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OBSERVATIONS ON GROWTH AND LIFE CYCLE OF THE SHIPWORM *TEREDO NAVALIS* L. (BIVALVIA, MOLLUSCA) IN THE ISEFJORD, DENMARK

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ABSTRACT

Using X-ray photography the growth of *Teredo navalis* was examined in the Isefjord, Denmark during the years 1967-1970. Given sufficient food and space, the growth continued for three years at a decreasing growth rate. A high population density depressed the growth rate. Growth was discontinued irregularly during the last growth periods. Specimens containing larvae were observed in June, July and August. Settling was estimated to take place mainly from mid-August to the end of September.

INTRODUCTION

Teredo navalis is widely distributed (Nair & Saraswathy 1971), and its range in Scandinavian waters has been discussed by several authors (see Kristensen (1969) and Norman (1977)). Although economically important, its growth and life cycle is only fragmentarily known within the area. The most extensive accounts are those of Norman (1976 a, b; 1977) from the Swedish west coast.

This paper gives the results of studies done on *Teredo navalis* in 1967-1970 in the Isefjord, Denmark, where the population in some aspect differs from those studied by Norman (1977).

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MATERIAL AND METHODS

The field studies were carried out in the harbours of Kyndby (inner broad) and Hundested (entrance area). The salinity and temperature records from the

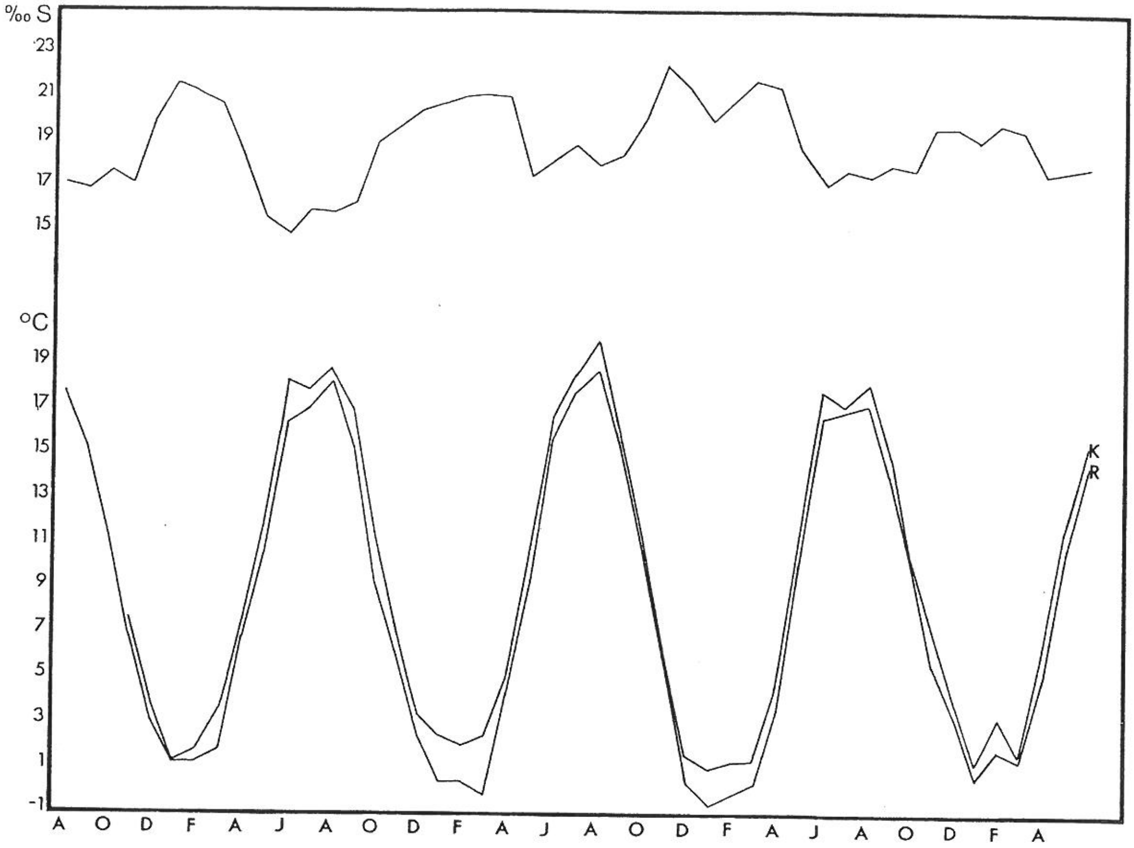

FIG. 1. Monthly means of temperature at Kyndby (K) and Rørvig (R) and of salinity at Rørvig (top). Data from Oceanogr. Obs. 1967-71.

