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Distribution of *Anoplostoma viviparum* (Nematoda) in Southampton Water Sediments

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Abstract

The juveniles, non-gravid females, gravid females and males of the free-living marine nematode *Anoplostoma viviparum* Bastian showed markedly different distributions within layers of mud from Southampton Water sampled during the early spring of 1975. Of the total population, 92% of gravid females occurred in the anoxic layer, 73% of juveniles occurred in the flocculant layer, non-gravid females and males were found in approximately equal numbers in both the flocculant and oxidised layers but none in the anoxic layer. A tentative activity cycle based on these distributions is put forward for consideration, taking into account the water movement within the estuary.

Introduction

Anoplostoma viviparum Bastian, a free-living viviparous nematode, is usually associated with very fine-grained sediments (Platt, 1977) in which the hydrogen sulphide layer is near the surface; Warwick (1971) found that in the Exe estuary it was characteristic of mud with low interstitial salinities. Although *A. viviparum* is a well-known cosmopolitan species (Gerlach and Riemann, 1974), little is known of its horizontal distribution within both littoral and sub-littoral sediments.

Materials and Methods

On 23 March 1975, thirty-six sediment cores were collected from 12 sites in Southampton Water (Table 1). These sites ranged from 2 m above mean low water (MLW) to 9 m below MLW, as shown in Fig. 1. In the deeper water, samples were collected by a SCUBA diver. Cores were taken using hand-held corer tubes, 30 cm in length and 2.3 cm internal diameter. The core tubes were kept sealed and vertical, and transported to the laboratory in an insulated container, keeping the samples at their ambient sea temperature. During collection of the samples, care was taken to include the supra-sediment flocculant layer.

In the laboratory, the flocculant layer over each sample was carefully removed, and then the remainder of the sample was sectioned into 0.5 cm segments. Previous investigation had shown that the oxidised layer of the sediment was generally only 0.5 cm thick, and that the free-living marine nematodes occurred only in the uppermost centimeter of the sediment (own unpublished data). Each core segment, together with the flocculant layer sample, was fixed with 4% formalin in buffered sea water, and a few drops of Rose Bengal added to stain the organic content, thus making the sorting of the meiofauna easier. All meiofauna present were removed by examining the sample under a microscope and picking out the individual animals. Sieving techniques, as used by other workers, were of no use because of the flocculant nature of the sediment and the presence in some samples of large amounts of oil.

The body length and diameter just posterior to the oesophagus were measured for each nematode, and from these measurements both the wet and dry weights were calculated, assuming the specific gravity of a marine nematode to be 1.13 and dry weight to be 20% of the wet weight (Wieser, 1960).

The top section (0.5 cm deep) of each core was regarded as oxidised (O) and the rest as anoxic (A); the flocculant (F) layer was treated as a separate section.

Anoplostoma viviparum Bastian was the only viviparous nematode present, and all stages of its developmental cycle were found in the sediment samples taken at this time.

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Table 1. Sampling sites of *Anoplostoma viviparum* in Southampton Water

Site (Fig. 1)	Height above (+) or depth below (–) mean low water (m)	Description
A	–7	Semi-liquid mud with high oil content
B	+2	Pool in fine-mud bank, covered by high spring tides
	0	On side of channel, very soft, fine-grained mud
	–2	Firm, fine-grained mud with a few shells; uncovered at exreme low spring tides
	–9	Firm, fine-grained mud in dredged channel
C	–9	Coarse sediment mixed with mud; some pebbles and shells
D	–1 –1 –1	Three sampling sites very close together. Coarse sediment overlying pebbles; large amounts of man-made items included in sediment
	–1	Mouth of the Hamble. Firm mud with sand; uncovered at low water
E	0	Pool on gravel and shell spit; uncovered at low water
	–7	Firm sediment with shells, on upper slope of dredged channel

