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VARIATIONS IN THE ACTIVITY OF THE THYROID GLAND OF THE COD, *GADUS CALLARIAS* L., IN RELATION TO ITS MIGRATIONS IN THE BARENTS SEA

II. THE 'DUMMY OF RUN' OF THE IMMATURE FISH

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(Text-figs. 1–3)

Describing the migrations and movements of the cod, *Gadus callarias* L., in the Barents Sea, Trout (1957) suggested that the immature fish carry out a false spawning migration. 'The pattern of migration of the immatures is basically similar to that of the matures . . . with increasing age, the immatures' southerly winter migration approached in length that of the mature cod, as if, in the years immediately prior to maturity they were making a "dummy run" towards the spawning ground.' The seasonal migrations of both the adult and immature cod have been related to changes in the activity of the thyroid gland in this fish (Woodhead, 1959). During the spring of 1956 and 1957, collections of thyroid glands from immature cod were made at stations from Bear Island to the Norwegian coast. It was hoped that a study of these glands might demonstrate further the relationship of the activity of the thyroid gland to the migration of the fish.

The thyroid glands and gonads were taken from immature cod of 50–90 cm, and preserved for histological examination by routine methods (Woodhead, 1959). Samples were taken in the four areas between Bear Island and Røst Bank, south-west of the Lofoten Islands, shown in Fig. 1. The lengths of all immature cod caught in these areas were recorded.

RESULTS

Lengths of the immature cod

The data for the lengths of the immature cod caught at Bear Island and on the Norwegian coast are summarized in Fig. 2. (An insufficient number of immature cod were caught in Areas II and IV for the construction of a length distribution histogram.) In March the length distribution of the immature fish on the Norwegian coast had a mode between 70 to 80 cm, whereas the immature cod caught at Bear Island were smaller with a mode at 55 to 65 cm. These results substantiate Trout's hypothesis of a lengthy 'dummy run' by the oldest immature cod.

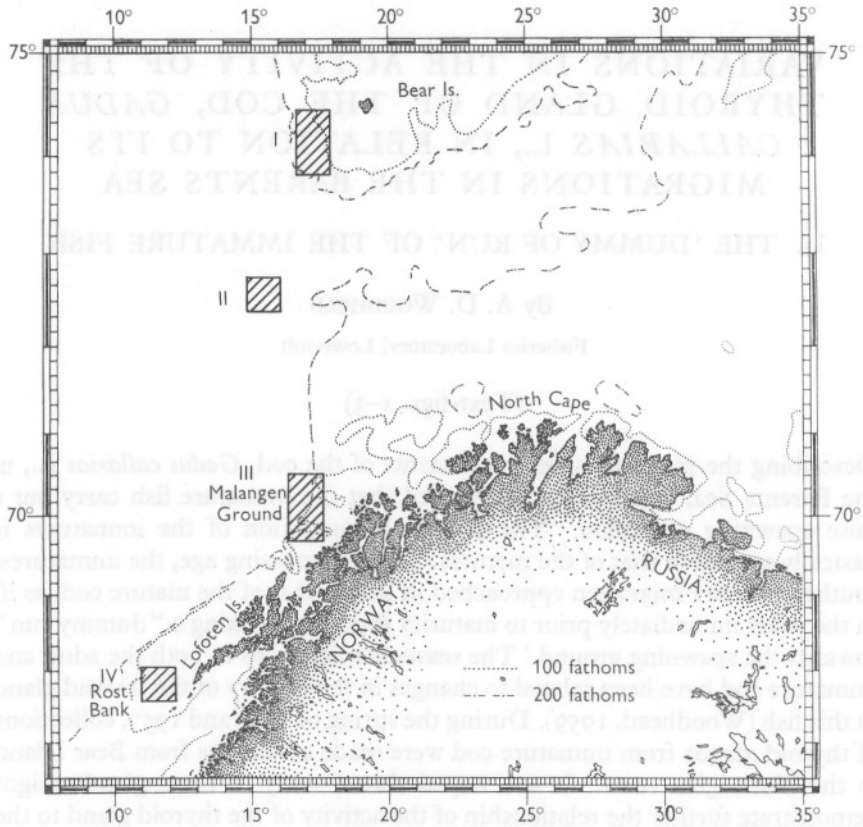

Fig. 1. Bear Island and the S.W. Barents Sea showing the four areas in which immature cod were caught in March 1957.

