	♂ v	1+32	56
391	1·4		4·4	10·9	12·3	13·8	17·35	22·15	23·3	25·9	15	16	2+16	2+16	147	♂ v–vi	0+32	56
392	1·3		4·1	9·95	10·4	12·45	14·5	19·2	20·35	22·75	14	15	2+17	2+15	90	♂ v–vi	1+32	55
393	1·64		4·9	12·3	12·9	15·25	18·3	23·3	24·55	27·3	16	17	3+17	3+15	164	♂ v	1+32	57

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
394	1·4			4·8	11·7	12·7	14·4	17·65	22·9	24·0	26·9	13	17	2+17	3+15	131	♂ v	0+33	56
395	1·53			4·85	12·15	12·9	15·15	17·95	23·2	24·4	27·05	14	17	2+17	3+15	162	♂ v	2+32	56
396	1·4			4·45	11·0	11·8	13·45	16·9	21·7	22·85	25·15	16	16	2+17	2+14	113	♀ iv–v	2+32	57
397	1·67			4·9	12·05	12·6	14·8	18·15	23·35	24·5	27·4	15	17	2+16	2+15	163	♀ v	1+32	56
398	1·5			4·74	11·8	12·6	13·7	18·15	23·1	24·3	27·25 Scales fused. 2+(1+1)+12	17		2+17	2+15	173	♀ v	1+32	56
399	1·5			4·8	11·5	12·3	14·05	17·4	22·45	23·65	26·3	14	17	3+15	2+16	161	♂ v–vi	1+33	57
400	1·7			5·0	12·5	13·25	15·5	18·8	24·1	25·3	28·25	15	18	2+18	2+16	177	♂ v	1+32	56
401	1·44			4·4	10·5	11·65	13·25	16·05	20·6	21·7	24·0	13	18	3+17	2+15	102	♂ iv	1+31	*55
402	1·33			4·2	10·2	11·2	12·75	15·55	20·25	21·3	23·75	14	17	2+17	2+15	108	♀ vi	†0+33	56
403	1·33			4·17	10·2	11·2	12·8	15·8	20·65	21·75	24·25	15	17	2+17	3+15	108	♂ iv	1+33	56
404	1·5			4·5	11·0	11·5	13·6	16·4	21·4	22·6	25·3	15	17	3+17	3+16	118	♂ v–vi	1+32	56
405	1·4			4·36	10·3	11·05	12·9	15·5	20·25	21·3	23·6	15	17	2+17	2+16	107	♀ v	1+30	56
406	1·6			4·85	11·8	12·5	14·65	17·6	22·8	23·9	26·45	15	17	2+17	2+16	160	♂ v	†0+33	56
407	1·47			4·53	11·7	12·6	14·4	17·55	22·55	23·65	26·3	15	17	2+16	2+15	140	♀ iv–v	2+31	56
408	1·5			4·6	11·4	12·3	14·3	17·0	22·35	23·5	26·2	14	17	2+17	2+15	140	♂ v–vi	1+32	56
409	1·5			4·75	11·9	12·1	14·75	17·2	22·7	24·0	26·75	15	17	2+17	2+16	153	♂ v	2+32	56
410	1·4			4·4	11·2	12·2	14·05	17·15	22·3	23·4	26·15	14	16	2+17	2+16	141	♂ iv–v	1+32	56
411	1·44			4·45	10·6	11·4	13·45	16·45	21·25	22·4	24·9	16	16	3+16	2+14	110	♂ iv	2+32	56
412	1·8			5·35	12·3	13·35	15·5	18·95	24·65	25·95	29·1	14	17	2+17	2+16	193	♀ v	1+33	56
413	1·5			4·6	11·8	12·3	14·85	17·85	23·1	24·4	27·1	16	17	2+18	2+16	167	♀ v	1+32	56
414	1·45			4·54	11·55	12·3	14·3	17·3	21·3	23·55	26·4	15	17	2+16	2+14	155	♀ v	0+33	56
415	1·75			5·38	13·5	14·65	16·95	20·25	25·7	27·1	30·15	15	17	3+17	2+16	213	♀ v	1+31	55
416	1·6			4·9	12·2	13·2	15·15	18·35	23·35	24·65	27·6	15	16	3+16	2+15	169	♂ v	1+32*	56
417	1·5			4·6	11·1	11·75	13·7	16·5	21·6	22·7	25·3	14	17	2+16	2+16	113	♀ vi–iii	2+32	56
418	1·6			4·8	11·65	12·5	14·5	17·75	22·5	23·7	26·3	15	16	3+17	2+15	151	♂ v	0+32	56
419	1·46			4·55	11·7	12·5	14·35	17·45	22·45	23·65	26·3	15	17	3+16	2+15	132	♂ iv–v	1+32	56
420	1·44			4·55	11·45	12·6	14·4	17·6	22·7	23·95	26·45	15	16	3+17	3+14	133	♀ vi	2+31	56
421	1·7			5·2	12·25	12·9	15·25	18·55	23·7	25·0	28·0	15	17	3+16	2+14	185	♂ v	2+33	56
422	1·5			4·5	10·6	11·7	13·1	16·25	20·85	22·05	24·55	15	17	2+16	2+16	105	♂ v	†0+32	55
423	1·3			4·15	10·25	10·95	12·85	15·5	20·15	22·2	23·65	15	16	2+18	2+15	95	♂ iv–v	2+30	55
424	1·6			5·0	11·95	12·9	14·9	18·2	23·3	24·55	27·25	14	18	3+17	2+16	163	♂ v	1+32	56
425	1·8			5·33	12·5	13·8	15·55	18·7	24·1	25·5	28·25	14	14	3+17	3+15	175	♀ v	2+31	56
426	1·4			4·37	10·25	11·5	12·8	15·9	20·9	21·95	24·55	15	17	2+17	2+15	115	♀ iii–iv	2+33	57
427	1·5			4·75	12·45	13·0	15·4	18·8	24·4	25·55	28·25	16	17	3+17	2+16	179	♂ v	2+33*	58
428	1·6			4·86	11·9	13·1	14·85	17·8	22·8	24·1	26·9	15	17	3+17	2+16	138	♂ iv	1+31	55
429	1·65			5·0	12·3	13·1	15·3	18·7	24·1	25·3	28·25	15	17	2+16	2+15	191	♂ v	1+32	56
430	1·5			4·65	11·2	11·9	14·2	16·9	22·1	23·3	26·1	14	17	2+17	2+17	153	♂ v	0+32	56
431	1·24			3·9	10·0	10·75	12·3	15·2	19·7	20·7	23·1	15	17	2+17	3+15	102	♀ v	0+33	56
432	1·36			4·36	10·8	11·8	13·65	16·4	21·3	22·5	25·15	15	17	2+17	2+17	128	♀ iv–v	1+33	56

433	1·36	4·5	10·6	11·6	13·4	16·45	21·25	22·35	25·05	14	16	2+17	2+15	110	♂ iv	1+31	55
434	1·7	5·3	12·8	13·3	15·85	18·7	24·1	25·35	28·25	15	17	3+17	1+16	156	♀ vi–iv	3+30	55
435	1·65	4·95	11·75	13·1	14·85	18·15	23·5	24·75	27·85	15	17	2+18	2+17	185	♀ v	1+32	*56
436	1·48	4·5	11·2	11·85	13·7	16·9	22·1	23·35	25·9	15	16	2+17	2+15	132	♂ v	1+31	56
437	1·54	4·9	12·05	13·15	15·05	18·4	24·05	25·2	27·95	5+000+7	17	3+16	2+15	161	♂ v	0+32	56
438	1·45	4·5	10·8	11·55	13·5	16·3	21·6	22·7	25·35	15	16	3+16	3+16	109	♀ vi–iv	1+32	56
439	1·34	4·25	10·3	11·25	12·95	15·45	20·2	21·3	23·6	14	17	2+17	3+15	99	♂ iv	†0+32	56
440	1·45	4·6	11·25	12·1	14·0	16·95	22·2	23·5	26·05	15	18	2+17	2+16	152	♀ iv–v	1+32	57
441	1·47	4·63	11·15	12·0	14·05	16·9	22·3	23·4	26·1	15	17	3+17	2+16	131	♂ iv–v	2+33	57
442	1·6	4·95	11·9	12·95	14·85	17·7	23·25	24·55	27·2	14	18	2+17	3+16	161	♀ v	0+33	56
443	1·36	4·44	11·0	11·45	13·75	16·5	21·8	23·0	25·55	15	17	2+17	2+17	140	♂ v	2+32	56
444	1·35	4·38	10·5	11·4	13·15	16·2	20·95	22·05	24·65	16	17	2+18	2+17	123	♀ iv–v	1+33	56
445	1·4	4·4	10·1	10·85	12·35	15·2	19·8	20·75	23·2	15	17	3+16	2+15	103	♂ v–vi	1+32	55
446	1·4	4·36	10·75	11·2	13·5	15·9	21·0	22·2	24·7	15	17	2+16	2+16	119	♀ iv–v	1+33	56
447	1·5	4·6	11·15	12·0	13·85	16·95	21·85	23·0	25·35	15	15	2+16	3+15	148	♀ v	1+31	55
448	1·35	4·25	10·5	10·95	13·1	15·75	20·4	21·5	24·05	15	16	3+17	2+16	100	♂ iv	2+32	56
449	1·4	4·43	10·65	10·5	13·0	15·65	20·4	21·5	23·85	16	17	2+17	2+16	105	♂ iv–vi	1+32	56
450	1·52	4·54	11·6	12·35	14·45	17·5	22·6	23·8	26·3	15	17	2+17	3+15	157	♀ v	0+33	56
451	1·38	4·43	10·9	13·55	11·9	16·25	21·4	22·55	25·15	15	16	3+16	2+16	121	♀ v	1+32	56
452	1·4	4·33	10·3	11·1	13·1	15·6	20·65	21·8	24·4	14	17	3+16	2+16	118	♂ v	2+32	56
453	1·6	4·98	12·95	13·7	15·9	19·3	24·6	26·05	28·85	15	17	2+15	3+15	194	♀ v	0+32*	55
454	1·53	4·65	10·6	11·05	13·2	15·95	20·95	22·15	24·8	13	16	3+17	2+17	113	♂ v	0+32	55
455	1·35	4·3	11·0	11·3	13·5	16·35	21·35	22·45	24·95	15	17	2+17	3+15	118	♀ iv–v	1+32	56
456	1·5	4·65	11·4	12·45	14·0	17·1	22·35	23·5	26·25	14	17	3+15	2+16	134	♀ v	2+32	57
457	1·5	4·5	11·0	11·65	13·7	16·25	21·4	22·5	25·15	15	17	2+17	2+16	126	♀ iv–v	1+32	56
458	1·47	4·55	11·35	12·2	14·0	17·25	22·05	23·3	26·0	14	16	2+15	2+13	155	♂ v	2+32	56
459	1·74	5·05	12·7	13·65	15·9	19·2	24·5	25·8	28·55	15	17	2+17	2+16	171	♀ iv–v	0+34	57
460	1·4	4·55	11·6	12·1	14·05	17·15	22·1	23·25	25·75	15	16	2+16	2+15	154	♂ v	1+32	56
461	1·43	4·6	11·1	11·9	13·75	16·4	21·5	22·6	25·05	14	17	2+17	2+16	117	♂ v–vi	1+32	56
462	1·48	4·4	10·95	11·55	13·8	16·5	21·7	22·95	25·5	15	16	3+17	2+16	126	♀ v 1+0*+32	56	
463	1·6	4·86	12·0	12·7	14·95	17·95	22·9	24·25	26·7	14	16	2+17	2+14	164	♂ v	1+32	56
464	1·6	4·9	11·8	12·65	14·6	17·65	22·85	24·0	26·6	14	17	3+16	1+16	134	♂ v	1+31	55
465	1·5	4·5	10·55	11·4	13·15	15·9	20·7	21·8	24·2	15	16	2+17	2+16	108	♀ iv–v	1+33	57
466	1·4	4·4	11·15	11·9	14·0	16·8	21·95	23·1	25·6	15	18	3+17	2+15	133	♀ ii–iii	2+31	56
467	1·38	4·38	10·75	11·45	13·25	15·8	21·0	22·15	24·6	14	17	2+17	1+15	100	♀ vi–iii	1+33	56
468	1·4	4·25	10·25	10·75	12·45	15·05	19·7	20·75	23·3	15	18	2+17	2+16	98	♂ v	0+33	57
469	1·43	4·42	10·6	11·1	13·2	16·05	20·85	22·0	24·4	14	17	3+17	2+15	98	♀ vii	1+33	57
470	1·56	4·72	11·65	12·65	14·7	17·95	22·85	24·0	26·7	15 (17l.) 11r. (abnrm.)		2+18	1+15	148	♀ v	1+32	56
471	1·4	4·38	10·5	10·95	13·2	15·4	20·5	21·65	24·05	14	16	3+17	1+15	98	♂ iii–iv	0+32	56
472	1·3	4·13	10·1	10·55	12·35	14·85	19·35	20·35	22·7	14	17	3+17	2+16	93	♂ v	1+32	56
473	1·46	4·45	10·65	11·1	13·35	15·6	20·9	22·0	24·5	14	16	3+17	1+15	111	♂ iv–v	1+33	56

No. of fish.	1	1a	1b	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
474	1·3			4·3	10·15	10·55	12·75	14·9	19·6	20·8	23·3	14	16	2+18	2+16	103	♀ iv	0+32	55
475	1·5			4·63	11·5	12·6	14·25	17·85	22·6	23·85	26·6	15	16	3+16	2+14	159	♀ v	1+32	56
476	1·35			4·25	10·65	11·45	13·25	16·0	21·0	22·1	24·5	14	16	3+17	2+15	116	♂ v–vi	0+32	56
477	1·7			5·1	12·65	13·7	15·55	19·1	24·6	25·8	28·7	14	17	3+16	2+15	155	♀ iv	1+32	56
478	1·5			4·68	11·3	12·2	13·95	17·45	22·05	23·3	26·15	16	16	3+16	2+14	141	♂ v–vi	1+31	55
479	1·3			4·0	9·75	11·0	12·45	15·1	19·75	20·85	23·05	15	17	2+17	2+15	94	♀ ii–iii	2+31	56
480	1·6			4·9	11·6	12·2	14·4	17·05	22·15	23·3	26·1	15	17	3+17	2+14	147	♀ v	2+31	56
481	1·4			4·32	10·3	10·8	12·45	15·5	19·6	20·7	23·15	14	17	2+17	2+14	99	♀ ii–iii	0+33	56
482	1·28			3·9	9·55	9·85	11·85	13·95	18·35	19·5	21·7	16	17	3+16	2+15	84	♂ v	1+31	56
483	1·53			4·9	12·35	12·9	15·6	18·65	23·9	25·3	28·2	14	18	3+18	2+16	185	♀ v	1+33	56
484	1·6			4·7	11·45	12·15	14·2	17·4	22·3	23·5	26·05	15	16	3+16	1+16	146	♀ v	1+34	57
485	1·38			4·35	10·5	11·15	13·2	15·6	20·75	21·8	24·45	13	17	3+18	2+16	102	♀ iii–iv	0+33	57
486	1·45			4·44	10·7	11·6	13·55	16·7	21·4	22·7	25·25	15	17	2+18	2+15	137	♂ v	1+30	55
487	1·5			4·42	10·8	11·5	13·5	16·7	21·3	22·5	25·1	15	17	2+17	1+14	125	♂ iv	0+32	56
488	1·7			5·14	12·36	13·3	15·7	18·55	23·8	25·1	28·0	16	17	3+18	2+16	190	♂ v	1+33	56
489	1·56			4·62	11·35	11·85	14·1	16·65	21·9	23·0	25·6	15	17	3+17	2+15	126	♂ iv–v	2+32	56
490	1·76			4·96	12·4	13·4	15·5	18·55	23·95	25·3	28·0	13	18	2+17	2+15	187	♀ v	0+32	56
491	1·36			4·2	10·25	11·1	13·0	15·75	20·6	21·75	24·15	1+0+12	16	2+17	2+15	103	♂ v	1+32	56
492	1·6			4·92	12·0	12·15	14·7	17·6	22·55	23·75	26·3	15	17	3+16	1+17	159	♂ v	2+31	56
493	1·5			4·36	10·75	11·6	13·45	16·45	21·35	22·5	25·2	16	17	3+16	2+15	133	♀ v	0+32	56
494	1·5			4·5	11·0	12·0	13·55	16·4	21·45	22·65	25·3	15	15	3+16	2+14	127	♀ iv–v	1+31	55
495	1·6			5·24	12·75	13·9	15·95	18·8	24·6	25·95	28·65	14	16	3+17	2+15	184	♂ v	2+30	55
496	1·7			5·03	12·3	13·75	15·25	18·4	23·7	25·05	27·8	14	15	3+15	2+15	163	♀ v	0+33	56
497	1·76			5·42	13·1	13·6	16·05	18·8	24·35	25·7	28·65	15	17	2+17	2+16	191	♂ v	1+32	56
498	1·7			5·0	11·8	12·8	14·5	17·7	22·8	24·15	27·1	15	18	2+16	1+15	154	♀ v	1+32	55
499	1·4			4·5	10·85	12·0	13·9	16·6	21·85	23·0	25·7	14	17	2+18	2+15	133	♂ iv–v	0+32	56
500	1·58			4·85	11·8	12·8	14·7	18·1	22·75	24·0	26·65	16	17	2+17	2+14	158	♂ v	0+33	55
501	1·58			4·72	11·95	13·0	14·9	17·9	23·3	24·55	27·45	15	18	2+17	2+16	175	♀ v	2+32	57
502	1·58			4·75	11·1	12·05	13·9	16·8	21·75	22·9	25·6	15	16	3+17	2+16	131	♂ v	2+31	56
503	1·6			4·62	11·6	12·1	14·2	17·35	22·35	23·6	26·25	14	17	3+16	3+15	136	♂ v–vi	0+32	55
504	1·42			4·3	10·85	11·65	13·75	16·4	21·65	22·75	25·2	15	17	2+17	2+15	121	♀ iv–v	0+32	56
505	1·6			4·65	11·3	12·0	14·15	16·8	22·5	23·6	26·25	15	17	3+17	2+17	136	♀ v	0+32	56
506	1·36			4·3	10·65	11·3	13·7	16·4	21·15	22·3	24·95	15	16	3+18	2+15	137	♂ v–vi	1+31	55
507	1·65			5·18	12·65	12·4	15·6	18·5	23·65	24·9	27·85	15	17	2+16	2+14	164	♂ v	1+32	56
508	1·45			4·4	10·15	10·85	12·7	15·0	19·95	21·05	23·5	14	17	2+16	2+15	109	♂ v	1+32	56
509	1·6			4·7	10·9	11·55	13·65	16·5	21·3	22·5	25·1	15	16	3+17	2+14	117	♂ iv–vi	0+32	56
510	1·48			4·55	10·8	11·55	13·2	16·25	21·0	22·1	24·7	16	16	2+15	2+15	111	♂ iii–iv	0+31	56
511	1·3			4·2	10·35	11·1	12·8	15·65	20·3	21·4	23·9	14	17	3+16	2+15	113	♂ v	1+32	56
512	1·45			4·38	10·4	11·1	12·7	15·7	20·4	21·5	24·0	14	17	3+16	2+14	106	♂ v	3+30	55