meteorological station at Rørvig can be regarded as representative of the hydrographical conditions at Hundested. For Kyndby, temperature observations of the power station Kyndby have been used (Fig. 1). A detailed treatment of the hydrography of the Isefjord area was given by Rasmussen (1973).

The test blocks of unplaned pine (10 × 3 × 20 cm) were fastened to a wire anchored by a lead and suspended from a bridge at the depth of 3-4 m below the surface. At intervals the blocks were X-rayed (35-45 kV/200 mAs) after removal of fouling organisms. For further information on this technique see Crisp *et al.* (1953). The individual specimens were marked on the photographs and followed during the test periods. As the shipworm is able to partly retract and start to bore in a different direction, the total burrow length is not always equal to the length of the animal, but is here considered an adequate, approximate expression of the latter. Moreover, it is of course the most important figure when estimating the destructive potential of the species. The recorded lengths are minimum estimates since burrows oriented obliquely to the photographic projection appear foreshortened. Displacement of the pallets was considered the only certain indication of death (Turner 1966).

RESULTS

Two Hundested test blocks from 1967 were attacked by 58 and 160 specimens, respectively. In the first block, growth could be followed for one year, whereas high tube density and a beginning decay of the wood impeded observations after about 8 months in the latter block. At Kyndby, only five specimens settled on the test block in 1967 and they could be followed until 1971.

Growth

The results are shown in Figs 2 & 3. The dotted part of the curves indicates probable growth between two observations, as inferred from Roch's laboratory findings (1932) that growth does not take place at temperatures below 5 °C. The decrease in recorded numbers from Hundested is primarily due to difficulties with distinguishing the individual tubes. The decrease is not even, because, at each inspection, specimens that had retracted from the foremost uncalcified part of the tube could not be taken into account. The highest growth rate occurs at temperatures of 15 °C and above, see Figs 1 & 2.

