

## Observations on the Growth of the Claspers and Cloaca in *Raia clavata* Linnaeus.

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With 7 Figures in the Text.

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### I. INTRODUCTORY.

IN the course of work on the life-history and biology of the *Raiidæ* in the English Channel, and especially of *R. clavata*, the most important species commercially (4, p. 9 *et seq.*), it has been found necessary to attempt to disentangle the migrations of sexually mature fishes from those of juvenile individuals by means of marking experiments. In both sexes sufficiently small individuals could with safety be written down as juveniles and the largest of both sexes as adults. There remained, however, a considerable but ill-defined range of sizes (different in the two sexes) within which might be found fishes of all stages—juveniles, adolescents and adults.

In dealing with male fishes this difficulty was overcome by noting the size and condition of the claspers. In the female, however, the writer was not aware of a corresponding—or any other—external feature from which could be deduced with reasonable accuracy *in a live fish* her state of sexual development. The present investigation was undertaken, therefore, in order to discover whether or not such a feature existed. Attention soon became directed to the greatly accelerated relative growth rate in the cloaca of adolescent fishes and the relatively much greater length of this organ in mature than in juvenile individuals.

During this adolescent period of greatly accelerated growth in length, the cloaca also changes markedly in shape, becoming very much widened out, especially at its inner end (*cf.* Figs. 4 and 5). These changes in the size and shape of the cloaca are so extensive as to be easily discernible by

digital examination. There is thus available in the female as well as in the male a ready means of ascertaining the sexual condition of the live fish. This method is now being applied in all further Ray-marking experiments.

The results of detailed observations on these changes in the growth of the claspers and cloaca in *R. clavata* form the substance of this paper.

## II. THE CLASPERS.

All species of Rays and Skates (Raiidæ) exhibit well-marked sexual dimorphism. Some of the secondary sexual characters, such as the presence of alar and malar spines and more pointed teeth in the male, become obvious only in sexually mature or nearly mature individuals. The presence of claspers in the male can be detected, however, at a very early stage of development. Thus, during at least the latter part of their embryonic development within the egg, and throughout the entire post-embryonic life of these fishes, the presence or absence of claspers forms a ready means of distinguishing male from female. In addition to their being the most characteristic and most easily discernible feature of the male fish, the claspers serve also, better than any other externally evident character, as an index of his state of sexual development. During the entire period of juvenile growth, before the onset of adolescence,\* the claspers remain relatively small and inconspicuous, so much so that they may be entirely invisible from the dorsal side being shorter than, and hidden by, the pelvic fins. But at the onset of adolescence the claspers suddenly begin to grow very rapidly, and their tips soon extend backwards far beyond the limits of the pelvic fins.

This sudden change in the size and condition of the claspers was long ago noticed by ichthyologists. In the year 1877, for example, Malm (3, p. 607) stated that in a male *R. clavata* 216 mm. long the claspers were only about 3 mm. in length. In 1895 Fries (2, p. 1106) wrote that in a male of this species about 45 cm. long the claspers were "still quite small and short, their tips extending only a little more than half-way along the ventral fins." In a specimen 52 cm. in length he records that the circumstances were "essentially the same" except that the claspers were just a little longer in relation to the fins. But in an individual "rather more than 60 cm. long" Fries remarks that the claspers were so well developed that their tips extended back to more than half-way along the length of the tail.

In order to follow more closely these changes in the relative growth rate

\* The post-embryonic life of a Ray is very clearly divided into the usual phases: (1) the *juvenile* phase, during which the fish simply grows in size; (2) the *adolescent* phase, during which fundamental changes take place very rapidly and bring the individual to puberty; (3) the *adult* (sexually mature) phase.

of the claspers, measurements have been made on representative samples of male *R. clavata* at all sizes from recently-hatched individuals upwards to the largest obtainable. In recording the lengths of the claspers, for the sake of uniformity all measurements have been made on the left clasper. The length has been taken as the distance between the tip of the clasper and its point of emergence from the skin on the inner side (Fig. 1). This point is sometimes not well defined in adult fishes with large claspers, and exact measurements are not with them possible. A small part of the variation in recorded clasper lengths of adult fishes must be ascribed,

