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NL-339 (3/77)

TAXONOMY AND ECOLOGY OF SOME FREE-LIVING MARINE NEMATODES FROM BRITISH COLUMBIA

by

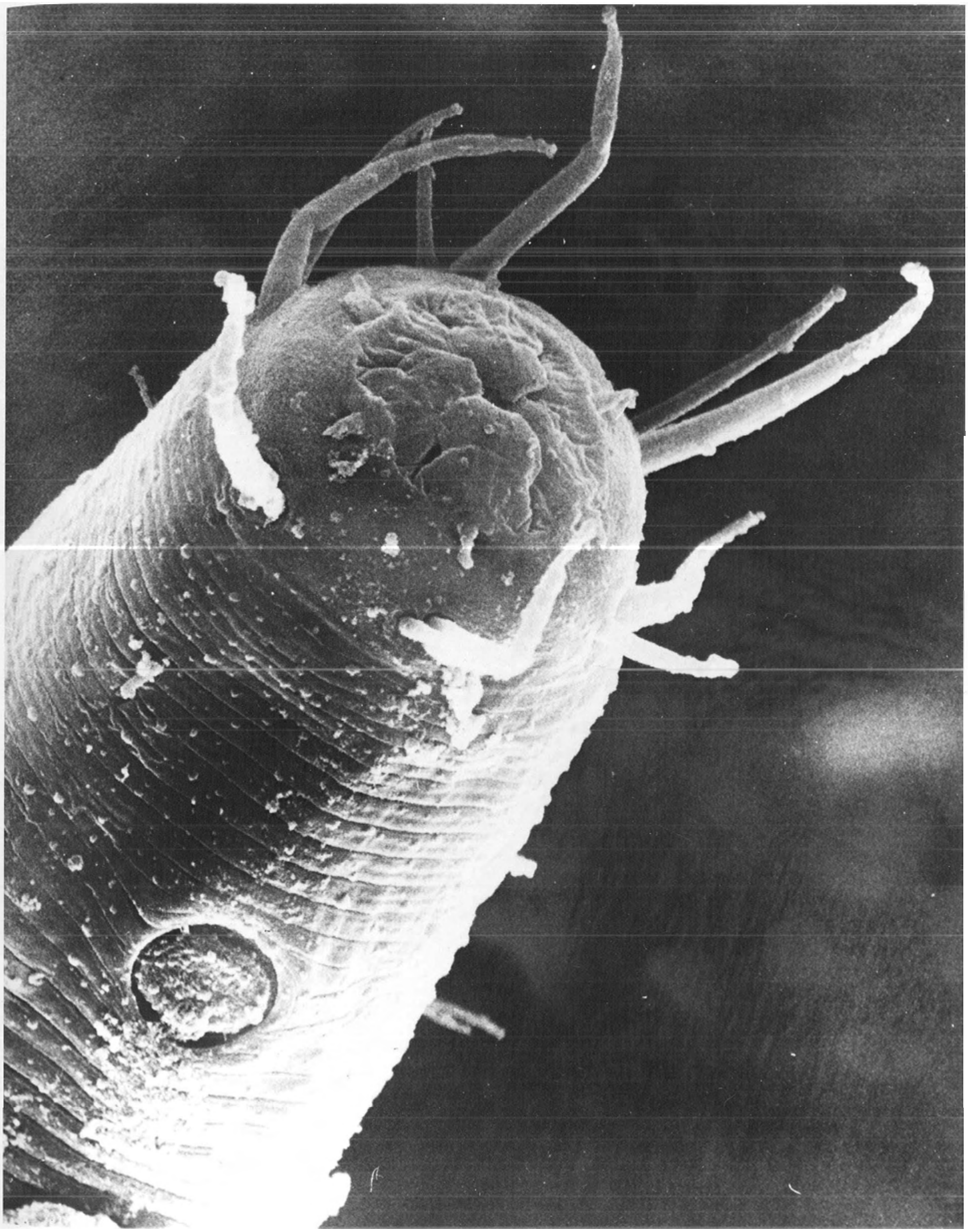
Jyotsna Sharma

B.Sc., University of Alberta, 1974

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
Master of Science
In the Department
of
Biological Sciences

Simon Fraser University
October, 1978

Frontispiece. Scanning electron micrograph of *Theristus* sp. showing cuticular annulations, circular amphidial aperture and a circular array of six pairs of cephalic setae.