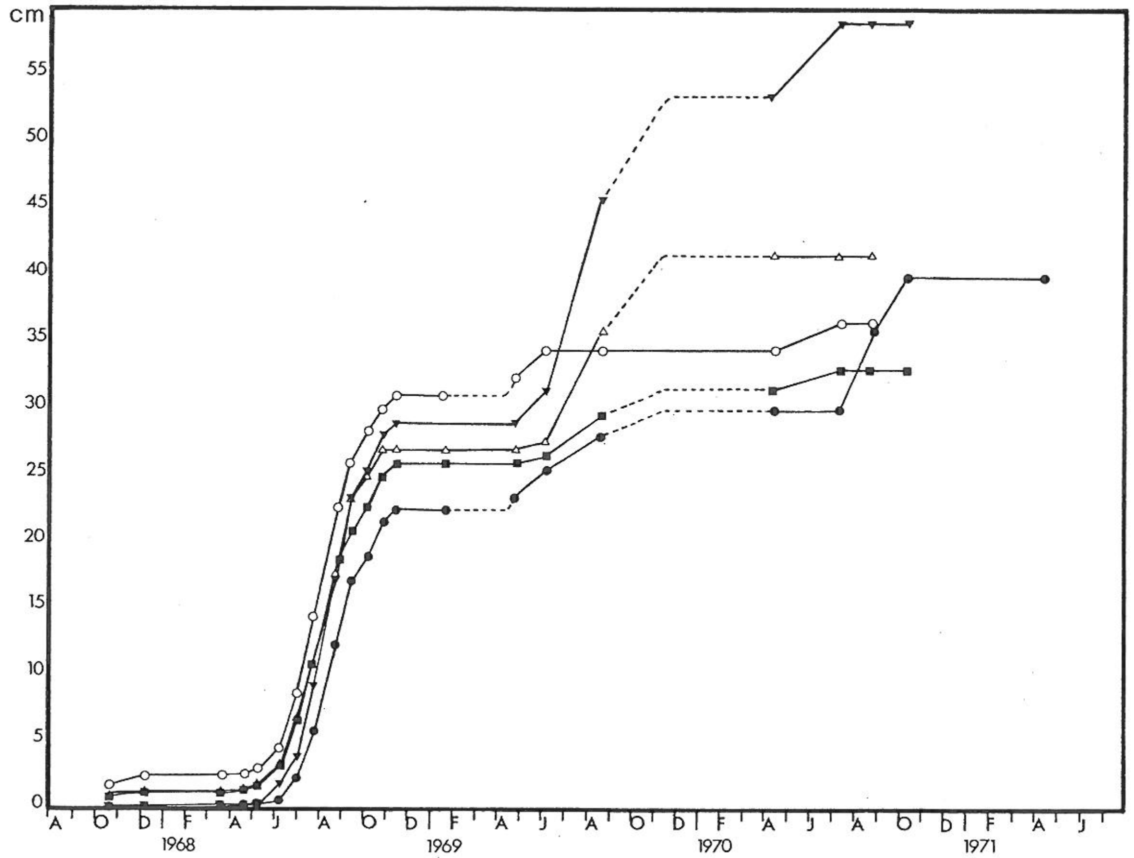

FIG. 2. Growth of *Teredo navalis* at Kyndby. Individual measurements. Test blocks were exposed in late July. Last marks on curves indicate time of death.