513	1·6		5·0	12·35	13·25	15·35	18·1	24·1	25·3	28·15	15	16	2+17	2+15	177	♂ v	2+31	56
514	1·6		4·65	11·8	12·75	14·55	17·85	22·9	24·15	26·8	15	17	2+16	2+15	168	♀ v	1+31	55
515	1·56		4·85	12·0	12·5	14·6	17·95	22·95	24·15	26·9	15	17	2+16	2+14	157	♀ iv-v	2+31	56
516	1·53		4·5	10·65	11·45	13·2	16·35	20·95	22·05	24·5	16	16	3+17	2+14	124	♂ iv-v	2+30	55
517	1·58		4·78	11·7	13·1	14·4	17·7	22·95	24·1	27·05	14	17	2+16	2+15	159	♀ iv-v	1+34	57
518	1·55		4·6	11·4	12·4	13·1	17·55	22·65	23·8	26·6	15	17	3+15	2+14	138	♂ iv	1+31	55
519	1·35		4·46	11·2	11·75	13·9	16·45	21·7	22·9	25·4	14	17	3+16	2+15	135	♂ iv	0+32	55
520	1·52		4·72	11·3	12·25	14·35	17·2	22·65	23·85	26·45	15	17	2+17	2+16	134	♀ vii	2+32	55
521	1·5		4·45	11·15	11·9	13·9	16·65	21·95	23·1	25·85	14	17	2+17	2+15	133	♀ vi	1+32	56
522	1·52		4·8	11·6	12·4	14·4	17·3	22·3	23·55	26·1	14	17	2+17	2+16	150	♂ iv-v	1+32	56
523	1·4		4·22	10·5	10·9	12·95	15·2	20·25	21·3	23·8	14	18	2+17	2+16	105	♂ iv	0+33	56
524	1·34		3·9	9·45	10·1	11·8	14·0	18·7	19·75	21·9	15	17	3+17	2+17	76	♂ iv	1+32	56
525	1·48		4·36	10·5	11·4	13·05	16·1	20·85	21·95	24·45	16	17	3+17	2+15	118	♀ vi	0+32	56
526	1·52		4·6	11·15	11·7	13·9	16·35	21·35	22·6	25·15	14	16	3+17	2+16	122	♂ iv-v	2+31	56
527	1·47		4·44	10·7	11·8	13·55	16·5	21·1	22·2	24·7	15	17	3+17	2+15	125	♀ iv-v	0+31	55
528	1·7		5·0	11·8	12·85	14·8	17·9	23·0	24·2	27·0	15	17	2+16	3+15	154	♂ v	1+32	56
529	1·5		4·4	10·8	11·05	12·7	15·45	20·05	21·2	23·75	14	18	2+16	2+16	109	♀ iv-v	2+30*	54
530	1·58		4·65	11·7	12·5	14·6	17·45	22·75	23·95	26·6	15	17	2+16	3+16	166	♂ v-vi	1+32	56
531	1·6		4·88	12·2	13·05	15·1	18·1	23·45	24·8	27·4	14	16	2+17	2+15	160	♂ v	1+31	55
532	1·64		4·97	11·95	12·6	15·1	17·7	22·7	24·0	26·65	15	16	2+17	2+15	152	♂ iv	3+30	56
533	1·42		4·4	10·4	11·3	12·8	15·6	20·25	21·25	23·65	15	17	2+16	2+15	100	♂ iv-v	1+32	56
534	1·36		4·4	10·55	11·4	13·0	15·4	20·4	21·5	23·9	15	17	2+17	2+16	104	♂ v	†0+32	56
535	1·5		4·25	10·2	10·95	12·9	15·3	20·1	21·2	23·5	15	17	2+18	2+16	111	♂ iv-v	2+32	56
536	1·44		4·47	10·95	11·5	13·5	16·45	21·45	22·5	25·0	15	17	2+16	2+15	139	♂ v-vi	1+33	56
537	1·4		4·3	10·55	11·7	13·15	16·0	20·9	22·05	24·5	15	17	3+16	2+15	115	♂ v	0+33	56
538	1·53		4·72	11·95	12·6	14·55	17·55	22·9	24·1	26·95	14	17	2+17	2+16	140	♀ vi-iii	2+32	57
539	1·5		4·8	11·95	12·4	14·7	17·8	22·85	24·1	26·8	16	17	2+17	2+15	163	♀ vi	1+32	56
540	1·5		4·65	11·7	12·3	14·25	17·3	22·4	23·7	26·35	15	17	2+16	2+15	143	♂ v	0+32	55
541	1·3		4·06	10·2	11·05	11·8	15·5	20·45	21·55	23·95	15	17	2+17	2+17	103	♀ v	†0+32	56
542	1·46		4·3	10·55	11·35	13·15	15·7	21·1	22·2	24·8	15	16	2+17	2+16	126	♀ v	1+32	57
543	1·5		4·64	10·95	11·85	13·65	16·55	21·6	22·75	25·3	13	17	1+17	2+16	136	♀ iv-v	0+32	56
544	1·6		4·96	12·85	13·85	15·8	19·0	24·5	25·7	28·35	16	17	2+16	2+15	199	♂ v	1+32	56
545	1·68		5·0	12·6	13·3	15·4	18·45	23·9	25·25	28·15	15	17	3+15	1+16	174	♂ v	0+32	55
546	1·4		4·3	10·25	10·7	13·0	15·1	20·0	21·1	23·6	14	17	3+18	3+16	115	♂ v	0+31*	55
547	1·44		4·5	11·1	12·05	13·85	16·9	21·8	23·0	25·6	14	17	2+17	2+16	136	♂ v	1+33	56
548	1·43		4·15	9·95	10·7	12·3	14·9	19·5	20·55	23·05	16	16	2+17	2+16	104	♂ v-vi	1+32	56
549	1·5		4·45	11·35	12·05	14·2	17·1	22·1	23·2	25·8	16	17	3+15	2+15	150	♂ v	0+33	56
550	1·6		4·8	11·8	12·65	14·6	18·15	23·4	24·6	27·3	15	17	3+16	3+15	173	♀ v	1+33	57

IV. Herring Race Investigations.

HAUL. SAMPLE IV.

Position . . Start Pt. E.N.E. about 8 miles to N.N.E. about 3 miles.   Number examined . . 525.
Date . . Jan. 6/15.   Landed 10.0 a.m.   Quantity of fish caught . 56 cran (about 50,500).
Vessel . . "G.M.V.," Lowestoft (Steam drifter).   Date examined . . Jan. 6/15.
Net . . Drift-herring.   Examined by . . J. H. Orton and others.

The characters are briefly : Length in centimetres from snout to (1) eye, (2) operculum edge, (3) front of dorsal fin, (4) pelvic, (5) back of dorsal, (6) front of anal, (7) root of tail, (8) end of mid-caudal, (9) end of longest caudal ray.   Number of (11) keeled scales (pelvics to anus), (12) rays in pectoral, (13) rays in dorsal, (14) rays in anal, (15) weight in grams, (16) sex and maturity, (17) vertebræ with hæmal arch, (18) total vertebræ.   * For explanation of signs see Appendix to Tables.

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
551	1·7	5·26	12·65	14·05	15·8	19·0	24·6	25·9	28·8	15	17	3+16	3+14	157	♂ iv–v	2+31	55
552	1·55	4·85	11·85	12·5	14·5	17·85	22·7	24·0	26·5	15	16	2+16	3+15	156	♀ vi	0+33*	56
553	1·7	5·2	12·45	13·45	15·6	19·45	24·5	25·9	28·75	16	16	3+16	3+14	140	♀ vii	2+32	56
554	1·6	4·8	11·8	12·55	14·6	17·65	22·75	24·0	26·9	15	16	3+16	1+3+13	154	♀ vi	2+32	55
555	1·5	4·85	12·1	13·0	15·1	18·15	23·65	24·85	27·7	16		3+17	3+15	172	♀ iv	1+33	56
556	1·8	5·4	12·95	13·7	16·1	18·85	24·6	26·0	28·75	15	Fused? 12+(1+1)+2	2+17	1+3+14	171	♀ vi	1+32	56
557	1·4	4·4	10·8	11·5	13·45	16·05	20·9	22·1	24·45	15	17	3+17	3+15	117	♂ iv–v	2+31	55
558	1·5	4·85	12·05	12·65	14·9	18·0	23·1	24·2	26·9	17	18	3+16	3+14	149	♂ iv–v	2+33	57
559	1·6	4·85	11·3	12·6	14·35	17·6	22·3	23·5	26·3	14	17	3+16	3+14	161	♀ vi	†0+32	55
560	1·57	4·8	12·1	12·7	14·8	18·15	23·4	24·7	27·2	14	16	3+16	4+15	167	♂ v–vi	1+33	57
561	1·46	4·6	11·5	12·15	14·4	17·1	22·2	23·5	26·15	14	17	3+17	3+14	162	♂ v–vi	2+31	56
562	1·47	4·65	11·4	12·2	14·3	17·3	22·4	23·65	26·25*	15	17	3+16	3+14	131	♂ v–vi	0+34	57
563	1·28	4·35	10·9	11·6	13·6	16·4	21·3	22·45	25·05	15	17	3+15	3+13	129	♀ vi	†1+32	56
564	1·5	4·9	12·5	13·2	15·55	18·5	23·45	24·65	27·5	14	17	3+16	3+13	145	♂ vii	1+31	56
565	1·38	4·4	11·9	11·9	13·65	16·4	21·3	22·5	25·05	14	18	3+16	3+15	121	♂ vi–iii	1+31	55
566	1·5	4·45	10·75	11·4	13·34	15·95	20·65	21·8	24·25	13	16	3+16	3+15*	118	♂ v	†0+33	56
567	1·5	4·88	11·75	12·8	14·6	18·0	22·95	24·2	26·65	15	17	3+17	3+14	153	♂ vi–iv	1+32	56
568	1·65	5·0	12·25	13·2	15·25	18·2	23·45	24·7	27·6	15	16	3+16	3+15	175	♂ v	2+31	55
569	1·5	4·7	11·1	11·95	13·8	16·5	21·55	22·7	25·5	15	17	3+16	3+14	137	♂ vi	2+31	56
570	1·45	4·6	11·36	12·6	13·95	17·25	22·3	23·5	26·2	14	17	3+15	3+14	139	♂ iv–v	†2+31	56
571	1·5	4·63	11·4	12·5	14·25	17·55	22·75	24·05	26·45	15	16	3+17	1+3+14	146	♂ v–vi	1+33	57
572	1·5	4·7	11·4	12·6	14·2	17·1	22·1	23·25	26·05	15	17	3+16	3+15	150	♂ vi	1+32	56
573	1·48	4·6	11·1	12·0	13·65	16·75	21·6	22·8	25·4	15	17	3+15	1+3+14	113	♂ vi–iii	1+32	(21+1 ?+2 =55)
574	1·5	4·7	12·2	12·8	14·9	18·0	23·55	24·8	27·5	14	17	3+15	3+13	167	♂ v–vi	0+33	56
575	1·65	5·1	12·5	13·45	15·35	18·6	23·5	24·8	27·55	14	17	3+16	4+13	141	♂ vii	1+31	55
576	1·54	4·85	11·9	12·4	14·55	17·2	22·35	23·6	26·3	14	17	3+15	3+15	129	♀ vii	†0+32	55

‡ Some may be missing here. Skeleton broken.

577	1·46	4·7	11·8	12·6	14·3	17·65	22·7	24·1	26·8	15	17	3+14	3+14	152	♀ v–vi	2+32	56
578	1·53	4·75	11·55	12·3	14·1	17·25	22·1	23·35	25·95	13	17	3+16	4+13	127	♀ vi–iii	3+31	55
579	1·7	5·1	12·35	13·4	15·6	18·55	24·0	25·4	28·15	14	18	3+16	3+13	192	♀ vi	2+31	55
580	1·5	4·75	12·45	13·25	15·4	18·8	23·9	25·2	27·8	17	17	3+16	3+14	190	♀ vi	2+32*	56
581	1·5	4·6	11·35	12·05	14·3	16·95	22·3	23·5	26·2	15	16	3+17	4+15	128	♀ iii	†0+33	56
582	1·33	4·38	10·95	11·55	13·85	16·8	21·5	22·8	25·05	15	17	3+17	4+13	131	♂ v–vi	1+32*	55
583	1·5	4·65	11·55	12·6	14·4	17·45	22·85	24·0	26·7	14	17	3+16	3+16	137	♂ vi–iii	1+32	55
584	1·74	5·2	12·5	13·3	15·45	18·7	23·95	25·4	28·05	15	18	3+16	3+14	169	♂ v–vi	2+31	55
585	1·45	4·6	11·35	12·2	14·15	17·35	22·3	23·45	26·05	16	16	2+16	3+13	151	♂ v–vi	2+32	56
586	1·56	4·75	11·75	12·9	14·5	18·45	23·4	24·65	27·3	15	17	2+16	3+14	167	♀ vi	1+32	56
587	1·44	4·6	11·3	12·25	14·05	17·5	22·45	23·65	26·25	15	Rt. broken, left 17.	3+16	3+14	144	♂ iv–v	2+32	56
588	1·7	5·05	12·3	12·9	15·2	18·3	23·4	24·7	27·3	15	18	3+16	3+14	145	♂ vi–iii	1+33	56*
589	1·78	5·26	12·6	13·1	15·6	18·0	24·3	25·65	28·45	14	17	3+16	4+14	157	♀ vii	1+32	57
590	1·48	4·65	11·85	12·45	14·7	17·45	22·4	23·65	26·3	14	17	3+17	4+14	140	♂ v–vi	†2+32	56
591	1·6	5·0	11·75	12·7	14·85	17·75	22·8	24·05	26·85	14	17	3+16	3+13	166	♀ vi–iv	3+31	55
592	1·5	4·6	11·5	12·3	14·4	16·95	22·15	23·4	26·15	14	16	2+16	3+15	119	♀ vi–iv	2+32	56
593	1·43	4·43	10·95	11·6	13·85	16·3	21·75	22·95	25·4	15	17	3+17	4+15	128	♂ v–vi	0+33	56
594	1·5	4·85	11·8	12·65	14·8	17·35	22·65	23·9	26·5	15	17	2+17	3+14	158	♂ v–vi	1+32	56
595	1·4	4·47	11·15	11·55	13·9	16·65	21·75	23·0	25·3	16	16	4+16	3+14	136	♂ vi	1+33	56
596	1·54	4·7	12·1	12·5	15·05	17·9	23·2	24·4	26·95	16	16	3+17	3+14	170	♀ vi	1+33	56
597	1·78	5·35	12·25	12·9	15·3	18·2	23·95	25·2	28·1	15	17	3+16	3+13	171	♂ v	1+33	56
598	1·48	4·55	11·2	12·1	14·0	16·85	21·95	23·1	25·65	15	17	3+16	3+15	134	♂ iv–vi	†0+34	57
599	1·56	4·9	12·25	13·05	15·5	18·3	23·7	24·9	28·0	15	17	3+17	3+15	151	♀ vii	2+31	56
600	1·5	4·4	10·85	11·6	13·7	16·2	21·2	22·3	24·85	15	17	3+16	4+13	123	♂ vi–iii	1+31	55
601	1·68	5·28	13·3	14·2	16·5	19·65	25·4	26·75	29·6	14	17	3+16	3+14	207	♂ vi	1+32	56
602	1·65	4·9	12·06	13·1	15·1	18·1	23·2	24·4	27·1	15	17	2+16	2+14	180	♀ vi	2+32	56
603	1·6	5·0	12·1	12·6	15·1	17·6	23·3	24·55	27·1	14	17	3+16	4+15	157	♀ iii	2+32	56
604	1·6	5·0	11·8	12·95	14·8	17·95	23·15	24·4	27·35	14	17	3+16	3+16	149	♀ vi–iv	†1+33	56
605	1·38	4·4	11·1	11·85	13·8	16·6	21·75	22·95	25·55	15	16	3+16	3+15	137	♂ v–vi	†0+32	55
606	1·56	4·7	11·3	12·4	14·2	17·65	22·7	24·0	26·7	16	16	3+16	3+15	160	♀ vi	1+32	56
607	1·52	4·65	11·5	12·5	14·6	17·6	22·65	23·9	26·4	16	16	3+16	4+13	157	♀ vi	1+32	55
608	1·68	5·14	12·3	13·00	15·55	18·55	24·0	25·3	28·2	15	17	3+16	3+14	176	♀ vi–iii	2+31	55
609	1·6	4·9	11·8	12·4	14·65	17·55	23·0	24·2	26·7	15	17	3+16	3+15	128	♂ vi–iii	†0+34	57
610	1·4	4·6	11·6	12·3	14·3	17·3	22·3	23·45	26·1	14	16	3+16	3+15	137	♀ vi–iv	†0+33	56
611	1·44	4·6	11·15	11·7	13·85	16·45	21·65	22·8	25·3	15	17	3+16	3+14	106	♂ iv–vi	2+32	56
612	1·48	4·45	10·65	10·95	13·35	15·65	20·55	21·65	24·15	15	16	3+17	3+14	117	♂ vi	0+33	56
613	1·3	4·15	10·2	10·55	12·7	15·1	19·55	20·6	22·7	15	18	3+16	3+14	101	♂ v–vi	2+32	56
614	1·25	4·2	10·15	10·7	12·85	15·05	19·85	21·0	23·3	16	17	2+17	3+13	108	♀ vi–iii	1+32	56
615	1·4	4·45	11·25	12·2	14·1	17·05	22·35	23·6	26·3	15	18	3+16	4+13	165	♂ vi	1+32	55
616	1·6	5·0	12·4	13·6	15·6	18·95	24·2	25·6	28·45	14	17	3+16	3+15	200	♀ vi	1+31	55
617	1·73	5·3	12·05	12·80	15·35	17·5	23·0	24·3	27·1	15	17	3+17	3+14	159	♀ vi–iii	1+32	56