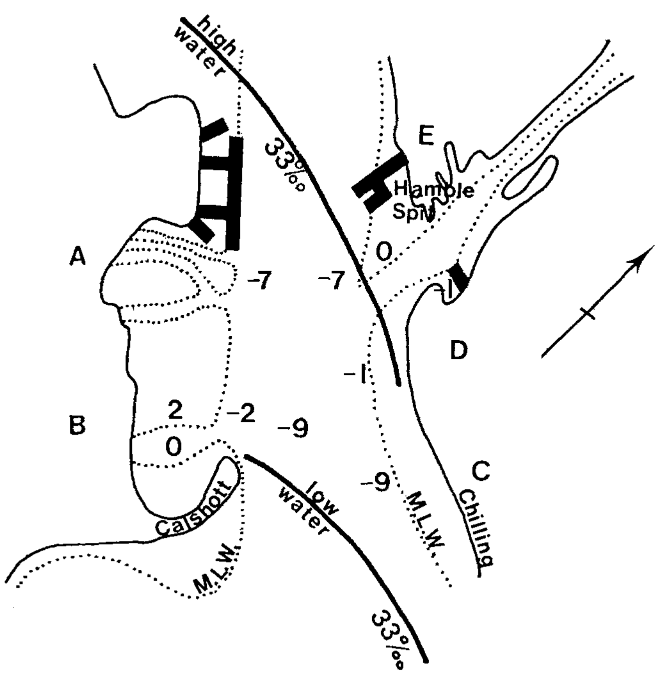

Fig. 1. Southampton Water. Positions of Sampling Sites, showing height above or depth below mean low water (MLW) mark; average position of the 33 ‰S bottom isohaline is shown for both high and low water. The 12 sites are described in Table 1

Samples from Site A were not analysed as they proved to be all liquid mud and oil, and thus could not be sectioned for comparison with other samples.

Results

The total biomass of all stages of *Anoplostoma viviparum* for each sampled site is shown in Fig. 2 as μg per m^2. To the northwest of a line from Calshott to Hamble Spit, biomass of the nematode was high (over 100 μg m^{-2}), coinciding with those areas where mud is deposited, whereas to the southeast of this line the biomass was low, especially at Chilling (38.4 μg m^{-2}), where the sediment is removed by wave and tidal action. Total biomass in the anoxic layer was higher than in the flocculant and oxidised layers. The biomass of the different stages is markedly different in the three layers (Fig. 3). Juveniles were concentrated in the F layer, with fewer in the O and very few in the A layer; these latter juveniles were the smallest specimens recorded. Non-gravid females and males had almost the same vertical distribution within the F and O layers, whereas 92% of all gravid females occurred in the A layer.

The horizontal distribution of gravid females in the A layer (Fig. 4) followed the same pattern as the total biomass (Fig. 2) with a higher mean biomass of 48.1 μg m^{-2} northwest of the Calshott/Hamble Spit line, and a lower mean biomass of 31.7 μg m^{-2} to the southeast. Non-gravid females and males had the same biomass at each sampled site. The pattern of nematode distribu-