Thyroid activity

Thyroid glands taken from three immature fish caught on the Malangen ground (Area III) in March 1956 were found to have a significantly higher mean follicular cell height than those of a sample of ten immature cod caught at Bear Island (Area I) (Table 1).

Larger collections of material were made in the four areas shown in Fig. 1 during an extended investigation in March 1957. The activity of these thyroid glands, expressed as the mean follicular cell height for each sample of ten fish, is given in Table 2. The thyroids of the fish caught at Bear Island had the same level of activity as in the previous year, but the thyroids of the fish caught farther south were more active than those at Bear Island; thyroid activity tended to increase with the distance south of Bear Island at which the cod were caught (Fig. 3).

The thyroids of the immature cod caught in the deep water between Bear Island and the Norwegian coast (Area II) had a significantly higher level of activity ($p = 0{\cdot}02$) than those of the cod caught at Bear Island (Area I). The two groups of fish caught on the Norwegian coast also had significantly more

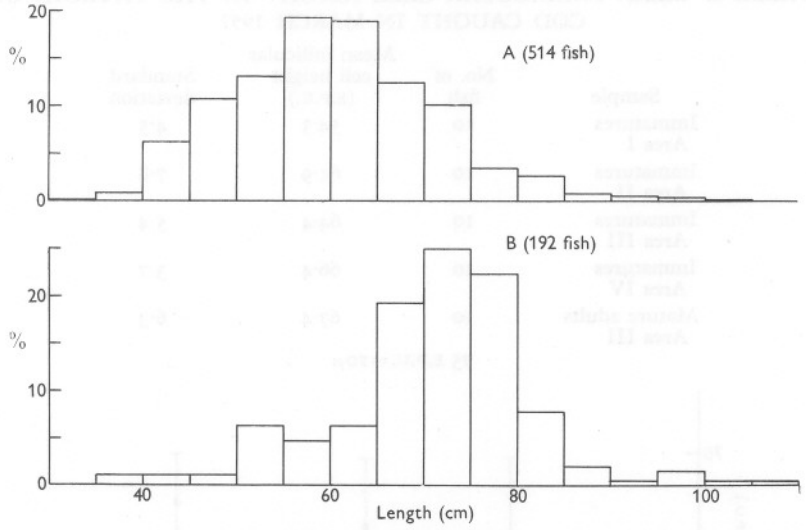

Fig. 2. The length distributions of the immature cod caught at (A) Bear Island and (B) on the Norwegian coast, in March 1957.

TABLE 1. MEAN FOLLICULAR CELL HEIGHT IN THE THYROID OF COD CAUGHT IN MARCH 1956

Sample	No. of fish	Mean follicular cell height (E.P.U.)	Standard deviation
Immatures Bear Island	10	55·1	3·2
Immatures Norway coast	3	68·7	6·8
Mature adults Norway coast	10	67·7	5·5

75 E.P.U. = 10 μ

active thyroids ($p < 0{\cdot}01$) than the Bear Island fish, but although the mean follicular cell height values increased in Areas II, III and IV the means were not significantly different (Table 3).

DISCUSSION

The extent of the southerly overwintering migration of the immature cod from the feeding grounds on the Bear Island–Spitsbergen shelf increased as the fish became older, the largest immature cod migrating to the Norwegian coast, within a short distance from the spawning grounds of the adults. Examination

of the thyroids of cod which had migrated farthest south showed that they were in a more active condition than those of the immature fish caught around Bear Island. In the Bear Island fish, which had reached their overwintering grounds

TABLE 2. MEAN FOLLICULAR CELL HEIGHT IN THE THYROID OF COD CAUGHT IN MARCH 1957

Sample	No. of fish	Mean follicular cell height (E.P.U.)	Standard deviation
Immatures Area I	10	54·3	4·5
Immatures Area II	10	61·9	7·8
Immatures Area III	10	64·4	5·4
Immatures Area IV	10	66·4	3·7
Mature adults Area III	10	67·4	6·3