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Taxonomy and ecology of free-living marine nematodes from British Columbia

Author:

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Jyotsna Sharma

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Nov. 5/1978

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ABSTRACT

In spite of the abundance of free-living nematodes in marine sediments and hence their importance in benthic food chains, there is no comprehensive study of these organisms on the Canadian Pacific coast.

This study examines the composition of the nematode fauna over one year at two intertidal sites, Iona Island and Belcarra Park near the city of Vancouver. Nematodes were extracted from the sediment by sieving and centrifugation techniques and differences between the sites examined in relation to the temperature, salinity, sediment grain size and organic carbon.

A checklist of the nematode fauna is included. The nematode fauna at the two sites is characterized by different morphological forms. While *Sabatieria pulchra* and *Tripyloides gracilis* are the major constituents of the Iona Island fauna, an abundance of the linhomoeids and monhysterids characterizes the Belcarra Park sediments. *Marylynnia* n.sp. from the family Cyatholaimidae is described and the taxonomic significance of hypodermal pores and punctations on the cuticle of this family is discussed.

The well sorted sediments of Iona Island offer homogenous interstitial spaces for the nematodes and have low numbers and few species of nematodes.

The sheltered Belcarra Park site has poorly sorted sediments and more organic carbon and visible detritus associated with the sediments. Here the numbers of nematodes and nematode species is high. At both sites most of the nematodes were found in the upper 2cm of the sediment and relatively few nematodes below 4cm.

A few dominant species, each of which comprised more than 10 percent of a sample, were chosen for detailed investigation of their seasonal fluctuations. Species that are epigrowth feeders and feed on algae and diatoms increased in numbers during the summer and non-selective deposit feeders, such as Sabatieria spp. were dominant in the winter. The patterns of these seasonal fluctuations are discussed.

Acknowledgements

I sincerely appreciate Dr. John Webster's efforts in providing me with excellent advice, encouragement and support in all phases of this study.

I would like to extend special thanks to Mr. Bruce Hopper for his encouragement and expert advice with the taxonomic aspects of this study, and for his valuable confirmation of specimen identification.

Further, I much appreciate the loan of *Marylynnia complexus* specimen by Dr. D. Hope of the Smithsonian Institute, Washington, D.C.

Thanks are also due to Drs. A.H. Burr, E.B. Hartwick, members of my supervisory committee and to Dr. L.D. Druehl and Dr. D.L. Baillie. In addition, I would like to thank Dr. D. Popham and Messrs. D. Morley and M. Yang and many more friends and colleagues for their moral support and helpful discussions.

Nematodes...'None of their grace and beauty is suggested by a name that carries the stigma "worm" '.

B. G. Chitwood
(Chitwood and Chitwood, 1950)

Table of Contents

List of Tables

List of Figures

List of Appendices

INTRODUCTION

The marine meiofauna has received increasing recognition since Mare (1942) identified this distinct community of organisms that pass through a 0.5-1.0 mm sieve. The importance of meiofaunal organisms as food for demersal fish and shrimp of commercial importance has been emphasized by Mills (1975) and Sibert et al. (1977). While their biomass is only 3% of that of the macrofauna, their metabolic rate is five times that of the macrofauna in the sublittoral silty sand in Helgoland Bay (Stripp, 1969). Comparable figures have been presented for other marine environments and the importance of marine meiofauna is emphasized in a review by Gerlach (1971).

Free-living marine nematodes are a major component of the marine meiofauna and Tietjen (1966) estimated that they comprise 80% of the total numbers and 60% of the meiofaunal biomass in a New England estuary. They are also the most numerous organisms in the benthos from the littoral to the deep sea (McIntyre, 1969). Free living nematodes are, in fact, the major interstitial component of the meiobenthos as only a few nematode species are large enough to be burrowers. In this habitat they feed on bacteria and algae, and so are important as primary consumers in benthic food chains.