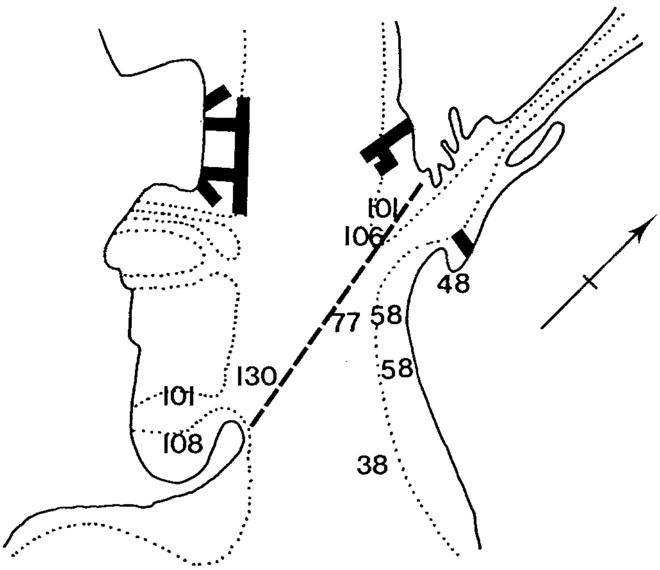

Fig. 2. *Anoplostoma viviparum.* Distribution ($\mu g\ m^{-2}$) of total biomass of all stages in Southampton Water sediments

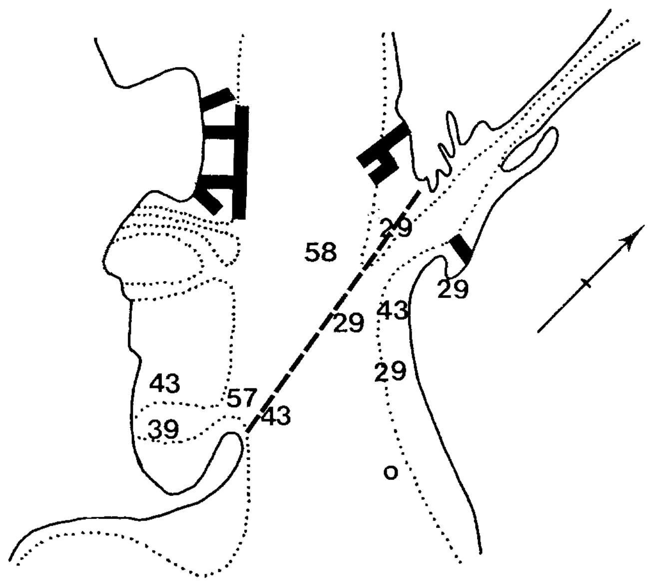

Fig. 4. *Anoplostoma viviparum.* Distribution ($\mu g\ m^{-2}$) of gravid female biomass in the anoxic layer of Southampton Water

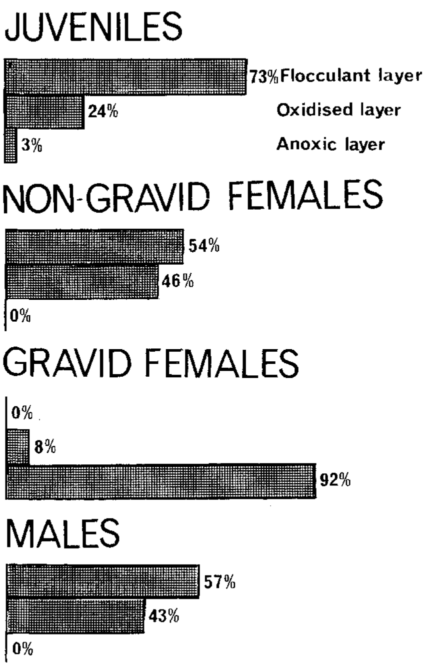

Fig. 3. *Anoplostoma viviparum*. Vertical distribution of various stages within sediment column

tion in the O layer is summarised in Table 2. Non-gravid females were present in those areas where the O layer had suffered little or no disturbance by tidal movement; males occurred more frequently on the east side of the estuary than on the west side; gravid females were found at Sites B and E, both areas of sediment deposition.

Organic material and mud together form a supra-sediment flocculant layer which moves with the tidal currents around the estuary. It is an important part of the sediment system, although difficult to sample quantitatively; therefore, the estimate of nematode biomass within this layer is tentative. Juveniles and non-gravid females were most numerous in the F layer.

