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# A NOTE ON THE BREEDING SEASON, SEX RATIO AND EMBRYONIC DEVELOPMENT OF THE DOGFISH *SCYLIORHINUS CANICULA* (L.)

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(With an Appendix by C. A. Hoodless and G. A. Steven)

(Text-figs. 1–3)

For many years past the Department of Zoology at Bristol has obtained all its dogfish from a single supplier, Mr E. G. Williams of Ilfracombe. In addition to those fish purchased for dissection, a large number has been obtained for work on the development of the behaviour pattern in the embryo, and over the last 3 years a certain amount of detailed but incidental information has been accumulated on the topics which form the title of this paper. This information supplements the interesting account given by Ford (1921), and since it is not proposed to carry out a more detailed study on these subjects, the material is offered in its present form as a short additional chapter on the biology of a common laboratory type, and in the hope of stimulating further work on these lines.

In addition to noting the numbers and sex of all dogfish delivered at the Department, all well-developed eggs are removed from the oviducts of the females and are reared in the laboratory aquarium, where a very high proportion of the embryos (70–100 % of those received in the cooler months of the year) develop successfully. There is no reason to believe that the fish received are other than random samples of the population caught, and the necessarily tentative deductions made below are based on this assumption.

## The Breeding Season

Ford (1921) presents evidence which suggests that eggs are laid throughout the year. This may well be true, but the Ilfracombe fish show a rather more sharply defined breeding season than the Plymouth material. No consignments have ever been delivered in the month of August, but for the remaining months of the year the number and percentage of females carrying egg-purses is shown in Table I and Fig. 2. The deliveries covered a continuous period from May 1949 to December 1951.

While the figures for some months are smaller than one could wish, they appear to show that breeding starts in November when only 18 % of the

females are carrying egg-purses, and continues at least until July. From December to July any sample examined will show about one-third of the females carrying egg-purses, and this proportion remains remarkably constant.

TABLE I

| Month | No. of fish delivered | | | No. of females carrying egg-purses |
|---|---|---|---|---|
| | Male | Female | Total | |
| Sept. | 7 | 50 | 57 | 0 |
| Oct. | 25 | 44 | 69 | 0 |
| Nov. | 83 | 197 | 280 | 35 |
| Dec. | 49 | 145 | 194 | 41 |
| Jan. | 7 | 172 | 179 | 73 |
| Feb. | 31 | 47 | 78 | 16 |
| Mar. | 115 | 186 | 301 | 62 |
| Apr. | 71 | 61 | 132 | 20 |
| May | 228 | 158 | 386 | 47 |
| June | 119 | 61 | 180 | 19 |
| July | 8 | 34 | 42 | 13 |
| Aug. | — | — | — | — |

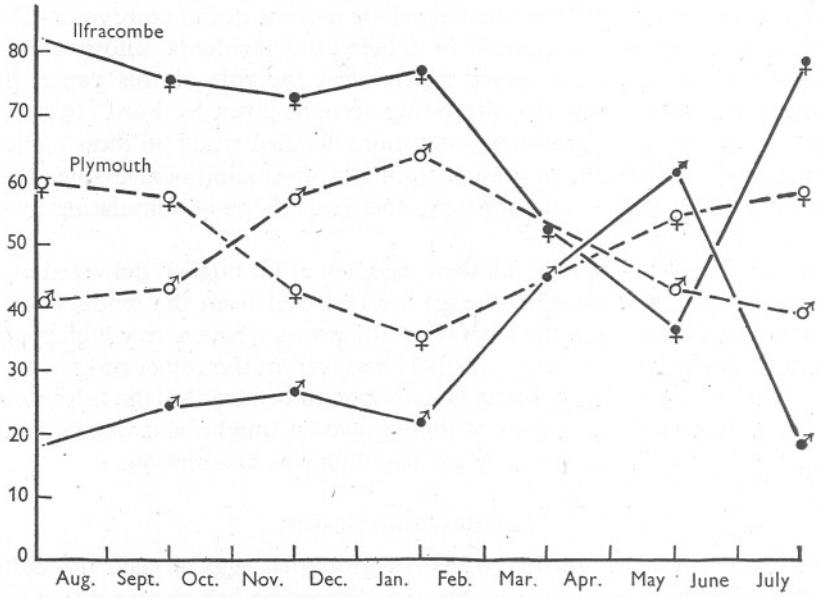


Fig. 1. *S. canicula*. The percentage of males and females in the Ilfracombe and Plymouth samples at different times of year (Plymouth figures from Ford, 1921).