Unlike their parasitic brethren free-living marine nematodes have received little recognition and this is probably due to their apparent lack of economic importance. Despite their abundance in all marine sediments only a few studies of meiobenthic ecology have identified nematodes at the species level. This may be attributed not only to the time consuming and laborious techniques necessary to extract nematodes but also to the inadequate taxonomy of this group (Hope, 1971). Since only free-living nematodes are considered here, the term 'marine nematodes' will be used hereafter with reference to this group.

Despite the drawback of the taxonomic difficulties a convenient method for investigating the ecological relationships of nematodes was initiated by Wieser (1952) who classified them into distinct feeding categories. It is based on correlations between the morphology of the stoma and scattered published observations on the feeding habits of the nematodes and may be summarized as follows:

1) Selective deposit feeders: no stoma or when it is present, it is reduced so food in suspension is ingested by esophageal suction. The group includes some linhomoeids and axonolaimids.

2) Unselective deposit feeders: stoma with unarmed or cylindrical cavity and esophageal action is supplemented with the movement of lips and stoma. The group includes comesomatids and tripyloidids.

3) Epigrowth feeders: the buccal cavity has teeth, rods or plates and food is scraped off sand particles before ingestion or the cells are pierced and the contents are sucked out. The group includes the chromadorids, monhysterids and linhomoeids.

4) Predators and Omnivores: have teeth and plates in their buccal cavity. The group includes the Oncholaimids and the large Enoplids choanolaimids and selachinematids.

Although Wieser (1960) has since revised the above classification, it still provides a useful basis for classifying nematode communities on the basis of the types of food they ingest. Coull (1970) and Marcotte and Coull (1974) used this method to examine the nematode populations of the meiobenthos. However, recent work by Tietjen and Lee (1977) suggests that nematodes are very selective in the ingestion and digestion of food. Hence, it is not sufficient to extrapolate from the morphology of nematodes and to generalize about their feeding characteristics and distribution of types. Instead, the nematode fauna must be characterized by its species composition and the specific nutritional requirements of individual species.

Most ecological studies on free-living nematodes have been on subtidal populations where there is little diurnal environmental change due to tides. This is a relatively stable habitat and the species composition remains stable throughout the year as was shown by Warwick and Buchanan (1971b) in the area off the Northumberland Coast of Britain. Littoral and shallow water sediments, however,are part of a fluctuating environment with its associated changing physico-chemical factors. Interstitial organisms in intertidal sediments are influenced by the sediment they inhabit, its water saturation, temperature, salinity, oxygen, organic detritus and microflora. Many of the interacting factors that influence the ecology of intertidal meiofauna have been discussed extensively in reviews (Delamare- Deboutteville ,1960; Swedmark,1964; Jansson, 1968b; McIntyre, 1969).

The composition of the sediment is one of the most important factors affecting the interstitial organisms and Wallace in a series of papers and reviews (eg.1959, 1971) has examined fully the influence of sediment composition on nematode behaviour. The sediment provides a medium for nematode movement and food availability and affects the physico-chemical nature of the environment differentially depending on whether the tide is in or out.

In his studies of marine organisms Wieser (1959b) stressed the importance of sand grain size. It determines the interstitial spaces and, hence, nematode movement but grain size is critical to organisms that scrape food off sand grains as there is a direct relationship between animal size and the microorganisms on the grain surface they feed on. The size and hardness of sand grains also affects their horizontal and vertical transport on a beach. The importance of beach drainage which is affected by pore size is discussed by Jansson (1967). Since the size of the interstitial spaces determines the size of the organisms inhabiting them, the variability in size of these spaces as determined by the sorting of the sediment will determine the diversity of organisms (Hulings and Gray, 1976).

A good review of the general ecology of marine nematodes is provided by Nicholas (1976) in his book on free-living nematodes. There have been only a few quantitative studies of the nematode fauna in littoral habitats. The distribution of free-living nematodes was examined by Capstick (1959) in relation to salinity in the middle and upper reaches of the Blythe river estuary in England. While studying the meiobenthos near Woods Hole, Massachusettes, U.S.A., Wieser (1960) and Wieser and Kanwisher (1961) noted nematode communties to be affected by the sediment and also recorded some seasonal changes in the nematode fauna.