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
618	1·47	4·7	11·7	12·7	14·55	17·5	22·6	23·9	26·65	15	17	3+16	4+13	154	♀ vi–iv	†0+33	56
619	1·56	4·9	12·2	12·9	15·05	17·8	23·15	24·35	27·1	14	17	3+16	4+14	188	♀ vi	0+32	57
620	1·64	4·8	12·1	12·6	14·9	17·8	22·85	24·15	26·8	15	17	3+16	4+15	146	♀ vi–iii	2+32	56
621	1·63	4·95	11·45	12·45	14·5	17·3	22·6	23·85	26·45	14	16	3+17	4+13	136	♀ vi–iii	0+33	56
622	1·4	4·6	11·25	12·3	14·2	17·4	22·45	23·8	26·2	15	17	3+17	3+13	160	♂ v–vi	0+32	56
623	1·45	4·55	11·4	12·4	14·2	17·0	22·4	23·6	26·05	14	17	3+15	2+14	143	♂ vi–iv	0+34	56
624	1·65	4·9	11·75	12·35	14·7	17·65	22·7	23·95	26·8	14	17	3+15	3+15	165	♀ iii	0+33	56
625	1·64	4·95	12·3	13·6	15·25	18·9	24·0	25·4	28·15	15	17	3+15	3+12	199	♀ vi	1+33	57
626	1·76	5·43	13·1	14·4	16·5	19·75	25·35	26·8	29·95	15	18	3+16	3+15	187	♂ vi	0+33	56
627	1·6	5·1	12·6	13·3	15·8	18·45	24·25	25·55	28·65	15	17	2+17	3+16	180	♂ vi	0+33	56
628	1·6	5·13	12·4	13·2	15·2	18·65	23·8	25·05	27·35*	16	16	3+15	3+13	136	♂ ii	1+31	55
629	1·43	4·45	10·8	11·7	13·4	16·6	21·4	22·55	25·1	15	19	3+16	3+14	142	♀ vi	1+32	56
630	1·53	4·85	12·0	12·8	14·95	17·7	23·2	24·45	27·2	14	17	3+16	3+14	148	♂ vi–iii	1+31	55
631	1·52	5·0	12·2	12·8	14·95	18·05	22·3	24·6	27·5	14	17	3+16	3+14	175	♂ vi	*0+[1+1+30]	55
632	1·6	5·0	12·55	13·00	15·55	18·35	24·15	25·4	27·95	15	18	3+16	3+15	168	♀ iii	0+33	57
633	1·6	4·85	12·45	13·3	15·45	18·6	24·1	25·45	27·7*	15	18	3+15	3+14	171	♂ vi	1+32	56
634	1·5	4·42	11·5	12·4	14·05	17·4	22·4	23·65	26·15	15	17	3+16	3+14	148	♀ iii–iv	1+33	56
635	1·4	4·7	11·3	11·7	14·05	16·75	21·8	23·05	25·65	14	17	3+17	3+13	117	♂ vi–iii	1+32	56
636	1·53	4·9	11·8	12·45	14·9	17·6	22·8	24·05	26·75	14	17	3+17	2+14	140	♂ vi	0+32	55
637	1·5	4·65	11·4	12·6	14·35	17·5	22·4	23·65	26·4	15	17	3+16	2+14	145	♀ vi	2+31	56
638	1·4	4·7	12·3	12·6	15·15	17·75	22·75	23·95	26·5	15	17	3+16	3+14	156	♀ vi	†0+32	56
639	1·55	4·85	11·6	12·85	14·6	17·8	22·8	24·1	26·75	15	16	3+17	3+14	141	♀ vi–iv	1+32	55
640	1·43	4·6	11·8	12·5	14·65	17·75	22·9	24·15	26·8	15	16	3+17	2+14	144	♂ vi	2+32	57
641	1·54	4·9	11·8	12·7	14·65	17·5	22·3	23·6	26·25	15	17	3+15	3+14	138	♂ vi–iii	1+31	55
642	1·43	4·65	11·5	12·25	14·2	17·1	22·0	23·1	25·95	14	16	3+16	3+14	137	♂ vi	1+32	56
643	1·47	4·44	10·9	11·55	13·55	16·0	21·15	22·35	24·85	14	16	3+16	4+14	129	♂ vi	1+33	56
644	1·6	4·9	12·1	12·7	14·75	17·9	23·15	24·35	27·15	15	17	3+16	3+15	148	♂ v–vi	0+32	55
645	1·48	4·6	11·15	11·85	13·9	16·7	21·8	22·9	25·5	16	16	4+16	3+14	127	♀ iii	1+33	57
646	1·55	4·8	12·0	12·7	14·8	17·9	23·15	24·5	27·2	14	18	3+16	3+14	177	♀ vi	1+30	54
647	1·48	4·65	11·55	12·5	14·35	17·5	22·25	23·6	26·35	14	16	3+16	2+13	152	♀ vi	0+32	55
648	1·67	5·37	12·95	13·7	16·05	19·2	24·65	25·95	28·7	17	17	3+16	1+3+14	181	♀ v	2+32	56
649	1·6	4·85	11·9	12·45	14·75	17·6	22·75	24·0	26·7	14	17	3+17	3+15	152	♂ ii	1+32	55
650	1·5	5·0	12·45	13·0	15·4	18·3	23·9	25·15	27·8	14	16	3+17	3+15	170	♀ vi	1+33	57
651	1·6	4·8	11·4	12·2	14·35	17·35	22·5	23·7	26·4	15	17	3+16	3+13	161	♀ vi	1+32	55
652	1·4	4·6	11·7	12·7	14·4	17·7	22·9	24·2	26·8	15	16	3+15	3+14	149	♂ vi–iii	2+32	55
653	1·63	5·05	11·75	12·4	14·7	17·4	22·55	23·8	26·6	15	17	3+17	4+14	135	♂ v	1+32	55
654	1·38	4·35	10·45	11·2	13·1	15·95	20·8	22·0	24·5	15	18	3+17	4+13	114	♀ vi–iii	†2+32	57
655	1·6	4·7	11·6	12·3	14·3	17·35	22·25	23·45	26·1 9+0+0+0+3	15	17	3+17	3+14	140	♂ vi	2+32	56
656	1·42	4·55	11·45	12·25	14·2	17·2	22·55	23·8	26·2	15	17	3+16	3+15	132	♂ v–vi	1+33	56

657	1·5	4·7	12·0	12·55	14·75	17·5	22·8	24·05	26·7	14	17	3+16	3+15	152	♀ vi	1+32	56
658	1·58	5·0	12·4	12·95	15·35	18·0	23·25	24·45	27·1	14	17	3+16	3+14	150	♂ v	2+31	55
659	1·6	4·7	11·2	12·2	14·05	16·5	21·55	22·8	25·3	14	17	3+17	3+15	136	♀ vi	0+33	56
660	1·5	5·0	12·3	12·8	15·2	18·0	23·4	24·5	27·4	14	17	3+16	1+4+13	155	♂ v–vi	2+32	55
661	1·47	4·7	11·65	12·3	14·6	17·3	22·55	23·8	26·6	14	16	3+16	3+14	160	♂ vi	2+31	55
662	1·45	4·6	11·05	11·85	13·65	16·25	21·2	22·45	25·15	14	16	3+16	3+14	128	♂ v–vi	2+30	54
663	1·55	5·15	12·75	13·25	15·8	18·8	24·15	25·5	28·35	16	17	3+16	3+14	144	♂ ii	2+31	56
664	1·36	4·42	11·1	11·7	13·85	16·55	21·6	22·7	25·2	16	18	3+16	3+16	135	♂ v–vi	0+32	55*
665	1·34	4·36	10·75	11·5	13·2	16·35	21·3	22·4	24·9	15	17	3+15	3+14	125	♂ v–vi	0+33	57
666	1·5	4·9	12·3	12·85	15·15	18·4	23·5	24·75	27·6	16	18	3+15	3+15	164	♂ v–vi	1+33	56
667	1·5	4·6	11·8		13·65	16·6	21·5	22·55	25·2	15	17	3+16	3+13	118	♂ ii	1+32	56*
668	1·38	4·3	10·75	11·3	13·4	16·0	20·65	21·8	24·4	15	16	3+16	3+14	119	♂ iii	1+31	55
669	1·4	4·5	11·1	11·75	13·95	16·6	22·1	23·3	25·8†	14	18	3+16	3+15	139	♀ vi	1+31	55
670	1·46	4·45	10·9	11·7	13·7	16·75	21·7	22·9	25·4	15	17	3+17	3+16	119	♂ vi	0+32	56
671	1·35	4·5	10·7	11·9	13·65	16·6	21·75	23·0	25·55	15	17	3+16	3+14	128	♀ i–ii	1+32	56
672	1·6	5·05	12·1	13·0	15·1	18·2	23·9	25·2	27·8	1+0+11	17	3+17	3+14	169	♀ iv	1+33	57
673	1·52	4·55	11·55	12·1	14·45	17·35	22·5	23·75	26·45	15	16	3+16	1+3+13	128	♀ vi–iii	1+32	55
674	1·5	4·53	11·55	12·8	14·45	17·9	22·9	24·1	26·8	14	16	3+16	Total 17. Rays broken.	140	♀ vi–iii	0+33	57
675	1·38	4·35	11·0	11·65	13·4	16·3	21·15	22·25	24·85	14	17	3+15	3+15	110	♀ vi–iii	0+33	56
676	1·4	4·68	11·4	12·35	14·3	17·3	22·5	23·7	26·5	15	17	3+16	3+14	137	♀ iv–v	†0+33	56
677	1·4	4·7	11·5	12·35	14·45	17·0	22·35	23·7	26·3	15	17	3+16	1+3+14	144	♂ vi	1+31	55
678	1·4	4·52	10·9	11·9	13·65	16·6	21·75	22·95	25·4	15	17	3+16	3+14	108	♂ vii	2+31	56
679	1·45	4·65	11·5	12·5	14·3	17·3	22·65	23·9	26·7	15	17	3+17	3+13	138	♀ vi	1+33	56
680	1·43	4·64	11·5	12·3	14·25	17·4	22·4	23·6	26·3	14	17	3+16	3+15	162	♀ vi	0+32	56
681	1·38	4·4	11·0	12·0	13·95	16·75	22·05	23·3	25·9	15	16	3+17	4+14	157	♀ vi	2+32	56
682	1·38	4·63	11·3	12·25	14·4	17·15	22·35	23·55	26·3	15	17	3+17	4+13	126	♀ vii	0+33	56
683	1·46	4·75	12·3	12·6	15·25	17·45	22·9	24·2	26·9	13	17	3+15	4+14	181	♂ v–vi	1+32	55
684	1·52	4·8	12·0	13·2	14·9	18·2	23·35	24·65	27·45	14	17	3+16	4+14	161	♂ vi	2+30	55
685	1·46	4·65	11·75	12·5	14·4	17·55	22·45	23·7	26·5	15	18	2+16	3+14	147	♂ v–vi	†0+32	55
686	1·55	4·8	11·7	12·75	14·9	17·9	23·3	24·55	27·45	15	16	3+17	3+15	161	♀ v	1+32	56
687	1·4	4·5	11·1	12·3	13·9	17·05	22·0	23·25	25·75	15	17	3+16	4+13	125	♂ iv–v	*1+31	55
688	1·65	4·9	11·55	12·75	14·3	17·7	22·8	24·0	26·6	16	17	3+16	4+13	136	♂ iv–v	2+32	57
689	1·45	4·6	11·45	13·05	14·3	17·85	23·2	24·45	27·1	14	16	3+17	3+14	166	♂ vi	1+33	56
690	1·5	4·75	11·65	12·5	14·65	17·6	22·85	24·1	26·8	15	16	3+16	4+15	146	♀ vi–iii	1+33	56
691	1·3	4·15	10·1	10·9	12·7	15·4	20·2	21·2	23·65	16	18	3+18	3+15	98	♀ vii	0+32	56
692	1·45	4·52	11·3	12·4	14·2	17·2	22·4	23·65	26·2	15	17	3+17	3+15	142	♀ vi	2+32	56
693	1·47	4·6	11·2	12·5	13·9	17·15	21·8	23·05	25·7	15	17	4+16	3+13	146	♀ v	1+33	56
694	1·5	4·65	11·4	12·4	14·05	17·2	22·5	23·65	26·35	15	17	3+17	3+14	139	♂ vi	2+32	56
695	1·48	4·55	11·4	12·1	14·35	17·05	22·15	23·25	25·75	15	16	3+17	3+14	140	♀ vi–iv	2+31	56
696	1·34	4·4	10·9	11·85	13·55	16·7	21·85	23·0	25·5*	15	17	3+16	3+14	125	♂ vi	1+32	56
697	1·46	4·7	11·85	12·4	14·65	17·45	22·55	23·7	26·4	14	17	3+16	2+16	125	♀ vi–iii	0+32	55

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
698	1·42	4·93	12·6	13·7	15·3	18·9	24·3	25·7	28·1*	14	17	Damaged. 3+13	4+13	156	♂ vi	2+31	55
699	1·46	4·7	11·25	12·75	14·3	17·65	22·8	24·0	26·7	15	16	2+16	3+13	143	♀ vi	†0+31	55
700	1·6	4·9	11·9	13·0	15·2	18·2	23·25	24·45	27·25	16	16	3+17	3+14	149	♂ v–vi	2+32	56
701	1·5	4·55	11·75	12·45	14·55	17·4	22·65	23·85	26·5	15	16	3+16	2+14	149	♂ vi	1+32	56
702	1·7	5·45	13·6	14·1	16·7	19·7	25·7	27·15	30·15	14	17	3+16	3+15	215	♀ vi	0+32	55
703	1·75	5·55	12·9	13·7	16·0	18·8	24·4	25·7	28·6	15	16	3+16	3+14	142	♂ vi–iii	1+32	55
704	1·5	4·9	12·3	13·25	15·3	18·0	23·6	24·9	27·75	14	18	3+16	4+13	144	♂ v	0+32	56
705	1·52	4·92	12·45	13·1	15·6	18·6	24·25	25·6	28·4	15	17	3+16	3+16	185	♀ vi	0+33	56
706	1·6	4·8	11·8	12·7	14·5	17·75	22·9	24·15	26·6	15	18	3+16	3+14	143	♂ vi–iv	1+32	56
707	1·43	4·38	11·15	11·65	13·85	16·35	21·6	22·75	25·3	14	18	3+16	3+15	136	♂ v	1+33	56
708	1·5	4·9	12·0	12·9	14·8	17·9	23·3	24·5	27·2	15	16	3+16	3+15	150	♂ v–vi	1+33	56
709	1·7	5·33	12·8	13·7	15·9	18·7	24·6	25·9	28·8	14	17	3+17	3+15	199	♂ vi	1+32*	56
710	1·52	4·8	12·4	13·2	15·55	18·65	23·95	25·15	27·85	15	18	3+16	3+13	201	♀ vi	2+32	56
711	1·43	4·35	11·6	12·3	14·4	17·35	22·55	23·7	26·45	16	17	3+16	3+14	158	♂ vi	0+33	55
712	1·4	4·4	11·1	11·95	13·8	16·7	21·4	22·55	25·05	16	18	3+16	3+14	129	♂ vi	2+31	56
713	1·5	4·8	11·75	12·6	14·65	17·4	22·85	24·1	26·8	15	17	2+17	3+15	148	♂ vi	2+32	56
714	1·6	5·0	12·2	12·9	15·2	18·1	23·45	24·8	27·4*	14	16	3+16	3+15	185	♂ vi	2+31	55
715	1·4	4·42	10·95	12·1	13·7	16·95	22·1	23·3	25·85	15	17	3+16	3+14	153	♂ vi	0+33	56
716	1·52	4·7	11·65	12·4	14·45	17·65	22·8	24·1	26·9	15	16	3+16	3+16	151	♀ vi	1+32	56
717	1·6	4·82	11·75	12·8	14·75	17·8	23·2	24·5	27·0	15	17	3+16	3+14	151	♂ iii–iv	0+33	56
718	1·45	4·8	11·7	12·35	14·5	17·2	22·65	23·85	26·45	16	17	3+16	3+14	142	♂ v–vi	1+32	56
719	1·6	4·6	11·6	12·3	14·3	17·3	22·5	23·7	26·2	15	16	3+17	3+14	129	♂ vi–iii	1+32	56
720	1·4	4·35	10·75	11·9	13·45	16·55	21·55	22·65	25·25	14	16	3+16	3+15	131	♂ v	†2+32	56
721	1·47	4·85	11·6	12·2	14·35	17·0	22·45	23·6	26·2	14	17	3+16	3+16	140	♂ vi	1+33	56
722	1·48	4·66	11·6	12·9	14·45	17·8	22·95	24·2	26·95	14	16	3+16	3+15	161	♂ vi	2+32	56
723	1·45	4·55	11·3	12·25	14·2	17·0	22·1	23·25	26·0	15	16	3+16	3+14	142	♀ vi–iv	1+32	56
724	1·57	4·7	11·5	12·45	14·05	17·1	22·3	23·55	26·3	12	17	2+16	3+15	143	♂ iii	1+31	55
725	1·67	5·05	12·45	13·5	15·35	18·8	23·9	25·2	28·1	15	17	3+16	3+14	168	♀ v	0+33	55
726	1·5	4·85	12·05	12·55	14·85	17·4	22·7	23·9	26·6	14	16	3+17	17 (3+14 probably.)	138	♂ v	1+32	56
727	1·46	4·54	11·6	12·2	14·4	17·3	22·15	23·35	25·9	15	18	3+16	4+13	144	♀ iv–v	0+33	56
728	1·47	4·8	11·8	12·9	14·7	17·8	22·8	24·0	26·8	15	18	3+16	3+14	154	♂ vi	0+34	56
729	1·5	4·68	11·45	11·9	14·2	17·4	22·4	23·65	26·25	14	16	3+15	3+13	139	♀ vi–iii	1+32	56
730	1·52	4·76	11·7	12·35	14·5	17·25	22·7	23·9	26·5	14	17	3+16	1+3+14	143	♂ v	2+32	56
731	1·5	4·95	11·85	12·65	14·8	17·4	22·8	24·05	26·8	13	18	3+17	3+14	154	♂ vi	2+31	56
732	1·78	5·42	13·4	14·1	16·35	19·7	25·55	26·95	29·6*	15	17	3+16	3+14	185	♀ vi–iv	2+32	56
733	1·73	5·4	13·05	13·85	16·4	19·2	24·85	26·15	29·15	14	17	3+17	1+3+13	179	♂ vi	1+32	55
734	1·5	4·8	12·0	12·95	15·15	18·1	23·3	24·6	27·4	15	17	2+17	3+14	179	♀ vi	1+31	55