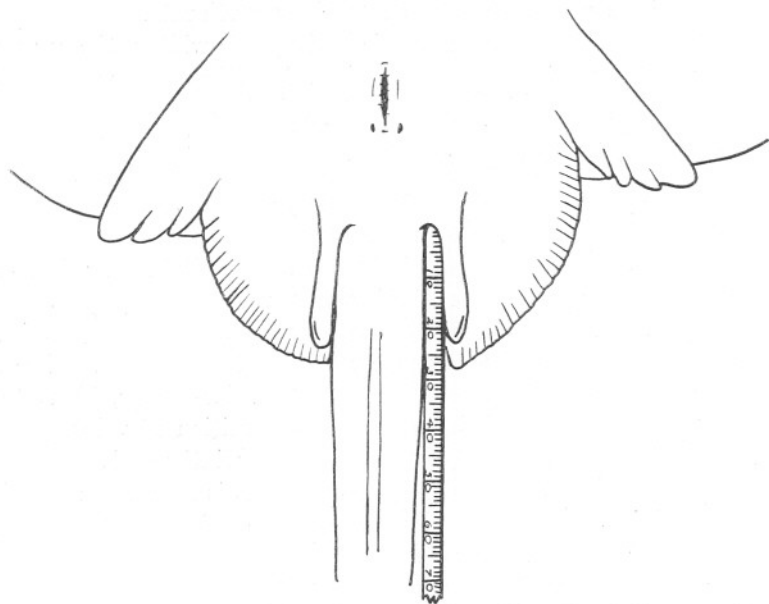


FIG. 1.—*R. clavata*—juvenile male; 31 cm. disc width; clasper 22 mm.  $\times \frac{2}{3}$ .  
(See text.)

therefore, to the action of this purely extrinsic factor as well as to the individual variations in size and body-proportions which are always found in the separate representatives of every animal (and plant) species.

It is found that throughout the immature stages of development the claspers grow slowly and regularly, their length at any time during the juvenile phase showing a linear correlation with the total size of the fish, as expressed, say, by width of disc; that is to say that points representing the length of the clasper at different times during the juvenile growth period plotted against the width of the disc fall upon a straight line. This is well shown in Figure 2. Each plotted point indicates the mean value of numerous clasper measurements in centimetre size-groups of fishes. The

lengths of the vertical lines drawn through those points indicate the ranges of the measurements from which the means were drawn.\*

It will be seen that for fishes up to and including the 43-cm. size-group the mean values lie very closely along the straight line *ab*, the correlation equation for which is  $Y=0.993 X-5.596$

where  $Y$ =length of clasper (in mm.), and  $X$ =width of disc (in cm.). In succeeding size-groups the ranges of clasper length measurements show progressive extension in an upward direction and the mean values rise rapidly above the line *ab*. This means that in some fishes the claspers are now exhibiting a greatly accelerated relative growth rate.

In size-groups 50 cm. to 54 cm. (inclusive) disc widths, the ranges of clasper lengths reach and retain maximum values, these organs now having attained the fully adult size in some fishes while in others they still remain in the juvenile condition. Examination of Figure 2 clearly shows that the onset of the change in relative growth rate of the claspers, with which are correlated all the other phenomena of adolescence, does not always take place in all fishes at the same size. In some this change takes place when they have attained a disc width of round about 44 cm.; in others it is delayed until a much larger size is reached.

In Figure 3 these results, for the larger fishes, are shown graphically in a different manner which brings out this point more fully. Here the length of the clasper in individual fishes of 5-cm. size-groups, from 36 cm. in width of disc upwards, is indicated by the position of a dot. In the smallest size-group represented—36–40 cm. disc widths—all the claspers are still short and the range of recorded lengths is small. In the size-group next above—41–45 cm. disc widths—most of the fishes still have short claspers, but a few have entered the adolescent phase and are showing increased relative growth rate of this organ. In the size-group next higher again this process has proceeded still farther and one individual has actually become fully mature.

The size-group 51–55 cm. disc widths is of particular interest. Here the clasper length measurements show two distinct modes—one at the lower end of the range, produced by fishes which are still in the juvenile phase, and one at the upper end of the range, produced by fully adult individuals.† The approximately symmetrical bi-modal curve produced by the clasper length measurements of this group confirms the conclusions to be deduced from analyses of the complete data presented in Figures 2 and 3. These are:—

- (1) that, in the English Channel area, in any sample of male *R. clavata*

\* Mean values for those size-groups which include adolescents and later stages are without significance and are not shown.