King (1960) recognized three distinct nematode communities isolated by physical aspects of their environment in Florida on the Gulf of Mexico. The horizontal and vertical distributions of nematodes in a Georgia salt marsh on the eastern coast of the U.S., were studied by Teal and Wieser (1966). The vertical and horizontal associations of nematode communities in an intertidal sandflat in North Carolina, U.S.A. are reported by Ott (1972).

Tietjen (1969) examined the distribution and abundance of shallow subtidal meiofauna in two New England estuaries in northeastern U.S.A., with particular reference to the size and structure of the nematode populations. The most detailed study on the seasonal fluctuations in the compostion of the nematode fauna is of Skoolmun and Gerlach (1971) in the Weser estuary of the German Bight. The vertical and horizontal distribution of nematodes has been reported by Platt (1977a, 1977b) from an intertidal sandflat in Strangford Lough, Northern Ireland.

There are only a few comprehensive studies on the free-living marine nematodes of the west coast of North America. They are from Puget Sound, Washington (Wieser, 1959a), and the coastline of Oregon (Murphy, 1961), northern California (Chitwood, 1960) and of southern California and Central America (Allgen, 1947, 1951). Only two short taxonomic reports are available from the Canadian Pacific coast, namely the redescription of Oncholaimus vesicarius (Nelson et al., 1971) and the description of a new species, Enoplus anisospiculus (Nelson et al., 1972). However, there have been some investigations on free-living marine nematodes from this area possessing eyespot pigments (Bollerup, 1973; Bollerup and Burr, 1971; Burr, 1970; Burr and Burr, 1975; and Burr and Webster, 1971). Since no comprehensive studies are available for the Canadian Pacific coast, a primary purpose of my study has been to investigate the nematode component of the meiofauna of this region.

This study examines the composition of the nematode fauna over one year at two sites near Vancouver, British Columbia, namely, Belcarra Park and Iona Island. A few qualitative samples were taken at other sites to help determine the nematode species distribution.

In order to determine the reasons for quantitative differences, the sediment grain size composition, organic carbon content of the sediments, and the temperature and salinity of surface water were determined. Several taxonomic problems were encountered, and in attempting to resolve these I studied the taxonomic status of the more abundant species. In particular, I studied the family Cyatholaimidae, and include the description of *Marylynnia* n.sp., a new species of this family. I have also examined the taxonomic importance of hypodermal pores and punctations in the cyatholaimids.