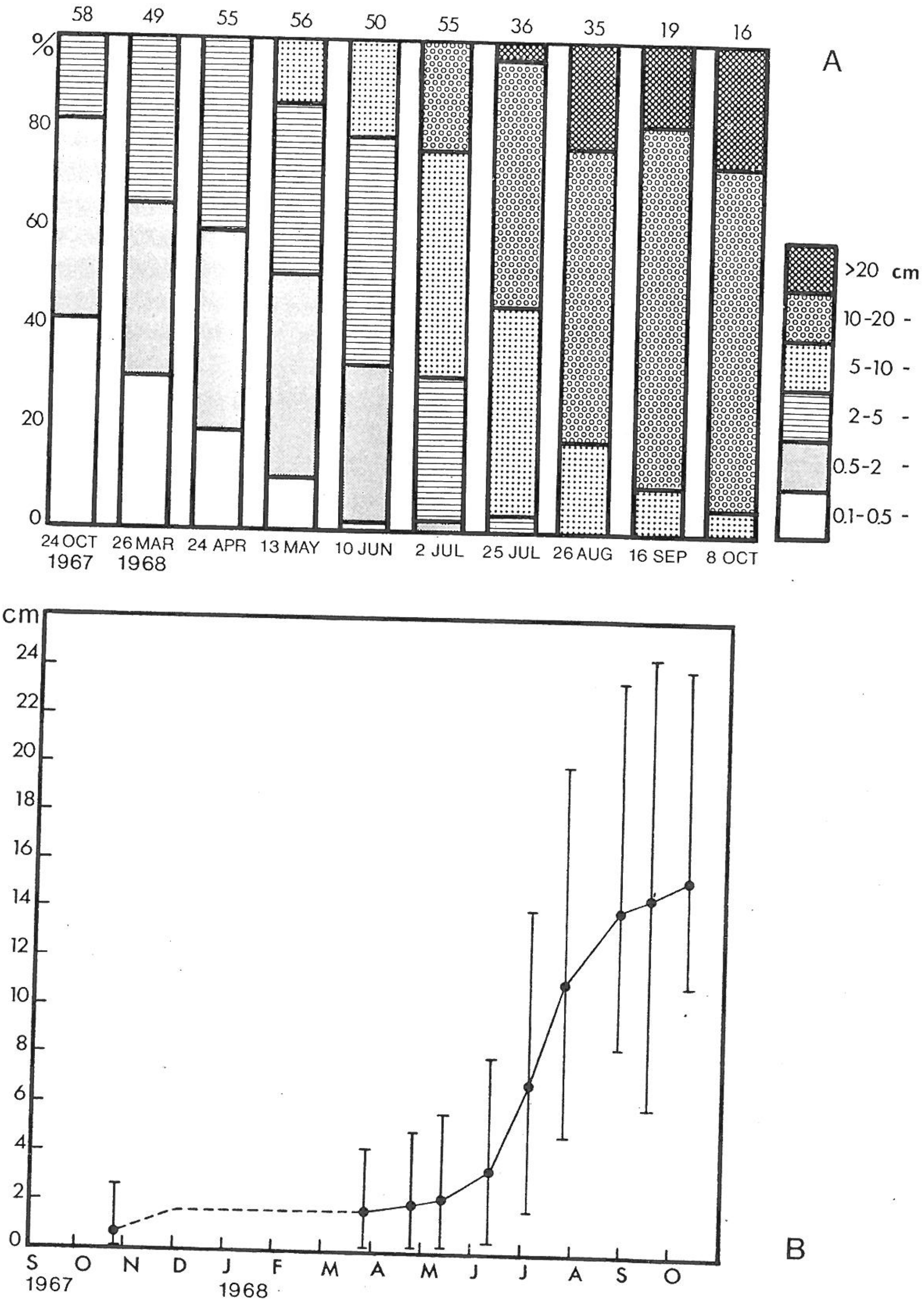

FIG. 3. Growth of *Teredo navalis* at Hundested estimated from test blocks exposed in late July and first examined in late September. A, percentage distribution of various length classes, with numbers of specimens examined on each date given on column tops. B, average length values with total variation indicated for each examination date.

At Kyndby, one specimen had a first and second year growth of 28 and 24 cm, respectively, whereas the other four specimens grew much less during the second year. Thus, the average growth of all five specimens was 25 cm in 1968, but only 9 cm in 1969 and about 6 cm in 1970. During the last two growth seasons some of the animals stopped growing for varying periods of time, the longest single period being from June 1969 to mid-April 1970. The longest specimen was 59 cm after 36 months and was in its third growth period.

The Hundested specimens from the least crowded block had an average first-year length increase of 15 cm. At the end of the first year the specimens became so crowded that they reacted by lining the anterior end of the burrow with calcium and, so encysted, growth was stopped, but they were still alive on 9 June 1969. Thirteen specimens in a block, which was X-rayed after one year of exposure, showed an average length (22 cm) similar to that found at Kyndby.

Reproduction

Two bands of increased density were observed in some of the specimens on the X-ray photographs taken in July (Fig. 4) and, to a lesser extent, in June and August. Since *T. navalis* retains the larvae in the suprabranchial chamber until the straight-hinge stage (Turner & Johnson 1971), the dense shadows are interpreted as masses of shell-bearing larvae.

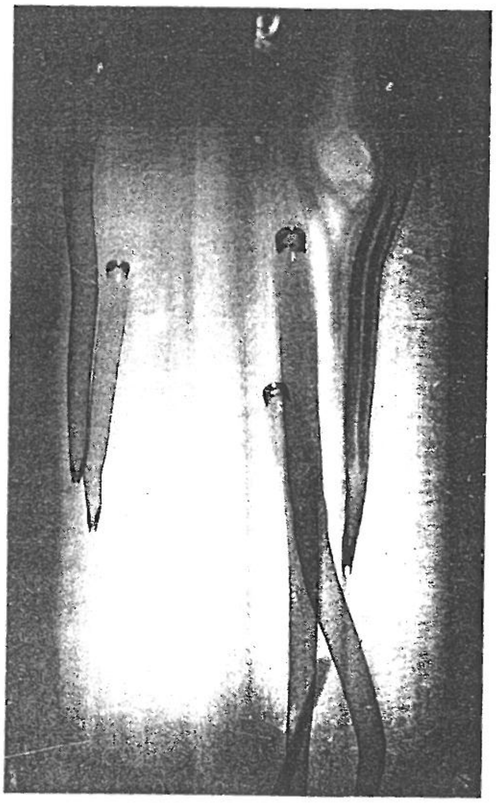

FIG 4. Test block X-rayed 25 June 1968. Specimen containing larvae at top right.