† Shortest clasper found in a fully mature male—176 mm. (*vide* dotted line, Figs. 2 and 3).

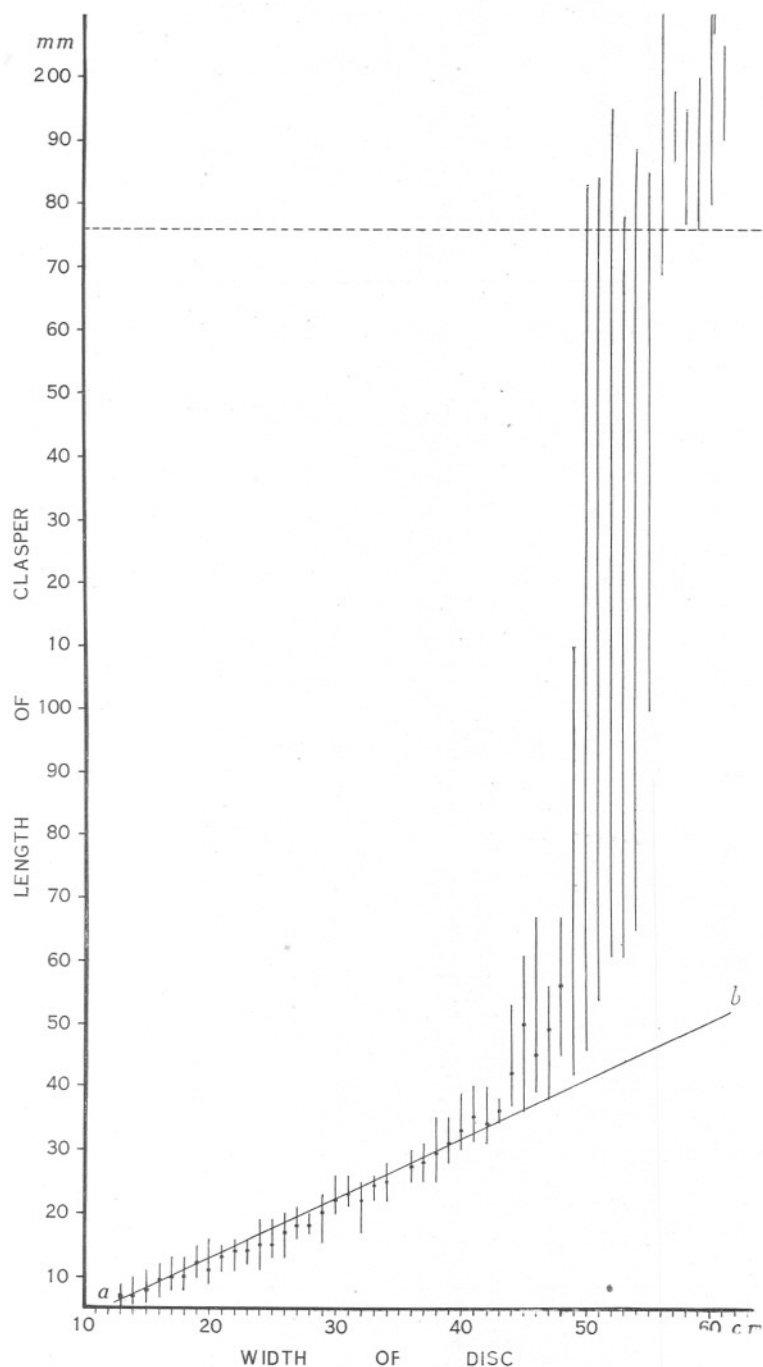


FIG. 2.—*R. clavata*—clasper length plotted against disc width in centimetre size-groups. (For explanation see text p. 889.)