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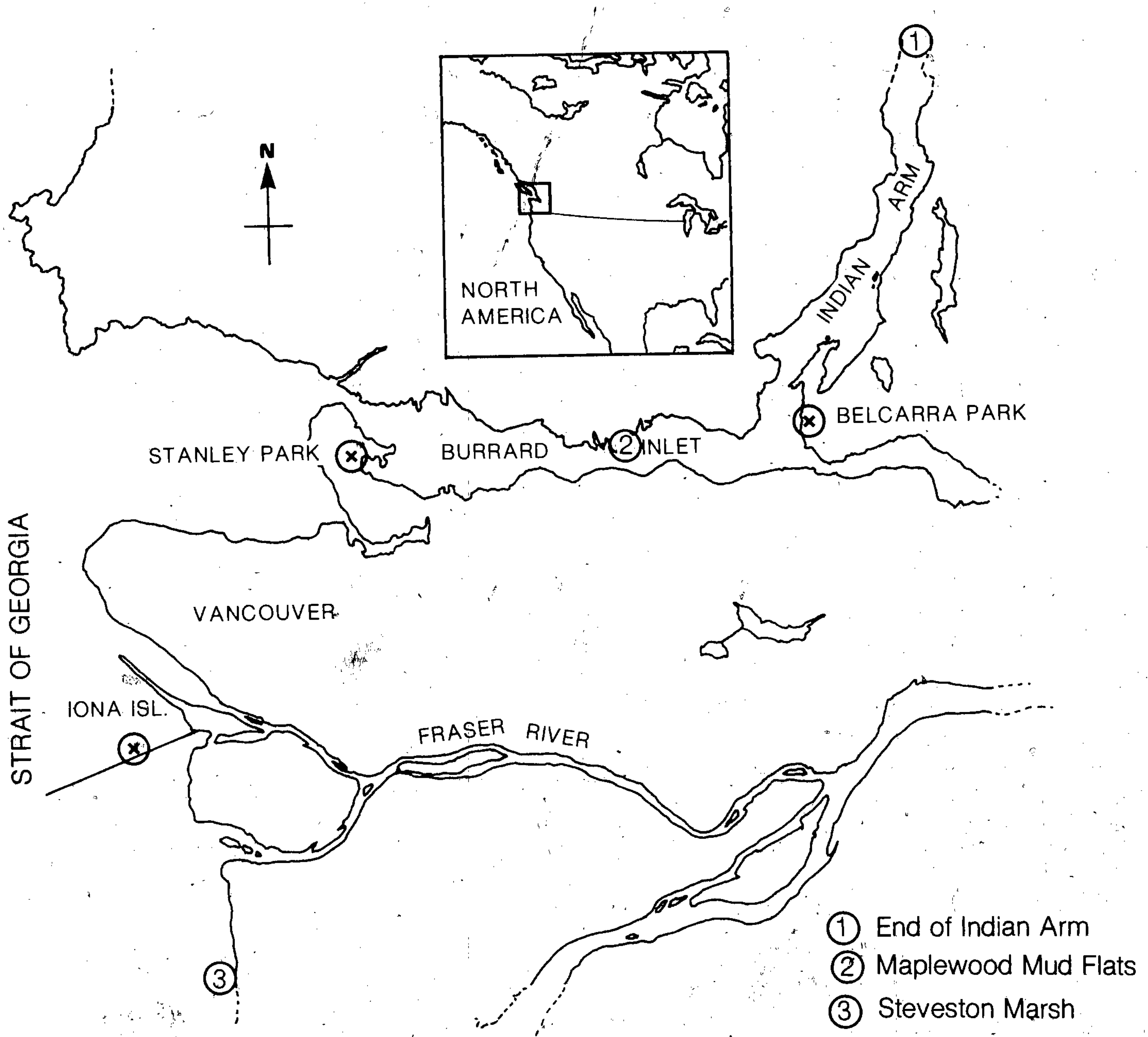
Fig. 1. Map of the Vancouver area of British Columbia showing the location of the three main sampling sites (marked ⊗) and of three supplementary sites (marked 1-3)


NORTH AMERICA
N
STRAIT OF GEORGIA
IONA ISL.
STANLEY PARK
VANCOUVER
BURRARD
INLET
INDIAN
ARM
BELCARRA PARK
FRASER RIVER
①
②
③
① End of Indian Arm
② Maplewood Mud Flats
③ Steveston Marsh

HABITAT DESCRIPTION

All samples were taken in the area of Vancouver, British Columbia. The Iona Island and Steveston marsh sites are exposed to the waters of Georgia Strait. The other sites, in Burrard Inlet and Indian Arm, are part of a single inlet system that opens into the Georgia strait (Fig.1).

Initially, three sites in the greater Vancouver area were chosen for quantitative sampling (see Fig. 1):

1). Iona Island: 123 15'W;49 10'N, a tidal flat facing west with a gently sloping beach (2 degrees), south of the city of Vancouver. Although it is in the estuary of the Fraser river it has jetties on either side. They minimize the influence of fresh river water, as noted by Hoos and Parkman (1974) 'the North Arm jetty and Iona Island causeway and outfall channel have effectively prevented dispersal of sediment from the north or south into the v-shaped section of Sturgeon Bank off the Iona Island sewage plant...sediments north of the causeway tend to be coarser than those immediately to the south.' The samples were taken on the north side of the jetty at a tide level of 7 feet above 0 tide. The site of sampling was a depression, approximately 50 meters from the telegraph poles, which was always covered with water.

2). Stanley Park: 123 08'W 49 17'N, a sandy beach near the mouth of Burrard Inlet that contains the dock facilities of a major port. The samples were taken at Coal Harbor where the slope is somewhat steeper than the beach at Iona Island and the area is heavily used for recreational and educational purposes. The samples were taken on January 10, 1977 and March 10, 1977.