In September and October, however, no egg-purses were found in ninety-four female fish. These are also the 2 months showing the smallest percentage of egg-bearing females in Ford's analysis (his figures for August are based on only five females of which two carried egg-purses). This observation would accord with the statement of Lloyd (1942) that, in the few specimens of

*Scyliorhinus canicula* taken at Weston in October and November, the gonads were developing.

The constant proportion of females carrying egg-purses over 8 months (perhaps 9) of the year, and the fact that no appreciable size variation has been associated with this condition, tempts one to suggest that within this period *all* the females in our Ilfracombe samples have been mature. Since fish which have just laid and which have not yet formed a hardened egg case around the next egg in the series would, on this assumption, constitute the remaining two-thirds of the female population, the figures suggest that the

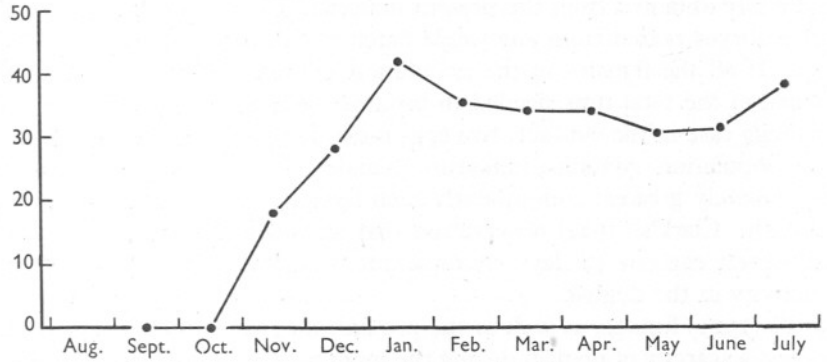


Fig. 2. *S. canicula*. The percentage of females carrying fully formed eggs. The proportion indicated therefore excludes (*a*) all fish which have just laid their eggs and have not yet completed the secretion of the next egg cases in the sequence, as well as (*b*) the immature females in the population.

time occupied by the fully formed egg-purse in the oviduct is one-third of the total time needed from ovulation to laying. If, on the other hand, a substantial number of immature females existed in the population during the winter months, the proportion of egg-bearing fish would be expected to rise as the breeding season progresses—which is apparently not true after November.

## The Sex Ratio

The total number of fish examined was 1898, of which 743 or 39·1 % were males. This presents an interesting difference from Ford's figures, in which out of 4368 fish, 2401 or 55·0 % were males. Apart from this predominantly female population in the Ilfracombe fish, the detailed analysis of the seasonal variation shows an almost exactly opposed trend to that at Plymouth; females predominate in the winter and spring months, and only in May and June is there an excess of males (Fig. 1).

The proportion of females in the Ilfracombe population is very high in September, and remains high until the end of January; not until February does the proportion of males begin to increase substantially. Yet we have

supposed that most, if not all, the females caught after November are fully mature and producing fertilized eggs. Metten (1939) has proved that the folds of the shell-secreting portion of the nidamentary gland serve as a sperm reservoir; viable sperm can be stored there for long periods. It is therefore quite possible that the females are inseminated in deeper waters before they come into the Ilfracombe region to lay their eggs. The fact that the Bristol channel region is a natural spawning ground for the females is indicated by records of egg cases taken in Bridgwater Bay, Kilve and Blue Anchor (Lloyd, 1941, 1942).

An approximate estimate of the productivity of the female *S. canicula* can be indirectly obtained from the present material. The maximum variation in age of embryos reared from any single batch of fish received has been about 2 days. If all the females in the population are mature, we have seen that one-third of the total time needed to produce each egg is spent by the fully formed egg case in the oviduct; two eggs must therefore be laid every 6 days. If the population contains immature females, the productivity must be proportionately greater; consequently each female must lay at least ten eggs per month. Clark's (1922) observation that an isolated *Raia brachyura* laid twenty-seven eggs in 49 days is consistent with this high estimate of egg productivity in the dogfish.