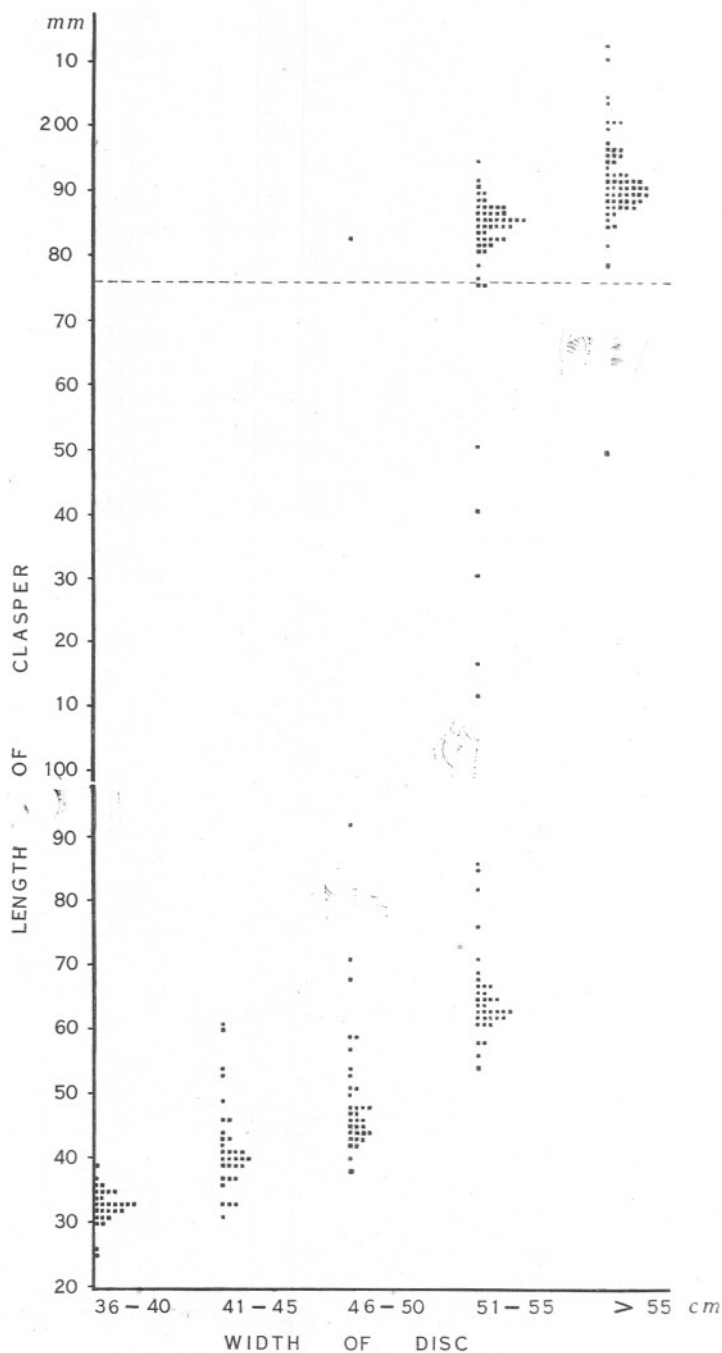


FIG. 3.—*R. clavata*—clasper length plotted against disc width in 5 cm. size-groups. (For explanation see text p. 890.)

in which no fish exceeds about 50 cm. disc width, the great majority of the individuals will be immature juveniles. This will hold true whether the sample be restricted to any arbitrary size-group of small range or consists of fishes at all sizes up to 50 cm. (about) disc width. Over most of this range samples of restricted size-groups will consist of 100 per cent juveniles, but samples at or near its extreme upper limit will contain a certain proportion of individuals at more advanced stages.

(2) that, similarly, in any sample which includes no fishes of less than approximately 56 cm. disc width, the majority of the individuals will be mature adults.

(3) that, in any representative sample of male fish of size-group 51–55 cm. (inclusive) disc widths, juveniles and adults will tend to be equally represented, while adolescents at all intermediate stages will also be found.

### III. THE CLOACA.

The cloaca of the female Ray exhibits growth phenomena very similar to those found in the claspers of the male, and cloacal measurements have been made on individuals at all stages of growth. The distance from the anterior edge of the cloacal opening to the anterior end of the cloaca (in the middle line) when in normal extension, has been used as the measure of cloacal length. This measurement is made by opening the abdominal cavity and placing the tip of one finger of the left hand against the anterior end of the cloaca as it lies in position. At the same time a not too sharply pointed rod, graduated in millimetres, is inserted into the cloacal aperture and pushed forward until it presses against the left-hand finger. The length of the cloaca is then read off where the anterior edge of the cloacal external opening crosses the rod (Figs. 4 and 5).