3). Belcarra Park: 123 56'W, 49 19'N, a small westward facing beach of muddy-sand with a 6 degree slope situated in Bedwell Bay at the mouth of Indian arm, a deep water fjord. The samples were taken at the 2.5 foot tide level approximately 30 meters north of the pier. It receives much recreational usage and is close to a bed of eel grass, <u>Zostera</u> <u>marina</u>, with some small kelp beds off the beach, which contain some coarse gravels and broken shell.

Qualitative samples were taken on an <u>ad</u> <u>hoc</u> basis in the following littoral and subtidal zones, in order to determine the range of nematode species.

1).Indian Arm: 122 54'W 49 28'N, a deep water fjord at the head of Burrard Inlet. The samples were taken at low tide near the pilings in the sandflat on February 15, 1977.

2).Maple Wood mud flats: 129 59'W 49 18'N, a large exposed mud flat close to a shipyard on the north shore of Burrard Inlet. The samples were taken on February 5, 1977.

3).Steveston Marsh: 123 10'W 49 05'N, a marsh adjoining an open sandflat on the south arm of the Fraser river. The samples were taken on the north side of Steveston jetty one week following an oil spill in a Steveston cannery. The site of sampling was approximately 80 meters from the mid-point of the jetty. The date of sampling was September 16, 1977.

4).Burrard Inlet: 123 12'W, 49 18' N. The samples were taken by boat off Jericho beach in English Bay at approximately 6 fathoms on November, 1976.

MATERIALS AND METHODS

1) Sampling

Both Belcarra Park and Iona Island were chosen for their accessibility and different physical characteristics and were sampled at convenient low tides. Three replicate samples were taken at each time interval with a hand held plexiglass corers (internal diameter 4.8cm. length 20cm.) within a one square meter quadrat . Nematodes were extracted from the samples by sieving and centrifugation techniques, and preserved for subsequent identification. In addition, the salinity, temperature, carbon cotent and sediment grain size were measured.

Each corer and its contained sample was transported to the laboratory in a closed plastic bag where the core of sediment was sliced into three 2cm sections , starting at the upper surface of the core. The volume of each 2cm section was 39.27cm3. The remaining sediment was discarded as Tietjen (1966) and personal observations showed that 95% of the nematodes occur in the upper 6 cm. In addition, the upper 4cm of the sediment were collected for determination of they, carbon content and grain size.

The subtidal samples were taken with an Eckman grab operated from a boat and then subsampled upon returning to the laboratory.

2) Extraction

The sediment was first passed through a 1.0mm sieve to remove coarse particles such as broken shell and organic debris, and subsequently through a 44u sieve to separate the silt-clay particles of the sediment. The material retained on the fine sieve was washed into 50ml centrifuge tubes, centrifuged for approximately 2min at 180xg in an International, model HN centrifuge, and the supernatant poured into a beaker. The remaining sediment was mixed with a 1:1 sea water-Karo syrup mixture and shaken to distribute the sediment (Teal, 1960, Hopper and Meyers, 1967). The sample was centrifuged at 180x g's for 2 1/2 min and poured through a 44um sieve together with the supernatant from the first centrifugation. The organisms retained in the sieve were washed off the sieve.They were concentrated in sea water, slowly heated to approximately 60 C to relax the nematodes and fixed in 5% formalin-sea water.

3) Processing

After being left in the fixative for at least 24 hours, the nematodes were separated from other components of the meiofauna by transferring them by hand into a glycerol-methanol mixture . The methanol evaporated, and the nematodes in the remaining glycerol were placed in a dehydrating chamber in BPI watchglasses until needed for identification.

4) Temperature and Salinity

Temperature and salinity measurements of the surface water were taken at the site of sampling using a YSI Model 33 S-C-T meter.

5) Organic Carbon

The per cent organic carbon in the sediment was measured with a Perkin-Elmer model 240 Elemental analyzer. The sediments were not pretreated as Byers et al.(1978) have shown that it is possible to recover almost 100% of the carbon by this method.