Ford's (1921) figures, as well as the present ones from Ilfracombe, appear to suggest a scarcity of dogfish during the months of July and August. This is not in fact true; the low figure for these months merely indicates the holiday season at Ilfracombe, and according to Ford (personal communication) a corresponding absence of records at Plymouth. Neither Ford nor the present writer would claim any quantitative significance in the figures for total catch per month; Hoodless and Steven's table (Appendix, Table II) therefore adds an interesting and useful summary on this point, showing no sign of any fall off in numbers during the summer months.

## Growth of the Embryo

In the course of the behaviour studies mentioned it has been necessary to assign accurate growth stages to the embryos, particularly in the period up to the development of the pelvic fins and external gill filaments, by which time the adult physiological pattern has been largely established. It is fortunate that over the whole of this range the correspondence with the stages of development of *Squalus acanthias*, so fully described and figured by Scammon (1911), is almost exact. Scammon's tables have therefore been used throughout the work, and have made possible a fairly accurate picture of the rate of development. The marine aquarium at Bristol is refrigerated and thermostatically controlled, but the refrigeration plant was out of action for a long period. During the whole time, morning and evening records of the

water temperature were kept, and the curves in Fig. 3 show the time taken to attain the various stages described by Scammon at several different temperatures. Where the temperature varied during development, the value given is the mean throughout the whole of the development up to the time the embryo was removed for examination.

The curves are useful for those who wish to obtain specimens of known morphology for embryological work, but they also offer one additional piece of information. The curve for 15·5° C. is reasonably complete, and the few

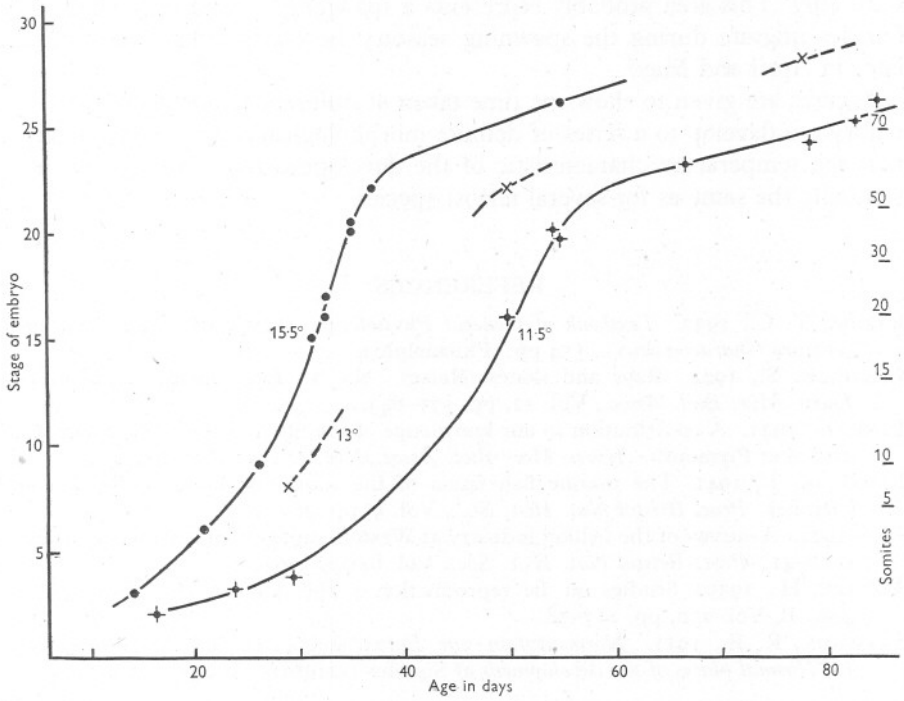


Fig. 3. *S. canicula.* Growth curves of the embryo dogfish. The stages correspond with those given in Scammon (1911).

points available on the 11·5° C. curve correspond exactly to a development time which, stage for stage, is 1·64 times as long as at the higher temperature. For what it is worth, this ratio corresponds to a temperature coefficient of rate of development with a value of $\mu = 20{,}000$. This figure is not very accurate, since the temperatures are not known to a sufficient degree of exactness, but it is probably within $\pm 10\,\%$. It appears, therefore, that the temperature characteristic of the development of this elasmobranch is close to the values obtained for several teleost fishes—trout, cod, plaice, etc. For a summary of these values the reader is referred to Barnes (1937).