735	1·5	4·7	11·95	12·75	15·1	18·35	23·65	24·9	27·65	16	17	4+16	3+14	182	♀ vi	1+32	56
736	1·45	4·32	11·35	12·4	14·15	17·25	22·15	23·4	26·0	15	17	3+16	3+15	153	♂ vi	†0+32	56
737	1·7	5·3	13·3	14·25	16·4	19·7	25·4	26·7	29·55	14	17	3+16	3+14	164	♀ vii	2+31	55
738	1·7	5·3	12·95	14·1	16·4	19·35	25·3	26·8	29·9	14	17	3+16	3+14	200	♂ vi	2+31	56
739	1·4	4·5	11·75	11·9	14·6	17·2	22·5	23·75	26·15	15	18	3+16	3+14	144	♂ v	1+31	55
740	1·4	4·88	12·2	13·15	15·35	18·15	23·65	24·95	27·3*	14	16	3+17	3+14	182	♂ v–vi	0+33	56*
741	1·48	4·65	12·0	12·6	14·7	17·6	22·9	24·15	26·85	14	17	3+16	3+14	143	♂ v	2+31	56
742	1·5	4·6	11·55	12·1	14·45	17·1	22·4	23·6	26·05	15	16	3+16	3+14	158	♀ vi	1+33	57
743	1·4	4·4	11·25	12·05	14·05	16·9	22·4	21·9	23·1	15	17	3+16	4+12	143	♀ vi	0+32	56
744	1·5	4·95	11·85	12·7	14·6	17·7	23·25	24·45	27·15	12	16	3+15	3+14	138	♀ i–ii	0+32	55
745	1·5	4·56	11·3	12·25	14·05	17·4	22·2	23·5	25·85	15	17	3+16	3+14	150	♂ v	2+31	57
746	1·5	4·67	11·35	12·1	14·1	17·05	22·0	23·3	25·9	15	16	3+16	3+14	138	♂ iii	2+31	54*
747	1·58	4·6	11·4	12·4	13·9	17·25	22·25	23·4	25·9	14	17	3+16	3+14	155	♂ vi	1+32	55
748	1·34	4·35	11·25	12·0	13·75	16·5	21·4	22·4	25·0	14	16	3+15	3+13	129	♂ vi	1+31	56
749	1·45	4·73	12·1	12·85	15·15	18·0	23·25	24·55	27·1	15	16	3+16	3+14	155	♂ v	0+32	55
750	1·4	4·57	11·4	12·0	14·3	17·0	22·35	23·55	26·25	15	17	3+16	3+14	168	♂ v	1+33	56
751	1·58	4·9	11·65	12·9	14·7	17·9	23·0	24·3	27·05	15	18	3+17	3+14	125	♀ vii	0+33	56
752	1·74	5·1	12·15	13·1	15·05	18·4	24·1	25·4	28·2	14	17	3+16	3+15	160	♀ vi–iv	1+33	56
753	1·74	4·95	12·4	13·15	15·4	18·45	23·95	25·2	28·05	15	16	3+16	3+15	192	♀ vi	1+32	56
754	1·74	5·3	12·6	13·4	15·35	18·25	23·65	24·95	27·85	13	18	3+15	3+14	164	♀ iv–v	2+32	56
755	1·55	4·67	11·8	12·5	14·85	17·3	22·95	24·1	26·7	15	17	3+16	3+13	158	♀ vi	†1+31	55
756	1·45	4·4	11·25	12·25	14·05	16·75	21·85	22·95	25·7	15	17	3+16	3+14	158	♂ v	2+32	56
757	1·5	4·64	11·5	12·4	14·35	17·05	22·2	23·35	26·0	14	18	3+16	1+2+16	165	♂ v	1+33	56
758	1·56	4·87	11·6	12·55	14·4	17·7	22·8	23·95	26·55	14	18	3+17	3+15	148	♂ vi	2+32	56
759	1·5	4·75	11·85	12·7	14·6	17·45	22·85	24·15	26·45	15	18	3+16	17 rays broken.	175	♂ v	0+33	56
760	1·55	4·88	12·25	12·65	15·0	18·6	23·4	24·7	27·2	15	18	3+16	3+13	122	♀ vi	2+30	55
761	1·38	4·2	10·6	11·4	13·15	16·15	20·7	21·9	24·6	14	16	3+16	3+14	162	♂ v	1+31	55
762	1·55	5·0	12·3	13·2	15·3	18·6	23·9	25·15	28·05	14	17	3+16	3+13	151	♀ vi	1+32	55
763	1·45	4·5	11·35	12·4	14·1	17·3	22·4	23·55	26·4	15	16	3+16	3+14	154	♂ v	†0+33	56
764	1·43	4·5	11·7	12·3	14·4	17·45	22·7	23·95	26·6	15	16	3+16	3+14	179	♀ vi	1+33	56
765	1·7	5·1	12·65	13·5	15·85	18·65	24·1	25·45	28·3	16	17	3+17	3+14	167	♂ vi	1+33	56
766	1·64	4·9	12·5	13·0	15·35	18·55	23·7	25·05	27·9	16	17	3+16	3+14	181	♀ vi	2+32	55*
767	1·7	5·1	12·3	13·9	15·5	18·8	24·3	25·6	28·3	15	17	3+15	1+14	151	♀ vi	1+0+33	56
768	1·55	4·6	11·75	13·0	14·6	17·7	23·0	24·3	26·85	14	17	3+17	3+14	162	♀ vi	0+33	55
769	1·55	4·8	11·75	12·65	14·8	18·1	23·4	24·7	27·25	14	16	3+16	3+14	151	♀ v	†0+32	56
770	1·42	4·57	11·4	12·1	14·2	17·25	22·05	23·25	25·85	16	17	3+16	3+15	159	♂ vi	1+33	56
771	1·6	4·64	11·75	12·5	14·45	17·5	22·9	24·2	26·95	16	16	3+17	4+13	162	♂ vi	0+32	55
772	1·6	4·83	11·95	12·2	14·8	17·8	22·8	24·0	26·8	16	16	3+17	3+13	160	♀ iv–v	0+33	56
773	1·62	4·72	11·7	12·85	14·65	17·85	23·05	24·25	26·7	15	16	3+16	3+13	136	♂ v	†1+31	55
774	1·57	4·66	11·6	12·25	14·2	17·25	22·5	23·8	26·3	14	17	3+16	3+14	120	♀ vi–iii	1+33	56
775	1·56	4·78	11·4	12·7	14·1	17·3	22·55	23·75	26·3	16	17	3+16	3+13	141	♂ iv	2+32	56
776	1·52	4·6	11·8	12·3	14·6	17·55	22·7	23·95	26·4	16	17	3+17	3+15	141	♂ iv	2+32	56

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
777	1·52	4·88	11·5	12·4	14·4	17·45	22·6	23·75	26·3	15	17	3+15	4+13	125	♂ iv	2+32	56
778	1·5	4·56	10·95	11·6	13·45	16·3	21·2	22·4	24·9	15	17	3+17	3+15	119	♂ iv–v	0+32	56
779	1·3	4·08	9·85	10·35	12·35	14·5	19·25	20·35	22·65	15	18	3+17	3+15	80	♂ vi–iii	1+32	56
780	1·65	4·9	11·9	12·6	14·8	17·85	22·95	24·3	27·05	15	17	4+16	4+14	154	♀ vi	†0+34	57
781	1·48	4·53	11·25	12·05	13·9	16·95	22·15	23·3	26·0	15	17	3+16	3+16	131	♂ vi	1+33	56
782	1·52	5·0	12·1	13·1	14·9	17·9	23·2	24·55	27·35	14	17	2+17	3+15	141	♀ vii	†0+31*	54
783	1·45	4·45	10·7	11·4	13·3	16·15	21·3	22·5	24·95	15	17	3+15	3+14	124	♀ v	1+32	55
784	1·5	4·6	11·45	12·2	14·4	17·2	22·4	23·6	26·2	15	17	3+16	3+15	146	♀ vi †0×[*1+1+31]	55
785	1·4	4·32	10·8	11·6	13·6	16·1	21·25	22·45	25·1	16	17	3+16	3+15	125	♂ vi–iv	1+31	55
786	1·72	5·1	12·8	13·9	15·9	19·1	24·6	25·95	28·8	15	17	3+17	4+15	184	♀ vi	2+31	56
787	1·65	4·9	12·15	13·0	15·0	18·1	23·25	24·4	27·0	15	17	3+16	3+15	157	♀ vi	2+32	56
788	1·5	4·5	11·25	12·4	14·15	16·9	22·15	23·35	25·85	13	17	3+17	4+15	138	♂ v	0+33	56
789	1·5	4·6	11·3	12·25	14·0	16·8	21·9	23·05	25·65	15	17	3+16	3+15	136	♂ vi	0+32	55
790	1·57	5·1	12·5	13·2	15·55	18·55	24·05	25·35	28·25 4+0+9	16		3+16	3+14	165	♂ vi	2+31	56
791	1·5	4·45	11·0	11·85	13·95	16·8	21·7	22·9	25·5	14	17	4+17	3+14	136	♀ vi	2+31	55
792	1·34	4·16	10·55	11·5	13·2	15·95	20·8	21·9	24·5	15	17	3+17	3+15	113	♂ vi	1+32	56
793	1·5	4·74	11·65	12·8	14·35	17·5	22·8	24·1	26·9	13	16	3+15	3+13	161	♂ v	1+32	55
794	1·44	4·45	11·1	12·3	14·2	16·95	22·05	23·2	25·75	15	17	3+16	3+16	139	♂ vi	†2+31	56
795	1·47	4·72	11·8	13·15	14·7	18·3	23·25	24·45	27·35	16	17	3+17	3+14	153	♂ vi	1+32	56
796	1·6	5·07	12·0	13·2	15·25	18·15	23·5	24·8	27·6	14	17	3+17	3+15	153	♀ i–ii	1+31	55
797	1·42	4·44	11·4	11·9	14·05	17·05	22·3	23·4	26·1	15	17	3+16	3+16	138	♂ vi	†1+32	56
798	1·46	4·77	12·1	12·9	14·8	17·95	23·05	24·3	26·9	15	17	3+16	3+13	152	♀ vi	1+32	55
799	1·6	5·0	12·35	13·8	15·4	18·7	24·2	25·6	28·4	14	18	3+17	3+15	146	♀ vii	†0+32	56
800	1·46	4·7	11·1	12·3	14·05	16·8	21·85	23·0	25·85	15	17	3+17	3+14	133	♀ vi	1+32	56
801	1·56	4·75	11·4	12·4	14·0	16·95	22·1	23·25	25·85	14	16	3+16	4+14	127	♀ vi	0+32	55
802	1·55	4·6	11·6	12·35	14·55	17·7	22·6	23·8	26·5	15	16	3+16	3+14	147	♀ vi	1+31	54
803	1·5	4·65	11·95	12·8	14·8	17·65	22·85	24·15	26·55	15	16	3+16	3+13	161	♀ vi	†0+33*	56
804	1·5	4·52	10·9	11·75	13·7	16·05	21·55	22·7	25·35	14	17	3+16	3+15	122	♂ vi	0+32	56
805	1·34	4·36	10·7	11·7	13·3	16·1	21·1	22·25	24·7	14	17	3+17	3+15	116	♂ vi	2+32	56
806	1·6	4·8	12·2	13·2	15·2	18·1	23·5	24·75	27·7	15	17	3+16	3+15	155	♀ iv–v	0+32	55
807	1·5	4·58	11·5	12·35	14·65	17·2	22·35	23·5	26·2	15	15	3+17	3+14	126	♀ vi–iii	1+32	55
808	1·5	4·7	11·65	12·2	14·35	17·0	22·6	23·8	26·45	15	16	4+15	4+14	138	♂ vi	0+32	55
809	1·53	4·55	11·35	12·35	14·0	17·1	22·0	23·35	25·75	14	16	3+16	1+3+14	133	♂ vi	1+32	57
810	1·5	4·8	11·3	11·6	14·1	16·7	22·0	23·2	25·85	16	17	4+16	3+14	101	♀ vii	2+32	56
811	1·55	4·82	11·3	12·1	14·25	16·8	22·2	23·55	26·25	14	17	3+17	1+3+15	133	♂ vi	2+32	55
812	1·52	4·8	11·8	12·5	14·75	17·35	22·8	23·95	26·55	15	17	3+16	3+15	164	♂ v–vi	0+33	55
813	1·4	4·54	11·1	12·15	13·85	16·75	22·05	23·3	26·0	15	17	3+17	3+15	135	♀ vi	†0+33	56
814	1·7	4·93	11·8	12·65	14·55	17·6	22·85	24·05	26·7	15	16	3+17	3+13	151	♀ vi	†0+32	56
815	1·52	4·84	12·2	13·1	14·9	18·4	23·4	24·65	27·4 11+0+4	17		3+16	1+3+14	176	♂ v	1+32	56