Throughout the juvenile phase the cloaca grows only slowly and, like the clasper of the male, preserves a linear correlation between its length and the body dimensions of the whole fish. In Figure 6 the cloaca lengths in fishes of centimetre size-groups are plotted against disc widths. For fishes up to and including the 59-cm. size-group the mean values lie very closely along the straight line *ab* whose correlation equation is

$$Y=0.574 X-2.175$$

where  $Y$ =length of cloaca (in mm.), and  $X$ =width of disc (in cm.). In fishes over this size the cloaca shows greatly accelerated relative growth rate in many individuals and the range of cloacal length measurements increases enormously, reaching and retaining maximum values in fishes of about 67–76 cm. (inclusive) disc widths.

In Figure 7 the length of the cloaca in individual fishes of 5-cm. size-groups, from 36-cm. disc width upwards, is plotted. In this figure the cloacal length measurements produce an approximately symmetrical

bi-modal curve in the size-group 66-70 cm. disc widths. From perusal of Figures 6 and 7, therefore, the following conclusions can be drawn concerning the females of *R. clavata* in the English Channel area :—

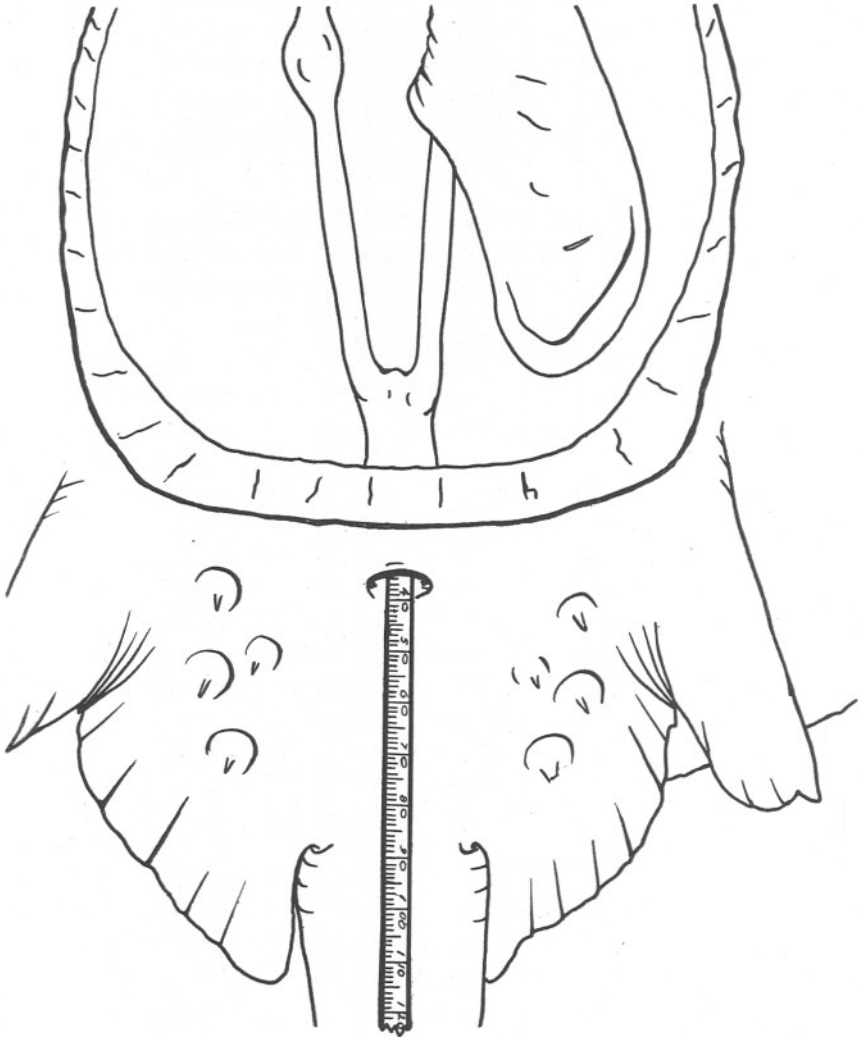


FIG. 4.—*R. clavata*—juvenile female; 65 cm. disc width; 36 mm. cloaca length. Dissected to show cloaca. Note immature left ovary (left *in situ*), and small shell gland.  $\times \frac{3}{4}$ . (For further explanation see text pp. 887 and 893.)