As well as to Mr E. G. Williams of Ilfracombe, who supplied the dogfish in such excellent condition, the writer is particularly indebted to Mr C. Bees, without whose accurate records and constant care of the aquarium this short paper could not have been written.

## Summary

Records of nearly 2000 dogfish collected from the Ilfracombe region suggest that the spawning season of this fish starts in November and continues at least until July. This area probably represents a spawning ground into which the females migrate during the spawning season; the males follow them much later in April and May.

Figures are given to show the time taken at different temperatures for the embryo to develop to a series of definite morphological stages; these suggest that the temperature characteristic of the development ($\mu = 20{,}000$) is substantially the same as for several teleost species.

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## Appendix

### *Occurrence of* Scyliorhinus canicula (*L.*) *off Plymouth*

By C. A. Hoodless and G. A. Steven

From the beginning of 1949 careful records have been kept of the number of adult dogfishes caught by R.V. *Sabella* while trawling off Plymouth. The results, shown in Table II, reveal that *Scyliorhinus canicula* is present in Plymouth waters all the year round, and that there is certainly no significant falling off in numbers during the summer months. Poorest catches are, in fact, generally noticeable in the winter months.

It is believed that the data here presented are a more accurate reflexion of population trends than are those of Ford (1921) and Harris; but even they are not as useful for that purpose as they might be because they are affected to

TABLE II. TRAWLED ROUGH DOGFISH. *SABELLA*. STOCK SIZE

| | 1949 | | | | 1950 | | | |
|---|---|---|---|---|---|---|---|---|
| | No. of hauls | Hours trawling | No. of dogs | Average catch per hour | No. of hauls | Hours trawling | No. of dogs | Average catch per hour |
| Jan. | 5 | 10·6 | 1 | 0·1 | 19 | 29·4 | 5 | 0·2 |
| Feb. | 11 | 21·1 | 8 | 0·4 | 3 | 5·8 | 51 | 8·8 |
| Mar. | 9 | 14·0 | 3 | 0·2 | 17 | 23·5 | 28 | 1·2 |
| Apr. | 15 | 25·2 | 44 | 1·7 | 1 | 2·0 | 3 | 1·5 |
| May | 9 | 15·0 | 195 | 13·0 | 7 | 12·0 | 86 | 7·2 |
| June | 11 | 17·7 | 188 | 10·6 | 7 | 11·2 | 70 | 6·2 |
| July | 4 | 5·4 | 52 | 9·6 | 15 | 27·1 | 49 | 1·8 |
| Aug. | 9 | 13·7 | 95 | 7·0 | 13 | 21·9 | 78 | 3·5 |
| Sept. | 15 | 23·3 | 162 | 7·0 | 20 | 34·2 | 114 | 3·3 |
| Oct. | 9 | 12·4 | 104 | 8·4 | 15 | 23·3 | 168 | 7·2 |
| Nov. | 17 | 29·8 | 83 | 2·8 | 16 | 26·6 | 127 | 4·8 |
| Dec. | 20 | 35·2 | 102 | 2·9 | 9 | 16·6 | 32 | 1·9 |

| | 1951 | | | |
|---|---|---|---|---|
| | No. of hauls | Hours trawling | No. of dogs | Average catch per hour |
| Jan. | 13 | 22·9 | 70 | 3·0 |
| Feb. | 13 | 27·7 | 22 | 0·8 |
| Mar. | 3 | 5·9 | 6 | 1·0 |
| Apr. | 16 | 26·5 | 73 | 2·8 |
| May | 20 | 32·8 | 428 | 13·0 |
| June | 10 | 17·7 | 301 | 17·0 |
| July | 19 | 27·0 | 677 | 25·1 |
| Aug. | 9 | 12·4 | 161 | 13·0 |
| Sept. | 13 | 18·5 | 227 | 12·3 |
| Oct. | 16 | 21·6 | 418 | 19·3 |
| Nov. | 16 | 24·6 | 251 | 10·2 |
| Dec. | 10 | 15·1 | 214 | 14·2 |

some extent by the requirements of the laboratory supply department. When demands for dogfish are heavy *Sabella* spends extra time on those grounds from which the best catches are to be expected. This influence on *Sabella*'s catches must not be overlooked, even though it cannot be evaluated.