816	1·38	4·2	9·8	10·7	12·2	14·85	19·24	20·3	22·5	15	17	3+17	1+3+15	72	♀ vii	†0+33	56
817	1·36	4·47	11·35	12·05	14·2	16·6	21·85	23·13	25·75	15	17	2+17	3+15	126	♂ vi–iv	0+33	56
818	1·6	4·9	12·3	12·65	15·3	18·0	23·7	24·9	27·15*	13	Rt. broken, l. 17.	3+16	3+14	127	♀ i–ii	1+33	57
819	1·32	4·3	10·7	11·4	13·3	15·9	20·85	22·0	24·45	15	16	3+16	3+15	113	♂ vi	1+32	55
820	1·58	5·1	11·85	13·2	15·1	17·95	23·2	24·45	27·25	16	16	3+17	3+13	126	♂ vii	3+30	56
821	1·5	4·38	10·65	11·55	13·15	16·0	20·75	21·9	24·45	15	17	2+17	3+14	105	♀ vii	†0+33	56
822	1·5	4·7	11·6	12·5	14·4	17·1	22·15	23·45	26·2	15	17	3+17	3+14	118	♀ vi–iv	2+31	56
823	1·6	4·95	11·95	12·3	14·9	17·25	22·9	24·05	26·9	15	17	3+16	3+15	139	♂ vi	1+32	56
824	1·47	4·4	10·75	11·7	13·55	15·85	21·0	22·15	24·7	14	17	3+16	1+2+16	114	♂ vi	†1+31	55
825	1·4	4·47	10·95	11·4	13·9	16·4	21·2	22·35	24·75	16	16	4+17	3+15	116	♂ vii	1+32	56
826	1·34	4·24	10·45	11·45	13·4	16·1	21·2	22·35	24·95	15	17	3+17	3+14	122	♂ vi	2+31	56
827	1·5	4·65	11·4	12·2	14·25	16·95	22·1	23·45	26·05	15	17	4+16	3+15	127	♂ vi	1+32	56
828	1·6	4·65	11·85	12·7	14·65	17·7	23·0	24·3	26·95	15	17	3+16	3+14	152	♀ v–vi	0+33	56
829	1·6	4·85	12·5	13·45	15·40	18·7	24·1	25·4	28·2	15	17	3+17	3+14	167	♀ vi	0+33	56
830	1·45	4·7	11·6	12·6	14·55	17·4	22·1	23·5	26·2	15	16	3+16	1+3+14	152	♂ vi	2+31	55
831	1·4	4·42	11·7	12·4	14·65	17·5	22·8	24·0	26·5	15	17	2+16	3+13	153	♀ vi	†0+32	55
832	1·36	4·34	11·1	12·05	13·9	16·3	21·6	22·8	25·35	13	16	3+17	1+3+15	139	♀ vi	†0+32	56
833	1·5	4·75	11·75	12·85	14·64	17·9	23·1	24·3	27·0	16	17	3+17	3+14	149	♂ v	2+30	55
834	1·37	4·3	10·55	11·15	13·05	15·8	20·55	21·8	24·3	15	18	4+15	1+3+14	122	♂ vi	1+32	55
835	1·4	4·38	11·1	11·7	13·9	16·65	21·9	23·1	25·7	15	17	3+16	1+3+14*	138	♂ vi	3+31	56
836	1·3	4·1	10·1	11·1	12·75	15·4	20·2	21·4	24·0	13	17	3+17	3+15	121	♂ vi	1+31	55
837	1·45	4·3	10·8	11·5	13·55	16·15	21·0	22·3	24·9	15	17	3+17	3+16	123	♀ vi	1+32	55
838	1·37	4·53	11·05	11·75	13·75	16·5	21·5	22·75	25·3	13	16	2+17	3+15	110	♀ vii	1+32	55
839	1·43	4·8	11·65	12·55	14·75	17·55	22·9	24·2	26·9	16	17	3+16	3+14	130	♂ vi	3+31	55
840	1·7	5·0	12·25	13·55	15·6	18·75	24·0	25·25	28·0*	14	16	3+17	3+14	191	♀ vi	2+31	55
841	1·7	5·12	12·3	12·9	15·15	18·4	23·85	25·1	27·85	15	16	3+16	1+3+15	188	♀ v	†0+33	58*
842	1·4	4·52	11·0	11·73	13·75	16·6	21·65	22·7	25·05	15	16	3+17	3+15	111	♂ i–ii	0+32	55
843	1·6	4·74	11·85	12·8	14·95	18·0	23·25	24·5	27·05	15	18	3+16	1+2+15	153	♀ vii	0+34*	56
844	1·56	5·03	12·85	13·85	16·0	19·0	24·55	25·8	28·65	15	16	3+17	2+14	178	♂ vi	1+32	56
845	1·45	4·44	11·0	12·05	13·9	16·7	21·65	22·85	25·3	15	17	3+16	3+14	111	♂ vi–iv	0+32	55
846	1·5	4·5	10·75	11·55	13·55	16·0	20·9	22·1	24·55	14	17	3+17	3+15	122	♂ vi	1+31	56
847	1·56	4·85	12·3	12·9	14·95	18·5	23·6	24·95	27·35	16	17	3+16	3+14	168	♂ vi	1+33	56
848	1·5	4·65	11·65	12·5	14·3	17·5	22·8	24·0	26·65	15	17	3+15	3+14	144	♀ vi	0+33	56
849	1·58	5·08	12·55	13·0	15·5	18·4	24·0	25·3	28·45	15	17	4+16	1+2+14	162	♀ vi–iv	0+32	55
850	1·4	4·4	11·05	11·65	13·9	16·7	21·8	23·1	25·75	15	16	3+16	3+14	133	♂ v	1+32	56
851	1·6	4·9	11·75	12·4	14·85	17·5	22·8	24·2	26·75	15	16	3+17	3+14	170	♂ v	†0+33	56
852	1·68	4·92	12·55	13·45	15·85	19·05	24·45	25·75	28·55	14	17	3+16	1+3+15	204	♂ vi	0+33	56
853	1·6	4·8	11·55	12·95	14·55	17·85	23·1	24·35	27·2	14	17	3+17	1+2+16	172	♂ v–vi	1+33	57
854	1·52	4·46	11·15	12·25	14·0	17·15	22·25	23·5	25·95	14	17	3+16	3+15	159	♀ vi	4+30	56
855	1·5	4·67	11·7	12·55	14·6	17·65	22·65	23·9	26·35	15	16	3+17	3+14	164·	♂ vi	0+32	55
856	1·4	4·58	11·5	12·4	14·2	17·4	22·4	23·6	25·75*	14	16	3+16	3+13	128	♀ iv–v	3+31	56

No. of fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
857	1·47	4·95	12·4	13·45	15·15	18·45	24·15	25·4	28·15	Fused. 4+(1+1)+8 =13 or 14.	16	3+16	3+14	141	♀ i–ii	2+31	56
858	1·68	5·03	12·05	12·55	14·95	17·4	23·05	24·3	27·15	15	17	3+16	3+14	171	♀ vi	0+34	56
859	1·63	5·07	13·05	14·2	16·1	19·75	25·3	26·6	29·55	15	17	3+16	3+15	150	♂ vi–iv	2+31	56
860	1·62	4·9	11·9	12·95	14·75	17·9	23·3	24·65	27·5	15	17	3+16	3+15	150	♀ vi	1+32	56
861	1·52	4·62	11·7	12·75	14·5	17·9	23·1	24·3	26·9	15	16	3+16	1+3+14	150	♀ iv–v	1+33	56
862	1·58	5·0	12·55	13·2	15·25	18·4	23·9	25·3	28·05	16	17	4+16	3+14	163	♂ vi	2+31	56
863	1·54	4·78	11·9	12·65	14·8	17·85	23·05	24·35	27·0	14	17	3+17	1+3+12	138	♀ vi–iii	2+31	55
864	1·55	4·43	10·95	11·8	13·4	16·4	21·2	22·4	24·8	14	16	3+15	3+14	124	♂ v	1+31	55
865	1·47	4·5	11·35	12·45	14·3	17·5	22·45	23·7	26·25	15	17	3+16	3+15	156	♂ v	1+32	56
866	1·44	4·5	11·2	11·85	14·1	16·75	21·85	23·05	25·5	15	17	4+16	3+14	123	♀ vi	1+32	56
867	1·63	4·85	11·3	11·95	14·1	16·9	22·05	23·2	25·8	14	17	3+16	3+15	124	♂ vii	0+33	56
868	1·63	5·07	12·1	13·35	15·0	18·35	23·95	25·35	28·15	15	17	3+15	3+14	142	♀ i–ii	1+32	56
869	1·5	4·66	12·15	12·75	15·1	17·95	22·9	24·3	26·85	14	16	3+16	1+3+14	162	♂ v	0+32	55
870	1·55	4·62	12·0	12·95	14·75	17·75	23·2	24·4	27·08	15	17	3+16	1+3+14	164	♀ v	0+32	56
871	1·74	4·9	11·8	12·7	14·85	18·0	23·35	24·7	27·5	15	16	3+16	2+16	154	♂ vi	0+32	56
872	1·42	4·52	11·4	12·2	14·25	17·15	22·25	23·5	26·1	15	16	3+16	3+14	126	♂ vi–iv	1+33	56
873	1·37	4·36	11·35	11·9	14·3	16·95	22·2	23·45	26·05	15	16	3+17	3+16	168	♀ vi	1+33	57
874	1·6	4·8	11·8	12·2	14·55	17·4	22·4	23·75	26·25	14	16	3+17	3+13	134	♂ v	1+33	56
875	1·5	4·85	12·1	12·95	14·95	17·85	23·15	24·4	27·1	14	16	3+16	3+14	149	♀ vi–iii	1+32	56
876	1·6	4·86	12·1	12·7	15·1	16·9	22·0	24·5	27·1	15	16	2+17	3+14	175	♀ vi	1+31	56
877	1·5	4·4	11·1	12·1	13·95	16·9	22·0	23·3	26·0	16	16	3+16	4+14	150	♂ v–vi	1+32	55
878	1·35	4·2	10·4	11·25	13·0	15·6	20·4	21·5	24·0	14	18	3+17	3+14	118	♂ vi	1+31	54
879	1·52	4·7	11·55	12·15	14·4	17·1	22·3	23·5	26·2	15	17	3+16	3+15	136	♂ vi	2+32	56
880	1·5	4·34	10·85	12·2	13·5	16·4	21·25	22·4	24·85	15	17	3+16	3+15	128	♂ vi	1+32	56
881	1·65	5·2	12·7	13·35	15·6	18·85	24·3	25·55	28·5	15	17	2+17	3+14	182	♂ vi	0+33	56
882	1·4	4·46	11·2	12·0	14·0	16·75	21·95	23·15	25·7	14	17	3+16	3+15	127	♂ v–vi	0+33	56
883	1·55	5·0	12·1	13·2	15·05	18·35	23·75	25·1	27·7	15	18	3+16	3+14	164	♂ vi	1+33	57
884	1·6	4·7	12·1	12·7	15·0	17·7	23·05	24·35	27·0	15	17	3+16	2+14	142	♀ vi	1+32	56
885	1·57	4·7	11·85	12·65	14·55	17·9	23·0	24·25	27·1	1+14	16	3+16	3+12	155	♂ vi	3+31	55
886	1·5	4·64	11·25	12·0	14·15	16·95	22·1	23·2	25·75	14	16	3+15	4+13	127	♀ i–ii	0+32	55
887	1·45	4·4	10·7	11·5	13·5	16·05	20·9	22·0	24·6	14	17	3+17	3+14	119	♂ v	2+31	55
888	1·5	4·76	11·9	12·8	14·7	17·8	22·85	24·1	26·8	15	18	3+16	3+14	135	♂ vi–iii	1+32	56
889	1·57	4·8	11·7	12·7	14·25	17·7	22·85	24·0	26·55	16	17	3+15	2+15	137	♂ vi–iii	0+33	56
890	1·58	4·84	11·85	13·2	14·6	18·0	23·25	24·45	27·1	13	17	3+15	3+14	155	♀ iv–v	1+32	56
891	1·6	4·9	12·0	12·8	15·05	18·2	23·45	24·75	27·4	16	18	3+17	3+14	164	♀ v	1+34	57
892	1·64	4·73	11·6	12·8	14·55	17·6	22·9	24·1	26·9	15	16	3+17	3+16	151	♂ vi–iv	0+33	56
893	1·7	5·4	13·1	14·05	16·3	19·45	25·35	26·75	29·85	15	16	3+16	3+15	173	♂ vii–ii	2+31	55
894	1·52	4·6	11·8	12·65	14·55	17·5	23·1	24·35	26·95	15	16	3+16	3+14	157	♀ iv–v	2+32	56

895	1·54	4·58	11·15	12·05	13·7	16·9	21·85	23·05	25·75	14	18	2+16	3+14	125	♂ vi–iv	1+33	56
896	1·4	4·7	12·1	13·1	15·15	18·15	23·5	24·8	27·6	14	17	3+16	3+13	165	♂ vi	1+32	56
897	1·5	4·52	11·25	12·2	13·95	17·35	22·45	23·65	26·25	17	17	3+15	3+14	149	♂ v	1+32*	57
898	1·35	4·42	10·8	11·8	13·4	16·4	21·0	22·25	24·75	15	17	3+15	3+14	131	♂ vi–iii	1+31	55
899	1·55	4·54	11·0	12·3	13·75	17·15	22·2	23·4	25·95	14	16	3+15	3+14	136	♂ iii–iv	2+31*	55
900	1·82	5·35	12·95	14·0	16·05	19·4	24·95	26·3	29·3	15	17	3+16	4+13	190	♀ vi–iii	1+32	56
901	1·5	4·5	11·2	12·1	13·9	17·0	22·0	23·2	25·8	14	17	3+15	3+12	135	♀ vi	1+32	56
902	1·5	4·5	11·1	12·0	13·9	16·85	21·55	22·7	25·2	15	18	3+17	3+14	153	♂ v	†0+32	55
903	1·47	4·66	11·15	12·4	13·85	16·85	22·2	23·4	26·05	14	17	3+15	3+13	128	♂ vi–iv	0+33	56
904	1·42	4·42	11·15	11·75	13·55	16·65	22·05	23·2	25·65	15	17	3+16	3+15	129	♂ vi	1+33	57
905	1·33	4·3	11·0	11·85	13·5	16·35	21·5	22·65	25·15	15	17	3+16	3+15	125	♀ iv–v	†0+32	55
906	1·5	4·67	12·0	13·05	15·0	17·07	22·95	24·2	26·9	15	16	3+16	4+14	159	♀ v	1+32	56
907	1·3	4·25	10·7	11·3	13·5	15·8	20·8	21·9	24·3	14	16	3+16	3+14	114	♂ vi	1+32	55
908	1·62	4·76	11·8	12·75	14·55	17·5	22·55	23·9	26·55	14	16	3+16	3+15	150	♂ vi	†1+32	56
909	1·54	4·6	12·2	12·6	15·1	17·85	23·0	24·3	27·45	15	17	3+16	3+15	154	♂ vi–iv	0+33	56
910	1·56	4·8	11·65	12·55	14·6	17·5	22·65	23·9	26·65	15	17	3+16	3+14	133	♂ v	0+32	55
911	1·55	4·6	12·0	13·15	15·35	18·2	23·45	25·04	27·3	15	17	3+17	4+13	184	♂ vi	0+32*	55
912	1·52	4·8	11·65	12·7	14·4	18·1	22·9	24·15	26·9	15	17	3+16	4+14	135	♀ vi–iv	0+32	55
913	1·56	4·6	11·95	12·9	14·8	17·75	23·1	24·4	27·0	16	17	3+16	4+14	171	♂ vi	1+32	56
914	1·43	4·27	10·4	11·65	13·1	16·15	20·75	21·9	24·45	15	16	3+17	3+14	115	♂ vi–iv	2+32	56
915	1·55	4·75	12·1	13·41	15·1	18·2	23·6	24·8	27·55	14	16	3+16	4+15	177	♂ v	1+32	55
916	1·52	4·77	11·5	12·4	14·4	17·25	22·5	23·75	26·35	14	17	3+17	4+15	131	♀ vi–iii	1+32	56
917	1·36	4·46	11·4	12·35	14·15	16·9	22·05	23·2	25·8	15	17	3+16	3+15	120	♀ vii	†2+31	56
918	1·5	4·6	11·45	12·45	14·25	17·4	22·5	23·75	26·25	15	16	3+16	4+14	142	♂ v	0+33	56
919	1·65	5·1	12·7	13·6	15·9	19·1	24·85	26·25	28·9	15	17	3+17	3+15	180	♂ vi	1+33	56
920	1·48	4·56	10·95	11·55	13·65	16·5	21·45	22·6	25·05	15	16	3+16	3+15	129	♀ vi	†1+32	56
921	1·46	4·26	10·15	11·25	12·7	15·75	20·0	21·15	23·45	16	18	3+16	3+14	95	♀ vi–iii	1+31*	55
922	1·45	4·7	11·45	12·4	14·45	17·5	22·55	23·8	26·45	15	18	3+17	3+14	151	♀ vi	0+33	56
923	1·58	4·65	11·75	12·3	14·6	17·9	22·95	24·3	27·0	16	17	3+15	2+13	163	♀ v–vi	2+32	56
924	1·6	5·07	12·2	13·0	15·2	18·2	23·6	24·9	27·8	16	16	2+16	4+14	182	♂ vi	1+33	56
925	1·58	4·72	11·65	12·5	14·55	17·6	22·6	23·8	26·2	14	16	3+16	3+15	145	♀ vi–iv	0+33	56
926	1·46	4·5	11·5	12·2	14·15	16·9	22·05	23·25	25·9	14	17	3+16	3+15	128	♀ vi–iv	0+33	56
927	1·5	4·52	11·3	12·2	13·9	16·8	21·55	22·8	25·25	14	18	4+15	4+13	118	♀ vii	†1+32	55
928	1·52	4·9	12·7	13·5	15·75	18·7	24·1	25·45	28·15	15	17	3+16	2+15	195	♀ v	1+32	56
929	1·6	5·0	12·0	13·0	15·25	18·2	23·5	24·75	27·55	3+0+11	17	3+16	3+12+several broken away.	168	♂ v	1+32	56
930	1·6	4·8	11·4	12·4	14·2	17·5	22·6	23·8	26·5	15	18	3+16	3+14	147	♂ vi	3+30	55
931	1·72	5·1	12·45	13·4	15·45	18·7	24·1	25·35	28·0	15	16	3+16	3+14	153	♂ iii–iv	2+31	56
932	1·5	4·55	11·25	12·0	13·9	16·6	21·5	22·65	25·1	16	17	3+16	3+14	125	♂ vi	†0+32	55
933	1·4	4·26	10·45	11·15	13·0	15·6	20·2	21·35	23·37	15	16	4+16	3+14	101	♂ vi–iii	†0+32	55
934	1·48	4·48	11·3	12·4	14·2	17·2	22·6	23·83	26·35	15	17	3+17	3+15	137	♂ vi–iv	0+34	57
935	1·55	4·58	11·15	11·95	14·05	16·75	21·9	23·1	25·8	15	17	3+17	3+14	128	♂ vi–iv	1+32	56