(1) that in any sample of female fishes of this species in which no individual exceeds about 65 cm. in width of disc the great majority will be immature juveniles. This will hold true whether the sample be restricted to any arbitrary size-group of small range or consists of fishes



at all sizes up to the 65 cm. (maximum) disc width. Over most of this range samples of restricted size-groups will consist of 100 per cent

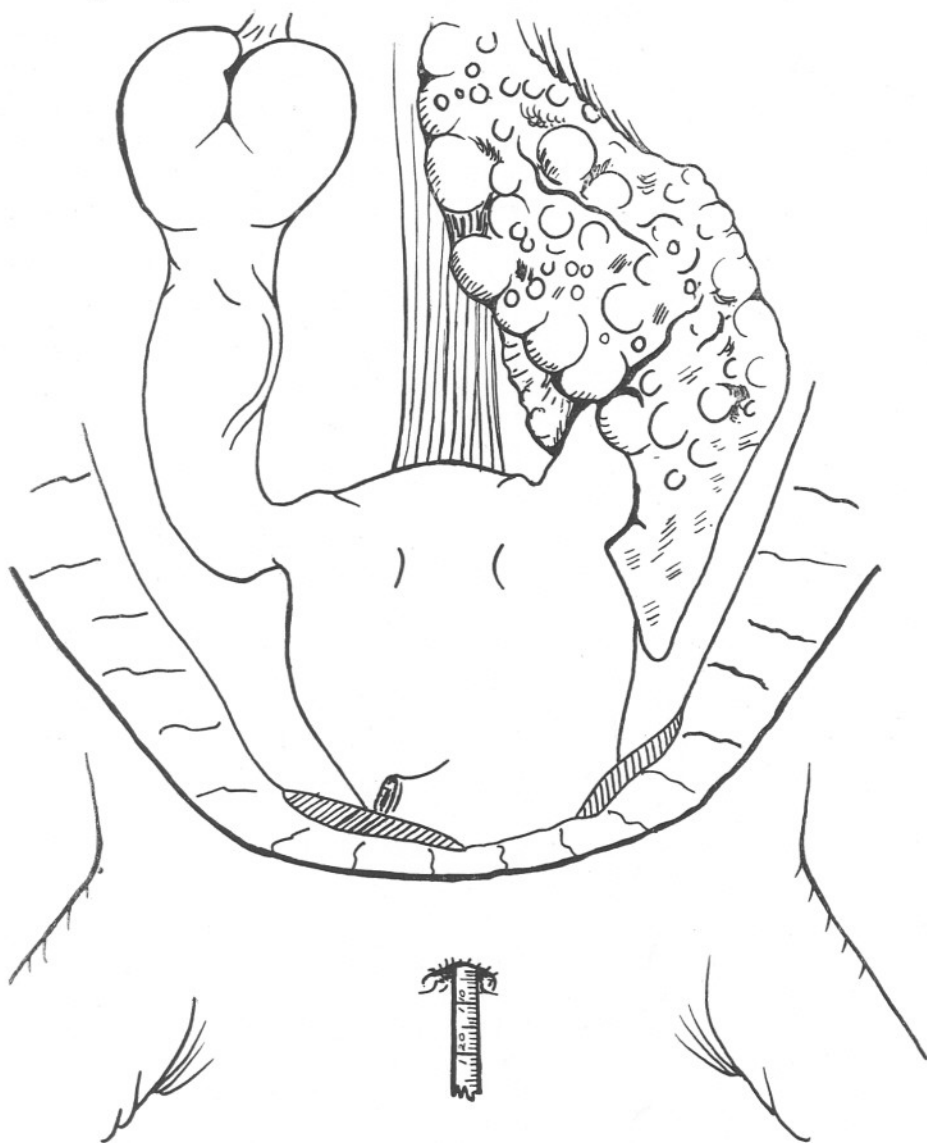


FIG. 5.—*R. clavata*—mature female; 72 cm. disc width; 102 mm. cloaca length. Dissected to show cloaca. Note also developing eggs in ovary and large shell gland.  $\times \frac{2}{3}$ . (For further explanation see pp. 887 and 893.)

juveniles, but samples at or near its extreme upper limit will contain a certain proportion of individuals at more advanced stages.

(2) that, similarly, in any sample which includes no fishes of less than approximately 70 cm. disc width, the majority—but not all—of the individuals will be mature adults.\*

(3) that in any representative sample of females of size-groups 66–70 cm. (inclusive) disc widths, juveniles and adults will tend to be equally represented, while adolescents at all intermediate stages will also be found.