Discussion

The main influence on the horizontal distribution of *Anoplostoma viviparum* appears to be the tidal flow pattern within Southampton Water. Although the tidal prism is large (Dyer, 1973), bottom salinities vary by only ± 1 ‰ (Fig. 1) owing to the small proportion of river water present. On the eastern side of the estuary, the gently sloping littoral sediment surface gives rise to fast ebb-tide currents which remove the flocculant layer. The flood-tide returns the flocculant material to other parts of the estuary, especially to the western side where deposition dominates, and where the highest number of nematodes are found.

The vertical distribution of *Anoplostoma viviparum* suggests that the gravid females remain in the anoxic layer while they produce their young. Wieser and Kanwisher (1961) noted that nematode species differ in their ability to survive anoxia, and Teal and Wieser (1966) showed that there are large numbers of nematodes living in sediments with a high level of hydrogen sulphide; indeed some are obligate anaerobes (Wieser *et al.*, 1974), with even the very youngest stages found in the same anoxic layer. Although *A. viviparum* occurs at one stage in its life in the anoxic layer, it is apparently tolerant of low oxygen levels. The anoxic sediment

Table 2. *Anoplostoma viviparum.* Distribution of non-gravid females, gravid females, and males in oxidised layer. na: not analysed

Sample sites (see Fig. 1)	± MLW	Non-gravid females	Gravid females	Males
A	–7	na	na	na
B	0	+	+	–
	2	+	–	–
	–2	+	–	–
	–9	–	–	–
C	–9	+	–	+
D	–1	–	–	+
E	0	+	+	–
	–7	+	–	+

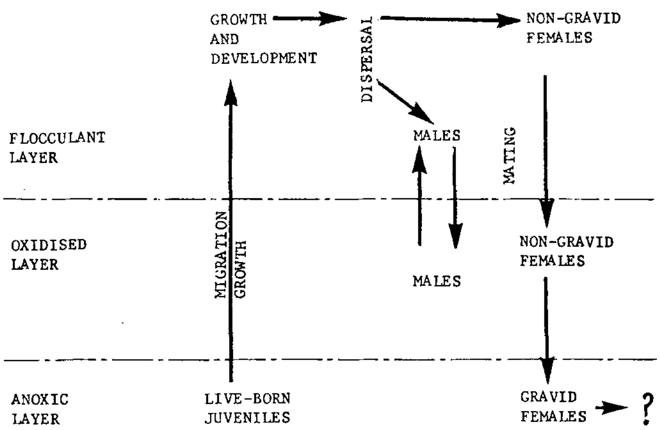

Fig. 5. *Anoplostoma viviparum.* Postulated activity cycle during early spring in Southampton Water

is possibly a safe place in which to reproduce, being firmer, more stable and with many of the predatory meiofauna species remaining in the oxidised layer above. Non-gravid females and males occurring in the same F and O layers suggest that these are the zones where mating occurs, with movement of the flocculant layer serving as a means of distributing the nematode throughout the estuary.

While the horizontal pattern of *Anoplostoma viviparum* appears to be a result of water movements within the estuary, the vertical pattern may be a consequence of active migration by the nematodes through the sediment, the gravid females moving down into stable anoxic mud, the juveniles moving up into open water. Such migratory movement is important in a viviparous nematode (Gerlach, 1977), as the juveniles must find their way into the moving sediment or water layers to effect dispersal. A postulated activity cycle for *A. viviparum* during the early spring in Southampton water is given in Fig. 5. The stability of the sedimentary environment during the study period gives additional support to the suggested activity cycle. Sediment temperatures both underwater and below the surface of the exposed mud were constant at 6 °C, organic carbon content and median grain size were almost identical for each site sampled, and salinity varied only by ± 1 ‰ over the tidal cycle.

This work forms part of an extensive survey of Southampton Water estuary; detailed investigation of the distributions of other nematode species has yet to be completed. Other meiofauna found in the samples (presented as average percentage over all the samples taken) were Polychaeta (1%), Harpacticoidea (1%), Turbellaria (3%), Gnathostomulida (5%) and Gastrotricha (2%).

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