No. of Fish.	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
936	1·42	4·3	10·7	11·1	13·3	16·0	20·4	21·65	23·8	14	16	3+15	3+15	122	♂ vi	1+32	55
937	1·5	4·7	12·0	12·4	15·05	17·8	23·15	24·3	26·93	16	17	3+16	18 fin broken.	161	♀ iv–v	2+30	55
938	1·78	5·34	13·3	14·35	16·6	19·4	25·4	26·8	29·8	14	17	3+16	3+15	190	♀ vi	3+32	56
939	1·46	4·7	12·4	13·3	15·05	18·6	24·0	25·3	27·8	14	16	3+15	1+3+13	152	♀ vi–iii	2+31	56
940	1·48	4·75	11·8	12·8	14·65	17·7	22·9	24·25	26·85	14	18	3+17	3+14	146	♂ vi	0+32	55
941	1·55	4·72	11·2	12·0	14·0	17·0	22·2	23·55	26·1	16	17	3+16	3+14	137	♂ vii	1+34	57
942	1·6	4·94	12·0	12·9	15·0	18·3	23·4	24·65	27·4	15	17	3+16	3+13	172	♀ v–vi	1+32	55
943	1·53	4·85	11·65	12·85	14·9	17·7	23·25	24·55	27·15	14	17	3+17	3+14	138	♂ vii	0+32	54*
944	1·5	4·86	12·05	12·55	15·05	17·6	22·75	23·9	26·5	15	17	3+16	3+16	137	♀ vi–iii	2+32	57
945	1·5	4·86	12·5	13·4	15·6	18·8	24·35	25·65	28·4	14	16	3+17	3+16	199	♀ vi	0+32	56
946	1·68	5·18	12·55	13·3	15·65	18·9	23·9	25·25	28·05	15	17	3+17	3+14	176	♂ v	2+33	56
947	1·52	4·5	11·2	12·0	14·05	16·8	22·1	23·3	25·85	15	17	3+16	4+15	138	♀ v	†1+31	55
948	1·5	4·6	11·4	12·85	14·25	17·6	22·7	23·95	26·25*	15	16	3+15	3+14	155	♀ vi	1+32	56
949	1·46	4·6	11·7	12·1	14·4	17·3	22·73	23·9	26·45	15	16	3+16	4+14	138	♀ vi–iv	Missing 1+0+31	55
950	1·55	5·0	12·7	13·3	15·55	18·2	24·1	25·35	28·1	13	17	3+16	4+15	168	♂ vi–iv	1+32	55
951	1·48	4·5	11·1	12·2	13·9	16·65	21·85	23·05	25·7	13	17	3+16	3+15	132	♂ vi–iv	2+31	55
952	1·47	4·82	11·7	12·5	14·8	17·85	23·05	24·2	26·85	18	16	3+17	3+15	171	♀ vi	0+34	57
953	1·65	4·86	12·0	12·85	14·9	17·55	22·8	24·05	26·8	14	17	3+16	3+14	135	♀ vi	2+31	56
954	1·55	4·62	11·2	12·45	14·0	17·3	22·15	23·3	25·95	15	17	3+17	3+14	149	♀ vi	1+31	56
955	1·38	4·48	11·2	11·75	13·7	16·95	21·8	23·05	25·7	14	17	2+16	3+15	153	♂ v	1+33	56
956	1·67	5·0	12·25	13·3	15·2	18·4	23·95	25·15	27·75	14	17	3+16	3+15	171	♀ vi	0+32	56
957	1·5	4·65	11·5	12·8	14·5	17·6	22·7	23·9	26·65	14	17	2+17	3+14	171	♀ vi	0+32	56
958	1·56	4·78	11·7	12·6	14·65	17·5	22·8	23·95	26·6	15	16	2+17	3+14	175	♂ v	0+33	56
959	1·52	4·75	11·95	12·7	15·0	17·85	23·25	24·5	27·05	14	18	3+16	2+14	168	♂ vi	0+34	56
960	1·38	4·3	11·2	11·45	13·95	16·5	21·6	22·75	25·4	14	15	3+17	3+14	127	♂ vi	1+32	55
961	1·52	4·45	10·7	11·65	13·55	16·38	21·25	22·35	25·05	15	17	3+17	3+14	132	♀ vi	2+31	56
962	1·44	4·57	10·95	11·0	13·65	15·8	20·65	21·85	24·45	15	18	3+17	4+14	116	♀ vi–iv	1+31	55*
963	1·33	4·57	11·6	12·0	14·25	16·6	22·1	23·3	25·9	14	17	3+16	3+16	128	♀ vii	1+32	55
964	1·62	4·88	12·15	12·85	15·0	17·9	23·1	24·3	27·1	16	16	3+17	4+15	155	♀ iv–v	0+32	55
965	1·3	4·28	10·25	11·05	12·9	15·45	20·05	21·15	23·65	14	17	2+17	3+15	118	♂ vi	2+31	55
966	1·42	4·4	10·9	11·85	13·9	16·1	21·2	22·35	24·85	14	16	2+17	3+15	107	♀ vi–iii	†0+33	57
967	1·5	4·86	12·2	12·95	15·05	18·35	23·7	24·95	27·8	14	17	3+15	4+13	146	♂ vi	0+32	56
968	1·3	4·22	10·5	11·2	12·9	15·35	20·05	21·1	23·5	14	16	3+16	3+15	106	♀ vi	†0+33	56
969	1·4	4·46	10·9	11·35	13·65	16·6	21·4	22·55	25·05	16	16	3+17	3+15	133	♂ vi	1+32	56
970	1·56	5·04	12·4	13·15	15·4	18·3	23·5	24·8	27·6	16	17	3+15	3+13	158	♂ vi	1+33	56
971	1·54	4·68	11·45	12·55	14·1	17·4	22·55	23·75	26·2	15	17	2+17	3+14	145	♀ vi	0+33	55
972	1·45	4·57	11·6	12·6	14·45	17·6	22·9	24·1	26·7	15	17	3+16	3+16	147	♀ vi	1+32	56
973	1·58	4·7	11·25	12·3	14·1	17·15	22·35	23·6	26·25	15	17	3+17	3+16	131	♂ vi	0+33	56

974	1·5	4·68	11·6	12·55	14·4	17·25	22·6	23·9	26·5	14	17	3+16	3+14	136	♀ vi	1+32	56
975	1·35	4·35	11·0	11·5	13·65	16·6	21·5	22·65	25·15	15	16	3+16	3+14	127	♀ v–vi	0+31	55*
976	1·5	4·6	11·55	12·05	14·65	17·2	22·5	24·0	26·7	14	16	3+17	3+16	136	♀ vii	1+32	56
977	1·48	4·63	11·0	11·65	13·75	16·3	21·1	22·28	24·7	15	16	3+17	3+13	106	♀ vi–iii	1+32	56
978	1·4	4·4	11·05	11·65	13·8	16·25	21·4	22·5	25·1	14	17	3+16	3+15	126	♀ vi	2+31	56
979	1·52	4·7	11·4	12·4	14·05	17·1	22·35	23·5	26·05	14	17	3+15	3+13	137	♂ v	2+31	56
980	1·52	4·66	11·75	12·65	14·8	17·5	22·8	23·95	26·7	15	16	2+17	3+13	157	♂ vi	0+33	56*
981	1·43	4·5	11·0	11·85	13·7	16·65	21·45	22·6	25·35	15	16	3+16	3+13	143	♀ vi	0+32	55
982	1·57	4·77	11·35	11·55	14·2	16·45	21·95	23·2	25·8	15	17	2+17	3+14	126	♂ vii	1+33	57
983	1·3	4·26	10·55	11·2	13·1	15·6	20·45	21·55	24·0	15	18	3+15	3+15	103	♀ vi–iv	2+33	57
984	1·66	5·15	12·55	13·7	15·45	18·85	24·05	25·4	28·3	14	16	3+15	3+13	152	♀ i–ii	2+30	55
985	1·42	4·72	12·0	13·2	15·2	18·65	24·05	25·3	28·35	16	16	4+16	3+14	185	♀ v–vi	1+32	56
986	1·53	4·4	11·4	12·0	14·0	17·0	22·1	23·25	25·9	15	17	3+16	3+14	132	♀ vi	1+32	56
987	1·42	4·26	10·56	11·4	13·15	16·4	21·25	22·4	24·75	16	17	3+16	4+13	117	♀ iv–v	1+33	57
988	1·54	4·66	11·6	12·4	14·3	17·55	22·9	24·05	26·7	15	16	3+15	3+13	145	♀ vi	†1+33	57
989	1·65	5·0	12·5	13·75	15·2	18·6	24·3	25·55	28·25	15	18	3+16	3+16	156	♀ vi	2+32	56
990	1·72	5·03	12·15	13·4	15·25	18·55	23·85	25·1	27·95	15	16	3+17	3+14	171	♀ vi	1+32	56
991	1·52	4·75	11·9	12·8	14·8	18·1	23·35	24·7	27·5*	14	17	3+16	1+3+14	171	♂ vi	0+32	55
992	1·68	5·05	12·35	13·15	15·3	18·35	24·0	25·3	28·15	14	17	3+16	4+14	147	♀ i–ii	2+31	55
993	1·47	4·67	11·45	12·4	14·15	17·65	22·6	23·85	26·45	15	17	3+16	3+13	149	♀ iv–v	1+33	56
994	1·48	4·53	11·0	11·6	13·95	16·4	21·45	22·6	25·05	14	17	3+17	4+14	134	♂ vi	†0 or 1+33	56
995	1·5	4·52	11·35	12·35	14·0	17·4	22·15	23·35	25·9	14	17	3+16	18 ray broken.	123	♂ vii	2+32	56
996	1·65	4·96	12·6	13·45	15·6	18·9	24·15	25·5	28·4	15	Fused. 9+(1+1)+5	3+15	4+14	191	♀ v	1+31	55
997	1·62	4·83	12·2	12·8	14·85	18·2	23·6	24·95	27·8	15	16	3+16	4+13	164	♀ vi	1+32	56
998	1·47	4·8	11·35	12·35	14·15	17·2	22·5	23·75	26·25	15	16	3+17	3+14	124	♂ vi–iv	1+33	57
999	1·6	4·8	12·1	12·9	15·0	18·15	23·3	24·6	27·3	14	17	2+15	3+14	173	♀ vi	1+33	57
1000	1·66	4·8	11·75	12·0	14·9	17·3	22·6	23·95	26·55	15	17	3+16	2+15	143	♂ v	1+32	54
1001	1·4	4·58	11·74	12·6	14·65	17·95	23·05	24·35	27·0	14	17	2+17	3+15	163	♀ vi–iii	1+32	56
1002	1·7	5·0	12·2	12·95	15·1	17·8	23·0	24·3	26·95	14	16	3+16	3+13	157	♂ v	2+31	56
1003	1·52	4·97	11·85	12·55	14·5	17·4	23·05	24·4	26·95	14	17	3+15	3+14	163	♂ vi	1+32	55
1004	1·4	4·7	12·15	12·65	14·7	17·45	22·65	23·85	26·55	14	17	3+16	3+15	152	♀ v	2+32	56
1005	1·9	5·74	14·1	14·77	17·45	20·6	26·7	28·1	31·2	15	17	3+16	3+14	218	♂ vi	2+31	57
1006	1·72	5·0	12·5	13·1	15·6	18·2	23·8	25·03	27·6	15	16	3+16	2+15	175	♂ vi	1+33	56
1007	1·6	5·0	12·65	14·0	15·75	18·9	24·35	25·7	28·6	14	17	3+17	3+14	184	♀ vi	1+32	56
1008	1·6	4·9	11·95	12·5	14·8	17·65	22·8	24·1	26·9	15	18	3+16	3+14	150	♂ vi	1+31	55
1009	1·65	5·0	12·0	12·55	14·9	17·55	22·9	24·2	27·1	15	18	3+17	3+15	159	♀ vi	1+32	56
1010	1·4	4·6	11·7	12·2	14·25	17·4	22·7	23·85	26·5	16	16	3+15	3+14	154	♂ vi	3+30	55*
1011	1·55	5·12	12·6	13·45	15·45	18·5	24·0	25·35	28·2	14	17	3+16	3+15	159	♂ vi–iii	0+33	56
1012	1·5	4·77	11·4	12·65	14·05	17·4	22·2	23·35	26·05	15	17	3+15	3+14	134	♂ vi	2+31	56
1013	1·52	4·75	11·7	12·87	14·7	17·8	23·2	24·5	27·15	15	16	Total 19. 3+16	3+16	151	♀ vi–iii	1+32	56
1014	1·63	4·9	12·0	13·2	15·05	18·15	23·45	24·7	27·55	14	16	3+16	2+15	167	♀ vi	1+33	56

No. of Fish	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
1015	1·43	4·5	11·15	11·7	13·9	16·3	21·35	22·65	25·1	13	15	3+15	3+14	128	♂ vi	2+32	56
1016	1·44	4·4	10·5	11·55	13·2	15·8	20·95	22·05	24·55	14	17	3+16	3+15	112	♂ vi	2+31	56
1017	1·5	4·66	12·35	13·15	15·45	18·5	23·8	25·05	27·85	14	17	3+16	3+14	167	♀ vi	†1+32	56
1018	1·55	4·5	11·95	12·55	14·7	17·95	22·75	24·0	26·55	15	17	3+16	3+13	159	♂ v	2+32	55
1019	1·35	4·63	11·45	12·4	14·25	17·45	22·6	23·7	26·5	15	17	3+16	3+15	116	♂ ii	1+34	57
1020	1·57	4·7	11·2	12·4	14·0	17·35	22·3	23·45	25·9	15	18	3+15	3+14	143	♂ vi	†1+32	56
1021	1·5	4·6	11·3	12·35	14·2	16·95	22·25	23·55	26·15	14	16	3+16	3+14	143	♂ vi	0+32	55
1022	1·6	4·8	11·95	12·45	14·7	17·3	22·9	24·1	26·8	12+0+2	16	3+16	3+15	160	♂ v	2+31	55
1023	1·5	4·56	11·35	12·25	14·3	17·4	22·3	23·5	26·2	15	16	3+17	3+15	143	♀ v-vi	2+31	56
1024	1·48	4·66	11·95	12·8	15·1	17·65	23·1	24·5	27·35	15	17	3+17	3+14	166	♀ vi	2+32	56
1025	1·5	4·6	11·75	12·15	14·6	16·9	22·05	23·3	25·8	16	18	3+16	4+15	148	♂ vi	1+32	56
1026	1·46	4·74	11·75	12·2	14·65	17·5	22·9	24·15	26·9	16	17	3+17	3+16	143	♀ v	2+33	56
1027	1·48	4·47	11·9	12·6	14·5	17·65	22·8	24·1	26·6	15	16	3+15	3+15	150	♂ v-vi	2+32	56
1028	1·45	4·58	11·35	12·45	14·2	17·15	22·5	23·7	26·3	14	17	3+16	3+16	124	♀ vii	†0+33	56
1029	1·55	4·9	11·75	12·6	14·9	17·55	23·05	24·35	27·15	14	17	3+17	3+15	150	♂ vi	0+33	56
1030	1·37	4·47	11·0	12·1	13·8	16·8	21·8	23·0	25·6	14	18	3+17	3+14	132	♂ vi	1+32	56
1031	1·34	4·27	10·8	11·8	13·55	16·65	21·4	22·5	24·85	15	16	3+16	3+14	121	♂ vi	1+32	56
1032	1·4	4·43	11·65	12·5	14·55	17·2	22·5	23·75	26·35	14	16	3+16	3+14	158	♂ v-vi	1+32	56
1033	1·5	4·86	12·15	13·05	14·8	18·1	23·2	24·45	27·3	15	17	3+15	3+14	140	♂ vi	1+32	56
1034	1·3	4·4	11·15	12·3	13·9	17·1	22·2	23·4	26·2	15	17	3+16	3+14	143	♀ v-vi	2+32	56
1035	1·5	4·78	11·9	13·0	15·0	17·75	23·3	24·6	27·3	15	16	3+16	3+14	146	♀ vi-iv	2+32	56
1036	1·48	4·3	10·9	11·9	13·6	16·3	21·0	22·2	24·75	15	17	3+15	3+14	129	♀ v	†0+33	56
1037	1·43	4·4	10·4	11·6	13·05	15·9	20·9	22·0	24·5	14	17	3+16	4+13	111	♂ vi	1+32	55
1038	1·4	4·3	10·3	11·0	12·7	15·5	20·3	21·3	23·6	16	17	3+15	3+14	108	♀ vi	0+34	57
1039	1·43	4·78	11·5	12·6	14·35	17·4	22·4	23·65	26·35	15	16	3+17	4+13	145	♂ v	†1+32	56
1040	1·45	4·3	11·4	12·5	14·1	17·25	22·45	23·65	26·3	14	17	3+16	3+15	154	♀ vi	0+33	56
1041	1·62	5·0	11·85	12·6	14·85	17·9	22·9	24·2	26·7	15	17	3+16	3+13	136	♀ vi-iii	1+32	56
1042	1·5	4·8	12·1	12·8	14·9	18·05	23·2	24·5	27·05	16	17	3+16	3+14	144	♂ vi	1+33	56
1043	1·67	5·15	12·5	12·95	15·45	18·1	23·9	25·2	28·2	15	17	3+17	3+15	153	♀ vii	1+33	57
1044	1·6	5·07	12·65	13·2	15·75	18·75	24·4	25·8	28·6	16	17	3+16	3+13	159	♀ vi-iii	3+31	57
1045	1·62	4·9	11·85	12·5	14·6	17·55	22·45	23·85	26·65	14	17	3+16	3+16	175	♂ v-vi	0+32	55
1046	1·56	4·8	12·55	13·3	15·65	18·75	24·15	25·33	28·3	14	16	3+17	3+14	173	♀ v	0+33	55
1047	1·53	4·85	12·1	12·4	15·05	17·6	22·95	24·2	26·9	15	18	3+17	3+14	153	♀ iv-v	0+33	56
1048	1·45	4·3	10·5	11·35	13·2	16·05	21·05	22·3	25·0	15	17	3+16	3+15	130	♂ vi	2+31	55
1049	1·3	4·18	10·75	11·5	13·35	16·15	20·95	22·0	24·45	15	17	3+16	3+14	116	♂ vi	1+32	56
1050	1·67	4·87	11·8	12·85	14·6	17·7	22·7	23·95	26·95	14	16	2+16	3+14	171	♂ v-vi	3+30	56
1051	1·67	5·1	11·95	12·7	14·8	17·8	23·05	24·3	27·05	14	18	3+16	3+14	158	♂ v-vi	3+31	55
1052	1·4	4·6	11·75	12·35	14·2	17·1	22·6	23·7	26·2	15	17	3+15	2+15	134	♂ vi-iii	0+33	56
1053	1·42	4·47	11·5	12·25	14·4	17·0	22·0	23·2	25·7	15	17	2+18	3+15	139	♂ v	1+31	57