In the course of this work, the possibility that, after all one season's eggs have been deposited, the cloaca may return to its virgin condition

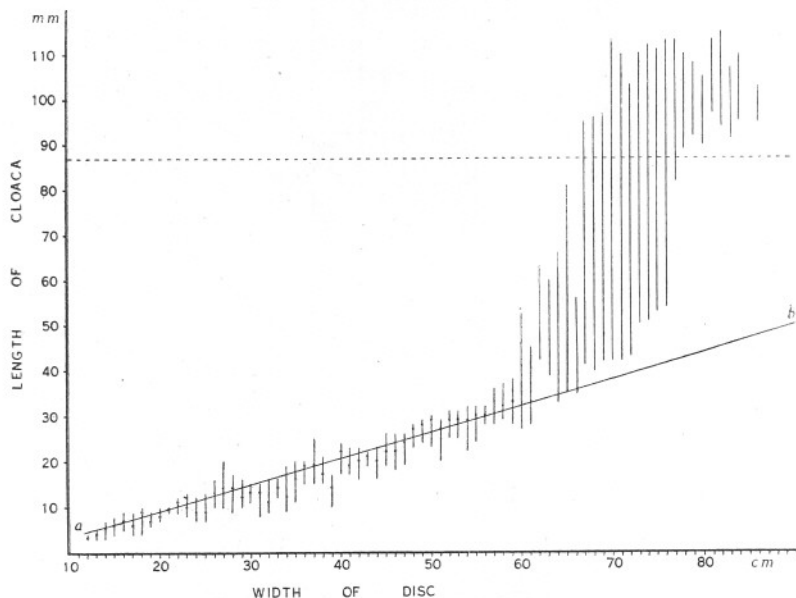


FIG. 6.—*R. clavata*—cloaca length plotted against disc width in centimetre size-groups. (For explanation see text p. 893.)

has not been overlooked. But the fact that the range of cloacal length measurements in all fishes of 76 cm. and upwards in width of disc is relatively small, grouped around a mean value of about 100 mm.—a figure far removed from that which would be expected in virgin females of those sizes—suggests very strongly that this does not happen. This conclusion is further supported by these additional observations. On Newlyn (Cornwall) fishmarket, in September, 1932, the plan was adopted of trying to find a fish of 76 cm. disc width or over with a small cloaca of say 50 mm. length or less. Though many hundreds of fishes were examined, including a large number with fully spent ovaries, the shortest cloaca length

\* Shortest cloaca length recorded in a fully mature fish—87 mm. (*vide* dotted line, Figs. 6 and 7).