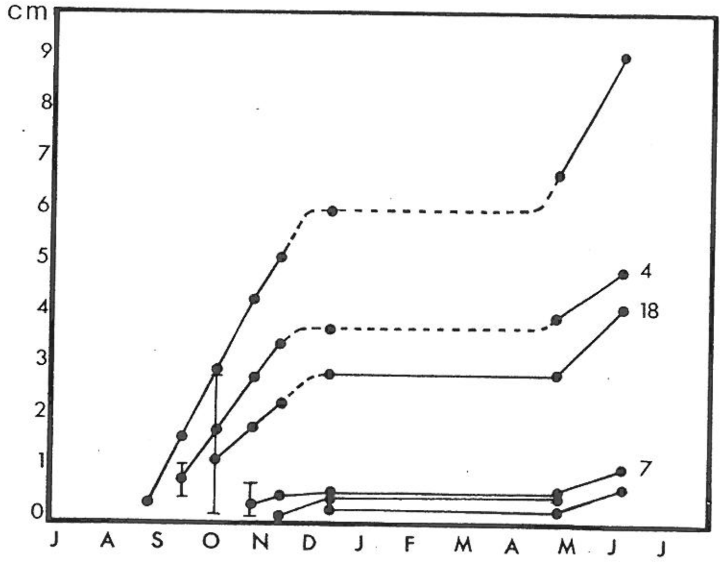

FIG. 5. Relation between settling date and growth pattern in young *Teredo navalis* at Hundested. On curves based on data from more than one specimen the dots indicate average length. Length variation is in each case shown for the initial sample, and sample sizes are given to the right.

The smallest specimens detectable on the X-ray pictures are one mm long. In 1967 they appeared at the end of October, none being found during the previous inspection at the end of September. In 1968 settling was followed in a test block exposed at Hundested at the beginning of March. Here the first specimen (3.5 mm long) was found at end of August, with the previous examination having been carried out at the end of July. The majority of the specimens (29) appeared during September and October, and the last one (2.5 mm long) in the middle of December (Fig. 5). Early settling seems to enhance growth, as also shown in Fig. 5.

DISCUSSION

The pronounced difference in the first-year average length between the uncrowded Kyndby and Hundested specimens (25-22 cm) and the crowded Hundested specimens (15 cm) is in accordance with the demonstration of Norman (1977) of a negative correlation between population density and growth rate in *T. navalis*. The difference in maximum length after 11 months at Kristineberg (7 cm) (Norman 1977, fig. 13) and the Isefjord is probably also mainly due to different conditions of competition for food and/or space.

The reason why settling at Kristineberg (22-279 specimens/dm^2) is so much heavier than in the Isefjord (max. 27/dm^2) may be the difference in salinity ranges during the reproductive period (21-28 ‰ against 15-19 ‰). Both Kühl (1957) and Kristensen (1969) showed that, provided the temperature was optimal, heavy attacks coincided with high salinity.

The longevity of the shipworms cannot be determined with certainty in the kind of experimental set-up used, because food/space may be a limiting factor, but some specimens lived for at least three years. The normal lifespan of *T. navalis* has been stated to be two years on the Swedish west coast (Norman 1976), 1-3 years on the DDR Baltic coast (Nakel 1954), and 2-3 years at Cuxhaven in the Elben estuary (Kühl 1957).

Larvae have previously been found in the Isefjord plankton in late July and August, but only two were found in both cases (Rasmussen 1973). In the Øresund they were found in July, September, October, November, and once in January (Jørgensen 1946). Kramp (1937) reports release of larvae in Danish waters during the whole period from March to November with the highest numbers occurring in the warmest periods. My material indicates that pelagic larvae occur at least from July to December.

At Woods Hole, Mass., U.S.A., Grave (1928) found an interval of 2-3 weeks between metamorphosis and the one mm stage, and I presume that the newly settled specimens need 2-4 weeks to reach that size in the Isefjord. Although the test block number is small, it can thus tentatively be estimated that peak settling of *T. navalis* occurs from mid-August to the end of September. This is in accordance with Kramp (1944) who reports that attacks by *T. navalis* at Helsingør for several years used to take place during September. Norman (1976) found July and the first half of August to be the peak period of settling at Kristineberg, but an interpretation of her data is difficult because of the variation in her experimental set-ups. However, it appears that settling occurs earlier at Kristineberg. All these findings are in accordance with Ryabchikov & Nikolaeva (1963) who state that peak settling coincide with the end of the period with the highest temperature.

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