No.																
1054	1·65	4·77	11·75	12·45	14·7	17·4	22·7	23·95	26·7	15	17	3+17	3+14	161	♂ v	1+32	55
1055	1·53	4·78	12·35	13·35	15·25	18·45	23·95	25·15	27·95	14	17	3+17	3+14	192	♀ v	†0+33	56
1056	1·66	4·98	12·05	13·4	15·05	17·9	23·25	24·55	27·25	14	16	3+17	3+14	163	♀ vi	1+32	56
1057	1·4	4·3	10·9	11·7	13·5	16·15	21·35	22·5	25·05	14	17	3+17	3+14	129	♂ vi	2+31	56
1058	1·57	4·65	11·2	12·05	14·0	16·7	22·0	23·1	25·85	14	17	3+17	3+14	136	♀ v	2+31	55
1059	1·53	4·57	11·5	12·05	14·3	17·15	22·55	23·75	26·45	14	17	3+16	3+16	171	♂ v	1+32	55
1060	1·47	4·5	11·55	12·2	14·25	17·15	22·3	23·55	26·25	14	16	3+16	3+14	144	♀ vi	1+32	55
1061	1·4	4·48	11·4	11·75	14·25	17·0	22·15	23·35	25·85	15	18	3+16	3+13	134	♀ v	0+32	56
1062	1·57	4·6	11·0	11·3	13·85	15·95	21·0	22·2	24·6	14	17	2+17	4+13	128	♂ v–vi	2+33	56
1063	1·5	4·93	12·2	13·3	15·0	18·05	23·5	24·8	27·6	13	16	3+16	3+15	146	♂ vi	2+32	56
1064	1·6	4·8	11·8	12·2	14·5	17·3	22·6	23·8	26·2	13	16	3+17	4+15	139	♀ vi 1+[1*+30]	1+32	55
1065	1·55	4·62	11·15	12·2	14·3	17·05	22·25	23·5	26·15	15	16	3+17	3+15	152	♀ vi	1+32	56
1066	1·43	4·4	11·05	11·9	14·05	16·95	21·9	23·0	25·5	15	16	3+17	3+14	116	♂ vi–iii	1+32	56
1067	1·7	5·08	12·5	13·2	15·5	18·6	23·85	25·2	28·1	14	16	3+17	3+14	154	♂ iv–v	3+31	56*
1068	1·54	4·6	11·35	12·45	14·35	17·1	22·1	23·3	25·75	14	15	3+16	3+14	129	♀ vi–iv	0+33	56
1069	1·5	4·44	10·45	11·1	13·0	15·75	20·6	21·7	24·2	14	16	3+16	3+15	113	♀ vii	1+31	54
1070	1·42	4·37	10·95	11·35	13·4	16·2	21·1	22·2	24·55	16	17	3+16	3+14	129	♂ vi	†2+31	56
1071	1·45	4·2	10·3	10·85	12·7	15·45	20·2	21·25	23·75	15	16	3+16	3+15	117	♂ vi	1+31	54
1072	1·7	5·1	12·7	13·7	15·8	18·8	24·2	25·63	28·65	15	16	3+16	2+15	182	♀ vi	1+32	56
1073	1·3	4·2	10·6	11·35	13·3	15·9	20·9	22·05	24·6	14	17	3+16	2+14	127	♂ v–vi	0+33	55
1074	1·5	4·72	11·7	12·35	14·45	17·5	22·6	23·85	26·6	15	16	3+16	2+14	121	♂ ii	3+31	56
1075	1·47	4·7	11·8	12·55	14·45	17·7	22·55	23·75	26·55	15	16	3+15	3+14	147	♂ v	†0+32*	55

APPENDIX TO TABLES.

† This sign in all cases indicates that no lateral processes are present in the vertebræ immediately preceding the 1st vertebra with complete hæmal arch or the most anterior incomplete arch denoted in the records. The processes in these cases have been cleaned away.

* This sign *on the measurements* (Columns 1 to 9) indicates that the character is slightly abnormal in some way or that the part measured is slightly damaged. In columns 17 and 18 the asterisks refer to the following :—

Sample III.

Fish No.

   3 * 12th vertebra with complete hæmal arch has two pairs of hæmal arches, but only one extra neural process on the right, which is attached to the 11th neural arch. The vertebra itself is slightly longer than adjacent ones, but has been counted as and appears to be only one. The left hæmal process of the 15th vertebra with complete hæmal arch is attached to the 14th hæmal arch and its fellow is free. The hæmal processes of the next vertebra, the 16th, are also free.

   9 * Right portion of 11 and 12 hæmal arches fused with left division of 11th hæmal spine. 12th, left portion of hæmal arch free.

 34 * 19th vertebra is very long and carries two pairs of neural and hæmal arches, the extra arches arising from the middle. It is recorded as one, but is apparently made up of two fused.

 98 * 9th and 10th vertebræ (with complete hæmal arch) have each two pairs of neural spines, the 10th has also two pairs of hæmal spines, the abnormal pair having one limb (the left) arising from the middle of the centrum, but the other arising near the origin of the right member of the 11th hæmal arch. These vertebræ are each recorded as one; they are of normal size, and neither appears to be composed of two vertebræ fused, as is undoubtedly the case in other skeletons.

125 * 2nd vertebra with well-developed ventrolateral processes (paired).

139 * 6th hæmal arch with extra spine arising from junction of processes.

157 * Processes missing almost entirely one side and entirely on other side.

161 * Anterior group of vertebræ lost.

241 * 1st hæmal arch has a supernumerary hæmal process in the middle of the vertebra on the left side.

243 * 1st hæmal arch broken, but still attached to vertebra.

267 * Incomplete arch, although nearly complete. The vertebra preceding had a complete hæmal arch as noted in the record.

270 * Transverse bars nearly joined. The right-hand figure of Fig. 3 is drawn from this vertebra.

277 * 10th and 11th hæmal arches are joined by a bony cross-piece.

288 * 14th and 15th vertebræ have each two pairs of hæmal spines, the subsidiary pair being in the middle, but only the 14th pair has also a corresponding neural arch.

291 * 19th neural spines quite free.

299 * 24th hæmal spines free ; no loop formed.

310 * 5th neural spines are separate, and there is an extra free neural spine on the right, and the 5th, 7th, and 8th hæmal arch processes are bifurcated at the tip, and three of the 7th are not joined together at all, that is both spines are free.

316 * 15th and 16th left rays of hæmal arches are joined up with the 15th right hæmal arch ray. The 16th right ray is free.

351 * In the case of high numbers as 33 and 34 the first hæmal arch is generally without the lateral processes.

352 * 11th hæmal arch, processes not fused, and right one bifurcated.

401 * Atlas with pair of well-developed dorso-lateral spines.

416 * Extra spine on 16th hæmal arch, arising from junction of processes of arch.

427 * Last vertebra but two is peculiar, being unusually small, and being somewhat fenestrated on the left side but normal on the right side. Otherwise the skeleton is quite normal.

435 * The eleventh vertebra bears on the left a hæmal spine showing a slight bifurcation at the tip ; the hæmal spines in the anterior region in this fish were very well developed.

453 * 1st arch broken, but still attached to vertebra.

462 * Less well developed than processes of anterior vertebra.

529 * The last vertebra but two is apparently made up of two fused, being almost twice as long as adjacent ones ; it bears two pairs of hæmal and neural spines, but has only an anterior and posterior articulation ; the centre is distinctly fused. This is only counted as one.

546 * 1st vertebra with complete hæmal arch has a supernumerary hæmal process on the left side, and the 14th vertebra with complete hæmal arch has a supernumerary pair of hæmal and neural spines arising from middle of vertebra ; both pairs of hæmal spines are joined by a cross-piece on the right side.

Sample IV.

552 * 1st hæmal arch broken off centrum, but still attached.

580 * Extra spine from junction of hæmal spines of 23rd vertebra from posterior end.

582 * On some posterior hæmal arches are spherical concretions which appear like little beads of melted metal. This phenomenon has been noticed on other skeletons also.

588 * Atlas, 1st, and axis, 2nd, vertebræ fused together ; counted as two.

631 * This one incomplete, but with an internal process on the right hæmal
      process. The arch of the vertebra anterior to it is complete.

664 * 7th vertebra from posterior end has two pairs of hæmal and neural
      spines, is longer than normal and apparently equal to two fused
      vertebræ. It is counted, however, as one.

667 * 4th, 5th, and 6th vertebræ from posterior end have been broken and
      recovered at some period of life of the fish.

687 * The last vertebra bears three pairs of neural and two pairs of hæmal
      spines, it is nearly twice as long as a normal one, and has a thickening
      in the middle of the centrum where apparently two vertebræ have
      fused. It is undoubtedly two vertebræ fused. It is, however, only
      counted as one in the table.

709 * 3rd complete arch has a tiny extra connecting hæmal process on the
      left.

711 * Middle tips of hæmal arches with curious concretionary appearance,
      just as though the arches were of metal and had been melted in parts.

740 * The right hæmal process of 28th vertebra is joined to junction of hæmal
      processes of 27th vertebra ; the left process of the 28th vertebra being
      free.

746 * 13th vertebra from anterior end is about half as long again as normal,
      and has ridges around its middle indicating fusion of two vertebræ.
      It is, however, counted as one.
        There is no normal articulation in the middle, but complete fusion.

767 * 9th vertebra very long and apparently two vertebræ fused, similar to
      704. It is counted, however, as one.

782 * It is quite possible that one or more arches are missing here ; possibly
      too well cleaned.

784 * Arch incomplete, though the one anterior to it is complete (broken, but
      still attached to centrum).

803 * 1st hæmal arch broken, but still attached to vertebra.

841 * There is nothing unusual in the appearance of this skeleton.

843 * 1st hæmal arch with a rib attached.

855 * 2nd, 3rd, 4th, 5th, and 6th rays of anal fin anastomising.

897 * In the region two-thirds from anterior end the hæmal and neural arches
      arise from abnormal positions and there are a few extra spines.

899 * Several hæmal arches with processes interchanged, i.e. processes on oppo-
      site sides not joined up with fellow, but with those anterior or
      posterior to them.

911 * 3rd hæmal arch broken, but was undoubtedly complete.

921 * 46th vertebra from anterior end, 3 pairs of hæmal and 2½ pairs of
      neural spines. The centrum is abnormally long, nearly twice normal
      length, and is apparently equal to at least 2 vertebræ fused. It is
      counted as one.

925 * In Character 17 the " a " portion is recorded hence first in order to avoid any bias towards making up the number to the apparent total of 33 or 34 potential arches.

943 * 35th vertebra with two pairs of neural and hæmal spines, nearly twice as long as normal, and apparently equals two fused. Counted as one.

962 * Arches about middle of skeleton a little abnormal.

975 * 12th vertebra nearly twice as long as normal, and apparently equal to two fused, but only counted as one. Also 30th vertebra with $1\frac{1}{2}$ hæmal arches and spines, but otherwise of normal size. 32nd also with abnormal hæmal arch processes.

980 * 39th vertebra with one hæmal arch attached to arch of 38th vertebra.

1010 * 37th vertebra has one extra neural and one extra hæmal spine, but is otherwise normal.

1064 * Vertebra behind 1st complete arch carries an incomplete but well-developed arch ; it is counted with those having complete arch.

1067 * Left process of 44th hæmal arch is joined up with junction of 43rd hæmal arch.

1075 * 1st hæmal arch broken, but still attached to centrum.

Note.—The lateral processes of the vertebræ preceding those with complete hæmal arch are sometimes long without internal processes, and at other times shorter with the internal process developing. Nevertheless, the arbitrary character chosen has been adhered to as closely as possible. There are, however, doubtful cases.

Very frequently the 4th, 5th, and 6th vertebræ from posterior end have the base of the hæmal arch passing diagonally across the ventral anterior half of the centrum, and in this respect are unlike the other vertebræ.

On the Amount of Phosphoric Acid in the Sea-Water off Plymouth Sound.

By

Donald J. Matthews.

IN spite of its biological importance, only a few investigators have turned their attention to the content of the sea in phosphoric acid. The older analyses by C. Schmidt (1) and Forchammer are quoted by K. Brandt (2). Schmidt found from 2·8 mg. to 5·5 mg. of P_2O_5 per 1000 grms. of water in the colder seas, and from 0·76 mg. to 1·8 mg. in warmer regions, while Forchammer found from 4·6 mg. to 12·5 mg. in the Gulf of Finland. Krümmel (4) refers to these as inaccurate, and quotes the results of analyses made much more recently by E. Raben, in connection with the International Fishery Investigations, as alone reliable. K. Brandt (3) also refers to Raben's work in various papers, but neither the present writer nor Professor Martin Knudsen, of Copenhagen, who has very kindly made a search also, has been able to find any original paper by Raben on the subject, so that we unfortunately know nothing of his methods beyond the fact, given by Brandt, that the samples were filtered immediately after collection through Schleicher and Schull's hardened paper. This is a very necessary precaution, as there would be danger of an increase in the phosphates owing to the decomposition of suspended organic matter by bacteria. The present writer has found that even a filtered sample cannot be put aside in safety for any length of time unless previously sterilised, as the whole of the phosphoric acid may be removed by the growth of moulds.

Krümmel mentions also some analyses by Sir John Murray as equally defective.

Raben's samples were collected in the Baltic and North Sea ; he found as a rule less than one milligram of P_2O_5 per litre, with a minimum of 0·14 mg. to 0·25 mg. in February and May, and a maximum of 1·46 mg. in the autumn.

The present writer, in sea-water taken half a mile outside the Breakwater at Plymouth, has found as a maximum 0·1 mg. per litre, less than the lowest result given by any of the workers mentioned above.

The determination of phosphoric acid in sea-water falls into two parts, first concentration in small bulk, and then determination of the amount. Concentration may be effected either by precipitating, by the addition of ammonia, a portion of the alkaline earths, which carries down the phosphoric acid, or by adding an iron salt, ammonium chloride, and ammonia and precipitating a mixture of ferric phosphate and hydroxide. The estimation may be carried out either gravimetrically as ammonium phospho-molybdate, or colorimetrically by the very sensitive reaction with nitro-molybdate of strychnine described by Pouget and Chouchak (5). The writer finally adopted the colorimetric method following concentration with iron, but all four processes have been used.

From April 21 to September 13, 1915, the method was as follows: About 1500 ccm. of filtered water was precipitated, after making slightly acid and heating, with iron and ammonium chloride and ammonia. The precipitate was filtered off, dissolved in warm dilute nitric acid, and evaporated to dryness several times with further addition of acid to remove silica. The phosphorus was determined by precipitating with ammonium molybdate and weighing as anhydride. For such small quantities, the amount of anhydride being only a few milligrams, the method cannot be considered satisfactory, as there is danger of loss through some of the precipitate dissolving in the wash-waters or being carried through the asbestos of the Gooch crucible, and on the other hand there is the risk of the results being too high owing to the simultaneous precipitation of a trace of molybdic acid. With one exception the figures obtained were much higher than most of those by the colorimetric method. From April 21 to July 14 about 0·07 mg. per litre was found gravimetrically; there was then a break in the series and the next analysis, made on September 13, showed a considerable fall to 0·04 mg. by the gravimetric method, in good agreement with that for September 21, when 0·046 mg. was found by the colorimetric method, which was adopted for all following work.

Samples for the colorimetric method were at first concentrated by precipitating 500 ccm. of filtered sea-water with 3 ccm. of pure concentrated ammonia, heating, and filtering off the voluminous precipitate of hydroxides, dissolving it in nitric acid, and evaporating on the waterbath to dryness, after which it was treated as described later. The method had the advantage that only one reagent was used for precipitation, and as a rule the solution filtered quickly and duplicate analyses agreed well, the average difference being 0·0029 mg. per litre. Its accuracy, however, was difficult to establish without making up an artificial sea-water free, or nearly so, from phosphates, and this was found to be

impossible with the purest chemicals of Merck and Kahlbaum. As an example, the artificial sea-water was found to contain 0·0143 mg. of P_2O_5 in 500 ccm.; 0·0234 mg. was added to 500 ccm. and 0·0328 mg. found, a loss of 0·0049 mg. In another experiment made on 250 ccm. the loss was only 0·0007 mg. These differences are both of about the same magnitude as those found between duplicate analyses of sea-water, so the experiments are not conclusive, though it shows that the method is at any rate approximately accurate. Comparison was also made with the method finally used ; simple precipitation by ammonia gave 0·0312 mg. per litre, against 0·0318 mg. and 0·0316 mg. by the final method. Again, precipitation by ammonia gave 0·057 mg. in duplicate analyses ; treatment of the filtrate from one of these by ammonia gave a further voluminous precipitate which contained no recognisable phosphates. The method is therefore probably accurate to about 0·003 mg.

In the end, concentration by iron was found to be the most satisfactory and quickest method, duplicate determinations taking five hours or less when the water had been previously filtered. The requisites are :—

Ferric nitrate or chloride solution, nearly neutral, containing 5 to 6 mg. of iron in 1 ccm.

Nitric acid, strong and 25 per cent by volume.

Ammonia, dilute ; 2 N is a convenient strength.

Ammonium chloride ; about 2 N.