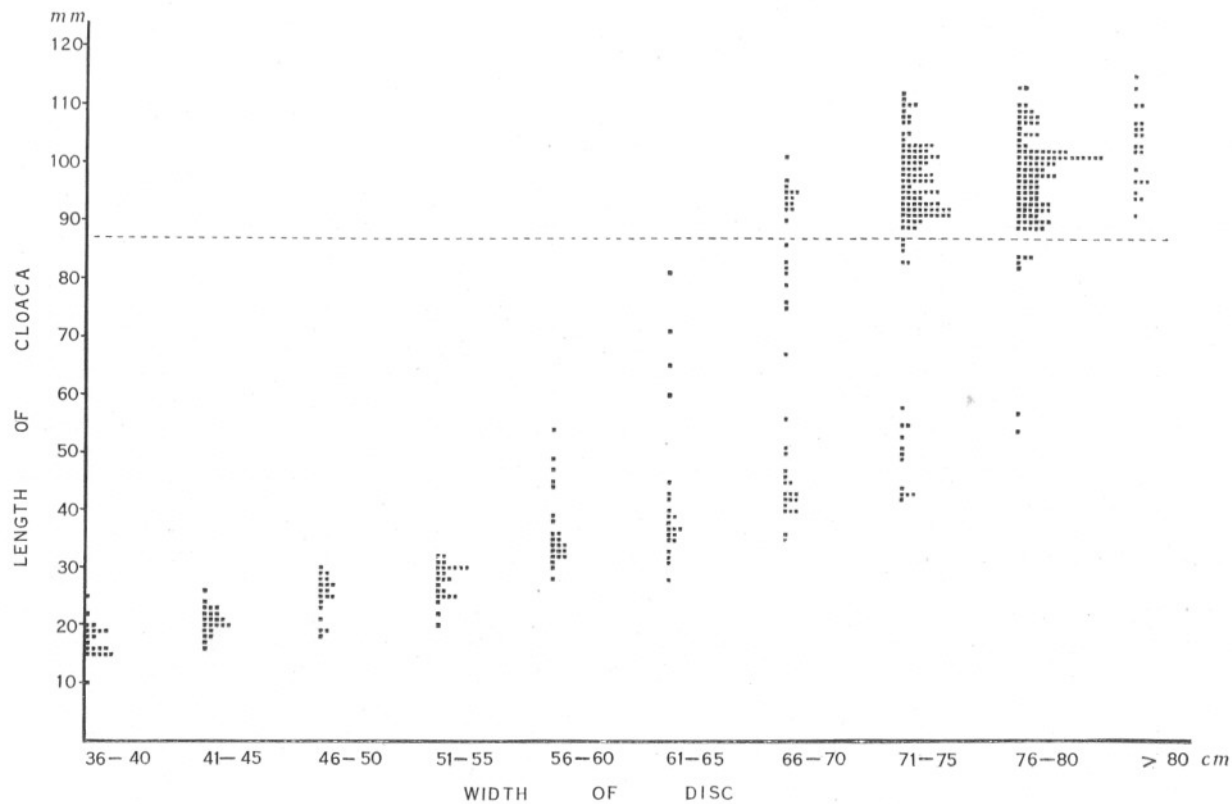


FIG. 7.—*R. clavata*—cloaca length plotted against disc width in 5 cm. size-groups. (For explanation see text p. 893.)

recorded was 87 mm. This was in a gravid female of 76 cm. disc width and containing in each uterus an egg ready for deposition.

#### IV. PRACTICAL APPLICATIONS.

A. It will be seen from Figure 2 that the 44-cm. (centimetre) size-group of male fishes contains the smallest individuals which show unmistakable acceleration in the relative growth rate of the claspers, thus indicating that they have entered the adolescent phase. The 50-cm. (centimetre) size-group contains the smallest fishes which have become fully mature.

It may with safety be assumed that the first (smallest) fishes to enter the adolescent phase will be also the first (smallest) fishes to reach puberty. It would thus appear that in the males of this species, the adolescent phase occupies roughly the time required to grow round about 6 cm. in width of disc.

Now the results (unpublished data) of the marking experiments so far carried out (*vide* p. 1) indicate that the adolescent males of *R. Clavata* grow at the rate of from about 3 cm. to 5 cm. disc width in the course of one annual growing period. The experiments are being continued and full details will be published in a subsequent paper. But sufficient data have already been collected to suggest that the above figures are reasonably reliable. If this be so, it would appear that in the males of this species the adolescent phase normally occupies rather more than one and not more than two growing periods. From this it may reasonably be concluded that these fishes enter the adolescent phase during one growing period and reach puberty during the growing period of the following year, the time occupied by the changes extending over part or all of the two periods.

In the females (Fig. 6) the difference in size between the smallest fishes to enter the adolescent phase and the smallest to reach puberty appears to be most frequently about 7 cm. disc width. Although females grow rather more rapidly at this stage than males, this difference in size represents in them too the growth increment of more than one and not more than two growing periods. The period of adolescence would appear, therefore, to be the same in both sexes.

B. It has been recorded in a previous paper (5, p. 617) that, on certain fishing grounds near Plymouth, there is in the spring months of every year, a congregation of large and fully mature Thornback Rays. At the same time that these adult fishes are being landed by fishing boats using fixed nets, other landings are being made by vessels using long lines or "boulders" on different grounds in the vicinity. A marked feature of the fishes caught on these lines at this time is that they frequently contain a high proportion of adolescent individuals. As with the adults from

the nets (5, p. 617), so also with these adolescents, a landing will often consist almost entirely of one sex, either male or female. From consideration of the data set forth above it seems likely that these adolescent fishes, typical of "boulter" landings in the spring, entered the adolescent phase during the growing period of the previous year and that the majority, at any rate, of the year-class to which they belong will reach puberty during the growing period immediately following—i.e. later on in the same year. By the ensuing spring these young adults will have joined the shoals of mature fish which will populate the fixed-net fishing grounds at that time.

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