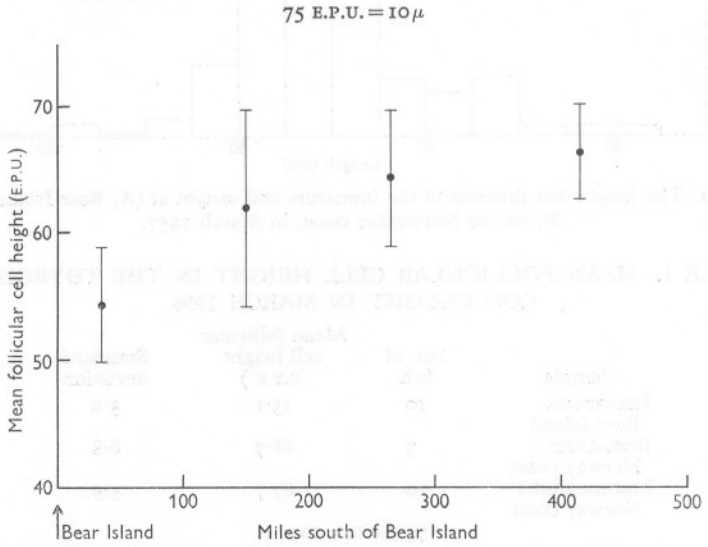

Fig. 3. The mean follicular cell height of the thyroid gland in immature cod caught in Areas I, II, III and IV, compared with the distance from Bear Island at which the fish were caught. The follicular cell height is expressed in eyepiece units (E.P.U.).

TABLE 3. COMPARISON OF THE MEAN FOLLICULAR CELL HEIGHT VALUES

Comparison between areas	Significance of difference (p)
I, II	0·02
II, III	0·4
III, IV	0·3
I, III	$<0·01$
II, IV	0·1

around the edge of the Bear Island shelf, the mean follicular cell height had declined from a January level of $64{\cdot}8 \pm 8{\cdot}7$ to a level of $54{\cdot}3 \pm 4{\cdot}5$. The fish caught on the Norwegian coast still had a follicular cell height of $64{\cdot}4 \pm 5{\cdot}4$, which was not significantly different from the January level; indeed there was no significant difference between the levels of activity in the thyroids of immature cod in the October, November–December, January and the March–Norwegian coast samples. It appears that the thyroid cycle in the immature cod does not rise to a peak as in the adults (Woodhead, 1959), but that once the gland has become active, activity continues at a steady level with a mean follicular cell height of about 66·4 E.P.U. In the large immature cod thyroid activity continues over a more prolonged period than in the smaller immatures; this coincides with the increase in the length and duration of their overwintering migration, which in the largest immatures approaches in length the spawning migration of the adult cod. It seems that in the immature cod the active contranatant migration continues as long as the thyroid gland remains active. This evidence lends further support to the suggestion that the activity of the thyroid gland in the cod may initiate and sustain active and lengthy migrations.

Although the larger immature cod carry out a winter migration which is nearly as long as that of the mature adult cod, the cycle of activity in the thyroid gland of these fish is of a lesser order, although of the same duration as that in the mature cod. Pickford has suggested (Pickford & Atz, 1957) that a minimal level of thyroid activity may be necessary for gonad maturation and it may be that in the cod this is represented by the difference between the thyroid cycle of the adults and that of the large immature fish.

SUMMARY

The average length of the immature cod caught between Bear Island and the Norwegian coast in March 1956 increased from north to south and it appeared that the length of the southerly overwintering migration increased as the fish became older. In the fish caught on the Norwegian coast the thyroid gland was still fully active, whereas in the smaller fish to the north thyroid activity had declined considerably. It is suggested that the greater length of the migration in the larger immature cod is related to the continued high level of thyroid activity.

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ADDENDUM

Since this work was submitted for publication, Swift (1959) has reported that in yearling brown trout the changes in the height of the thyroid follicular epithelium are inversely related to the temperature of the environment, and he interprets this as further evidence that the basic function of the thyroid is in the control of the animal's metabolism, in this case in such a fashion as to compensate for changes in the environmental temperature. Changes in environmental temperature cannot similarly explain the seasonal cycle of activity in the thyroid of the Barents Sea cod. The cod were found at the lowest temperatures (down to $-0{\cdot}5^{\circ}$ C.) in shallow water on the Bear Island—Spitsbergen Shelf during the summer months, when thyroid activity was at a minimum. Highest water temperatures (5 to 6° C.) were encountered during mid-winter when the matures and the oldest of the immature cod were caught in warm water of Gulf Stream origin on the Norwegian coast; the thyroids of these fish were then maximally active. The comparison of thyroid glands taken from fish caught at different temperatures on the same cruise failed to show any significant differences in mean epithelial cell height, except during March when the immature cod around Bear Island at 1 to 2° C. had less active thyroids than those immatures at 5 to 6° C. on the Norwegian coast.

REFERENCE

SWIFT, D. R. (1959). Seasonal variation in the activity of the thyroid gland of yearling brown trout *Salmo trutta*. *J. exp. Biol.*, Vol. 35, pp. 120–25.