Pouget and Chouchak's reagent ; two solutions are required. A : 95 grms. of molybdic acid and 30 grms. of anhydrous carbonate of soda are dissolved in 500–600 ccm. of warm water, and after cooling 141 ccm. of strong nitric acid are added. The solution is made up to 1000 ccm. B : a 2 per cent solution of strychnine sulphate. For use 1 ccm. of B is added to 10 ccm. of A and the mixture filtered and used at once. With 0·03 mg. of P_2O_5 in 50 ccm. of 3·7 per cent nitric acid, this reagent gives a strong opalescence at once, while 0·005 mg. will give the reaction in a few minutes. This opalescence is yellow when examined in the colorimeter ; it takes twenty minutes to attain its full strength, and after three or four hours a precipitate is thrown down, so the comparisons should be made as soon as possible after the twenty minutes have elapsed. The colour is proportional to the amount of phosphoric acid when the content in P_2O_5 lies between 0·01 mg. and 0·05 mg. in 50 ccm. ; it is affected by variations in the amount of reagent used and by the amount of free nitric acid. Pouget and Chouchak give a number of determinations in the presence of various oxides, and show that the results are very good unless the oxides are present in very large amount ; for instance, lime is without influence when there is not more present than 20,000

times the weight of the phosphorus pentoxide, while iron should not exceed 1200 times its weight. They recommend also that for the greatest accuracy two standard solutions should be made up, one containing 0·03 mg. P_2O_5 for use with samples containing this amount or more, and another containing 0·02 mg. for samples containing less than 0·03 mg.

Colorimeter. The writer has used the Dubosq pattern with comparison tubes 5 cm. in height and a swinging shade in front to cut off side light. For the comparison of phosphorus samples the model with 10 cm. tubes would probably have been better.

Filter papers should be washed with dilute nitric acid and hot water. The writer has found traces of phosphoric acid in two of the best-known hydrofluoric-acid washed papers.

Porcelain and *glass* should be tested before use by extraction with hot dilute nitric acid and dilute ammonia. There are some varieties which will give up several milligrams of P_2O_5 during an analysis.

India-rubber should not be allowed to come in contact with the acid or alkaline solutions.

The analyses have been carried out as follows : The samples were taken in glass-stoppered " Winchester quart " bottles, holding about 2700 ccm. As they were collected so near to the Laboratory it was generally possible to begin the filtration within three hours, so that there was no necessity for sterilisation. Filtration was carried out by replacing the glass stopper by one of rubber through which passed two glass tubes, which projected about 6 mm. on the inner side ; outside the bottle one projected about 25 or 30 mm., the other a few millimetres less. The bottle, full to the stopper, was quickly inverted on a retort ring with the tubes projecting into the filtering funnel below the upper edge of the filter paper. Filtration then goes on without attention ; as a rule it was started in the afternoon and was finished by the following morning. Double papers were always used, sometimes Schleicher and Schull, No. 589, " black band " inside, to catch the coarser particles, with a " blue band " outside ; at other times Whatman's papers, No. 1 or No. 40. If there is much sediment No. 40 is almost too slow ; one sample took thirty-six hours to filter.

As a rule 500 ccm. was taken. The water was measured into a hard glass beaker, and 10 ccm. of 2 N ammonium chloride and 1 ccm. of the iron mixture were added, with a few drops of dilute nitric acid to dissolve the precipitate. The mixture was heated to 70° or 80° C. on the water-bath and precipitated with the smallest possible quantity of dilute ammonia ; the heating was continued until the precipitate had collected

together, when it was filtered on a small washed paper and washed twice with hot water. The precipitate on the filter and adhering to the beaker was dissolved in warm dilute nitric acid and evaporated to dryness on the water-bath to remove silica. Seven cubic centimetres of 25% HNO_3 and 20 ccm. of water were added, the dish covered, and the solution heated for twenty minutes, when it was transferred to a 50 ccm. graduated flask. If there is much insoluble residue the solution should be filtered. The bulk was then made up to about 47 ccm., leaving space for 2 ccm. of reagent. The standards were prepared by making up the requisite amounts of P_2O_5 to about 47 ccm. with 7 ccm. of 25% HNO_3 and water; the writer has generally diluted the $\frac{1}{15}$-molecular phosphate solutions used in determining hydrogen-ion concentrations by the Sorensen method. Two cubic centimetres of the strychnine-molybdate reagent were then added to each flask, the bulk completed to the mark, and the whole well shaken. In twenty minutes the solutions are ready for comparison.

The writer has never been able to secure perfect equality of illumination in the two halves of the field of the colorimeter owing to the shape and setting of the window in the Laboratory, so the precaution was always taken of reversing the position of the tubes after six readings and then taking another six. The accuracy with which the readings could be made varied very much. On some days a set of six have been obtained which did not differ by more than 0·2 mm. on 40 mm., while at other times the uncertainty was from five to ten times as great. A large sheet of ground glass between the colorimeter and the window was often of great assistance. Comparisons by artificial light were very difficult and fatiguing, but the results were satisfactory.

To test the accuracy of the method the following experiments were made :—

Part of a standard, containing 0·0237 mg., was analysed against itself. In two experiments the results were too low by 0·0005 mg. and 0·0004 mg. Three lots of 500 ccm. each of distilled water, to which 0·0237 mg. had been added, were analysed ; the errors were, +0·0010 mg., +0·0041 mg., and +0·0001 mg. From another 500 ccm., to which no phosphate had been added, 0·0036 mg. was obtained. The filtrate from this was acidified and analysed again without adding any more ammonium chloride. The amount found was again 0·0036 mg. This value was taken as the blank instead of the mean, 0·0025 mg. The result in which an excess of 0·0001 mg. was found was probably erroneous owing to the evaporation having been carried out on the sand-bath, which might give rise to overheating and formation of pyrophosphates. An artificial sea-water was

made up and found to contain 0·0100 mg. To this was added 0·0150 mg.,
and analysis showed a loss of 0·0008 mg. The result is not conclusive as
the blank on the sea-water was so high.

To test the effect of varying bulk, two lots of natural sea-water were
examined, one in its natural state, the other after evaporation to small
bulk. The amounts found were 0·0318 mg. and 0·0316 mg. respectively.
A third portion, precipitated by strong ammonia only, gave 0·0312 mg.

Filtrates from the iron precipitate were also examined. The amount
found by analysis of two lots of a sea-water were 0·0378 mg. and 0·0391
mg. To one filtrate 0·0237 mg. was added and 0·0266 mg. found, a gain
of 0·0029 mg. No more phosphate was added to the other and 0·0025 mg.
was found, using a very dilute standard. In another experiment the
figures for the original analyses were 0·0336 mg. and 0·0348 mg. ; 0·0237
mg. was added to each filtrate and gains of 0·0013 mg. and 0·003 mg.
were obtained. These gains are all small, the average being 0·0018 mg.,
half the blank on the reagents. Finally the filtrate from the sample
mentioned above as having been concentrated to small bulk was
examined after the addition of 0·0237 mg. The gain in this case was
higher, 0·0058 mg.

The fact that the errors on the filtrates, though small, were all positive,
made it seem possible that there was still phosphorus, though not neces-
sarily phosphoric acid, unprecipitated. To test this three lots of 500 ccm.
were taken ; two were analysed in their natural condition, giving 0·0336
mg. and 0·0348 mg. The third portion was boiled for three-quarters of
an hour with 10 ccm. of decinormal potassium permanganate in Jena
glass ; it was then acidified with HCl. and boiled for two hours longer.
On analysis 0·0558 mg. was found, a gain of 0·0216 mg. Another sea-
water gave 0·0415 mg. and 0·0566 mg. for the natural and oxidised por-
tions, a gain of 0·0147 mg. The filtrate from the oxidised portion was
analysed without the addition of more phosphoric acid and 0·0018 mg.
found. A similar experiment made earlier by the gravimetric method
showed an increase from 0·082 mg. to 0·147 mg. on oxidation. In one
case an untreated water was found to contain 0·09 mg. by the gravi-
metric method ; the filtrate was oxidised and yielded a further 0·07 mg

There are two possible explanations of this increase of the phosphates
by oxidation. One is that there may be in sea-water a small quantity
of organic matter which hinders but does not completely prevent the
separation of the phosphoric acid by iron ; the objection to this is that
the action would probably be irregular and the duplicate analyses would
differ more widely than they do. The other, to which the writer inclines,
is that there is a considerable amount of phosphorus present in forms

other than phosphoric acid, perhaps as phosphites or as an organic compound, which is oxidised to phosphoric acid by potassium permanganate.

The ratio of phosphoric acid found in the untreated sample to the total shows a tendency to constancy, but it has not been determined yet whether the permanganate method converts the whole of the phosphorus into phosphoric acid, and experiments on this are in progress.

The samples of sea-water, with two exceptions, were taken at the Knap Buoy, half a mile outside the lighthouse on Plymouth Breakwater. The other two were taken close to the rocks under the Laboratory.

The results are given in the following table, and also the method by which they were obtained.

The salinity was determined against the *International Normal Water*.

SURFACE SAMPLES TAKEN AT THE KNAP BUOY.

Date.	G.M.T.	S. ‰	Method.	P_2O_5, mg. per litre.	
				Found in duplicates.	Mean.
1915					
April 21	10.30 a.m.	—	Iron and gravimetric	—	0·1
,, 23	,, ,,	—	,, ,,	—	0·1
June 21	10.30 a.m.	—	,, ,,	—	0·049
July 5	noon	—	,, ,,	—	0·064
,, 12	10.30 a.m.	—	,, ,,	—	0·09
,, 14	11.40 a.m.	34·83	,, ,,	—	0·082
Sept. 13	11.30 a.m.	34·92	,, ,,	—	0·04
,, 21	10.30 a.m.	34·96	Ammonia and colour	—	0·046
Nov. 24	11.35 a.m.	34·78	,, ,,	0·042, 0·041	0·0415
,, 26	11.45 a.m.	34·43	,, ,,	0·040, 0·034	0·037
,, 29	11.10 a.m.	34·14	,, ,,	0·040, 0·037	0·0385
Dec. 2	12.20 p.m.	—	,, ,,	0·0484, 0·0435	0·0460
,, 9	10.30 a.m.	31·46	,, ,,	0·049, 0·047	0·048
,, 13	11.30 a.m.	—	,, ,,	0·044, 0·041	0·0425
,, 16	12.10 p.m.	26·20	,, ,,	—	0·043
,, 20	11.25 a.m.	29·69	,, ,,	0·058, 0·064	0·061
1916					
Jan. 3	11.35 a.m.	25·66	,, ,,	0·057, 0·057	0·057
,, 14	1.55 p.m.	33·87	Iron and colour	0·0318, 0·0316	0·0317
,, 18	2.30 p.m.	33·93	,, ,,	0·0336, 0·0348	0·0342
,, 24	11.20 a.m.	33·42	,, ,,	0·0378, 0·0391	0·0384
Feb. 5	12.30 p.m.	31·58	,, ,,	0·0507, 0·0414	0·0460

SURFACE SAMPLES TAKEN UNDER LABORATORY.

Date.	G.M.T.	S. ‰	Method.	Found in duplicates.	Mean.
1916					
Jan. 17	—	—	Iron and colour	0·0602, 0·0572	0·0587
Feb. 11	—	—	,, ,,	0·0408, 0·0421	0·0414

A few points come out clearly from the results.

In the first place, the results are much lower than those obtained by Raben for the Baltic and North Sea, his lowest being 0·14 mg. per litre against 0·1 mg., the highest found at Plymouth. The salinity at the Knap Buoy is nominally 33·5 per thousand up to nearly 35, comparable with a large part of the North Sea. But the North Sea receives enough fresh water from the great rivers of Russia and Germany to keep the salinity of nearly the whole of it below 35 per thousand, while the effect of the land drainage in the western part of the English Channel is confined to a comparatively narrow band along the coast. The effect of an increased supply of land water in increasing the phosphoric acid is seen in the results for December 20 and January 3, when the salinity was very low ; a sudden rise occurred then after the figures had been fairly constant for two months or more. This rise did not show itself till a few days after the salinity had fallen, which suggests that much of the phosphorus from the land enters the sea in an incompletely oxidised form and is then converted, by bacterial action, into phosphoric acid.

If the earlier gravimetric results are taken as correct there is a decided seasonal change, the higher values being found in spring and summer, but the writer is not inclined to place much confidence in them. The experiments are being continued and it is hoped that the next few months will settle the question.

It is unfortunate that so far it has not been possible to obtain samples at a greater distance from shore, as it may be that the increased phosphoric acid found after oxidation is a purely littoral or estuarine phenomenon resulting from the form in which part of the phosphoric acid is carried down by land-water. It does not seem likely that it arises from diatoms or bacteria which pass through a paper filter, as the same increase was noticed on oxidising a filtrate from a solution in which iron had been precipitated by ammonia, a very efficient method of removing the finest suspended particles. The approximately constant ratio of the two forms of phosphorus is also an objection to this explanation.

SUMMARY.

1. Phosphoric acid in sea-water may be determined with an accuracy of about 0·003 mg. per litre by concentration with iron and colorimetric examination.

2. If the sea-water be previously oxidised by potassium permanganate the amount found is considerably increased.

3. From September, 1915, to February, 1916, the average amount of phosphoric acid in water collected half a mile outside Plymouth Break-

water was 0·044 mg. per litre ; this showed signs of an increase when the supply of land-water rose after rain. The figures are much lower than those found by Raben for the Baltic and North Sea.

4. The amounts found by another method during the previous spring and summer are higher, but the figures cannot be considered quite trustworthy.

Note.—Since the above was written, it has been found that boiling with potassium permanganate does not oxidise the whole of the phosphorus with certainty. Duplicate analyses of a sample taken on Jan. 17th, 1916, both gave 0·0190 mg. per litre. Two other portions were oxidised and found to contain 0·0449 mg. and 0·0569 mg. per litre.

An attempt has also been made to determine whether any of the phosphoric acid is reduced to other forms in the short interval between the collection of the water and the beginning of the analysis. A sample of water was sterilised with toluol immediately after taking. A single determination showed 0·0350 mg. per litre in the original sample, and 0·0375 mg. after oxidation. But the water for over a week had been extraordinarily clear and free from suspended matter, far more so than any of the samples given in the table, so that the experiment cannot be considered conclusive.

BIBLIOGRAPHY.

1. C. Schmidt.—Hydrologische Untersuchungen. Bull. Akad. Petersburg. Bd. 24, 1878. Quoted by Brandt.

2. K. Brandt.—Ueber den Stoffwechsel im Meere. 2 Abhandlung. Wiss. Meeresuntersuch. Kiel, 1902.

3. K. Brandt.—Untersuch. über den Gehalt des Meerwassers an spurenweise vertretenen Pflanzen-Nahrstoffen. Beteil. Deutschlands a.d. internat. Meeresforch. I, II and III Jahresbericht.

4. O. Krümmel.—Ozeanographie I, p. 323.

5. Pouget, I., and Chouchak, D.—Dosage colorimétrique de l'acide phosphorique. Bull. Soc. Chim. France. 4 series, V, 1909, p. 104, and IX, 1911, p. 649.

In Memoriam.

H. C. DANNEVIG, Director; G. W. C. PIM, Master; C. T. HARRISSON, Biologist; and eighteen others, comprising the crew of the Australian Fishery Investigation steamer *Endeavour*, who were lost at sea in December, 1914.

THE FEDERAL GOVERNMENT TRAWLER "ENDEAVOUR"
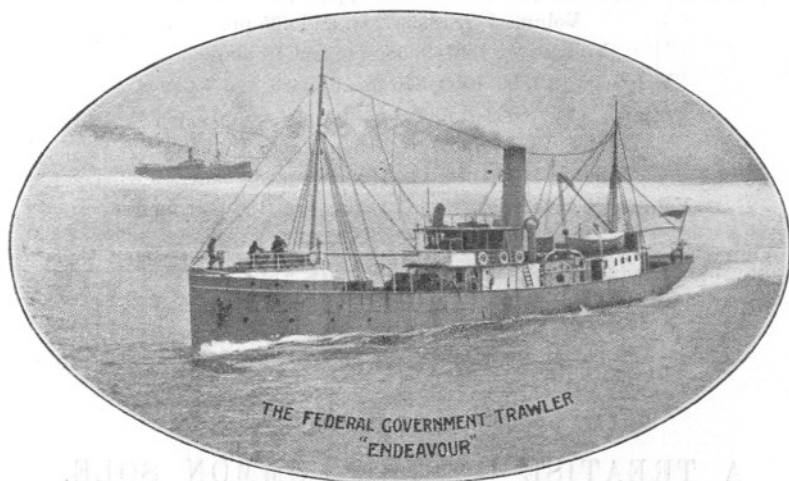
The Department of Trade and Customs of the Commonwealth of Australia have issued a memorial number of their Report on Fisheries, giving particulars, as far as they are known, of the loss at sea of their investigation steamer *Endeavour*, with all on board, including the Commonwealth Director of Fisheries, Harald Christian Dannevig; the Biologist, Charles Turnbull Harrisson; the Captain, George William Charles Pim, and a crew of eighteen men. The ship left Macquarie Island on December 3rd, 1914, to return to Australia and was not heard of again. It is thought that she perished in a heavy gale which was experienced on the island two days after she had left.

The work carried out by Dannevig with the *Endeavour*—a steam trawler specially built for fishery investigations in Australian waters—is well known to all Marine Biologists, and ranks with the best work of the kind which has been accomplished anywhere. The sympathy of British naturalists will be extended to their Australian colleagues, as well as to the relatives and friends of those whom the sea has claimed, in the sad loss they have sustained.

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E. RAY LANKESTER, M.A., LL.D., F.R.S.,

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

OBJECTS

OF THE

Marine Biological Association

OF THE UNITED KINGDOM.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the late Duke of ARGYLL, the late Sir LYON PLAYFAIR, the late Lord AVEBURY, the late Sir JOSEPH HOOKER, the late Dr. CARPENTER, the late Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Sir E. RAY LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where researches on food-fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing-boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the Staff.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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All correspondence should be addressed to the Director, The Laboratory, Plymouth.