6) Sediment Grain Size Analysis

The grain size of the sediment was determined by the technique of Buchanan (1964). 25g of air-dried sediment was mixed with 10ml sodium hexametaphosphate in a beaker and left for 24 h. It was then sieved through a 63u sieve to remove the silt-clay fraction and the remaining sediment was oven dried and weighed. The sediment was then sieved through 0.105, 0.250, 0.5, 1.0, and 2.0mm sieves and the material retained on each sieve was weighed.

The results are expressed in phi units;the standard unit for expression of grain sizes. The percentage of sediments in each range of grain sizes was plotted on a cumulative per cent curve (see appendix 1). The sorting of the sediment was determined by the quartile deviation (QD=(QD3-QD1)/2). It is the degree of spread between the size of sediments comprising 75% of the total sediments and the size of sediments comprising 25% of the sediments, divided by two. The sediments with a smaller spread between the quartiles are regarded as being well sorted while a large spread indicates a poorly sorted heterogenous sediment.

7) Statistical Analysis

A 3-level, nested analysis of variance was performed using a BMDP2V program. Since there were only two replicate samples from Iona Island in January, these samples were not considered and the corresponding ones from Belcarra Park were eliminated so as to have equal cell sizes (appendices 7 and 8). Log n+1 transformations were used as the population of nematodes shows a contagious distribution and zero values were present in some samples.

TAXONOMY

1) Checklist of the Nematode Fauna

The identification of free-living marine nematodes has received little attention in ecological studies because of the difficult task of assimilating the scattered literature and the time consuming process of describing such large numbers of superficially similar organisms. Nevertheless, a thorough taxonomic survey was deemed necessary in this work in order for the ecological material to be more valuable. The following checklist is a record of the nematodes found in my ecological studies. It also lists previous records of these species on the Pacific Coast of North America as well as valid synonyms. Several of the species were identified only to genus because insufficient specimens were available for more precise identification. For some of the species additional taxonomic information is recorded, and their taxonomic status is discussed.

The nematodes recorded and described here are classified according to the system originally proposed by Chitwood and Chitwood (1950) and modified by Gerlach and Riemann (1973). The Chitwood classification is the most widely accepted one despite the useful historical perspective and new taxonomic subdivisions proposed by Andrássy (1976).

Class Secernentea

Order Rhabditida

Family Rhabditidae

Rhabditis Dujardin, 1845

R. marina Bastian, 1865

Murphy, 1961, Oregon

Class Adenophorea

Order Araeolaimida De Coninck and Stekhoven, 1933

Family Leptolaimidae Orley, 1880

Subfamily Leptolaiminae Orley, 1880

Leptolaimus De Man, 1876

Family Axonolaimidae Filipjev, 1918

Subfamily Diplopeltinae Filipjev, 1918

Araeolaimus De Man, 1888

Length:3.2mm, esoph.:268u, tail:168u

spicule arc:160u, spicule chord:140u

The specimen resemble A. elegans de Man, 1883 nec Steiner but setal length (13.0u) and arrangement are not in agreement with that given by Wieser, 1954. In my specimen there are 4 rows of setae in the anterior region with 9 of the anteriormost setae clustered together.

A. boomerangifer Wieser, 1959

Although the pigment spot is distinct the setal arrangement in my specimen is not in agreement with the description by Wieser, 1959.

Axonolaimus De Man, 1889

A. spinosus (Bütschli, 1874) De Man, 1889

syn. *Anoplostoma spinosum* Bütschli, 1874

Odontophora Bütschli, 1874

O. peritricha Wieser, 1956

Wieser, 1959, Washington

Paraodontophora Timm, 1963

P. pacifica (Allgén, 1947) Timm, 1963

syn. *Odontophora pacifica* Allgén, 1947

Allgén, 1951, Central America

Parascolaimus Wieser, 1959

The spicule shape of my specimens does not agree with that of either of the two species described by Wieser, 1959 and this may, therefore, be an undescribed species.

Order Monhysterida Filipjev, 1918

Family Sipholaimidae Filipjev, 1918

Paraterschellingia Kreis in Schuurmans-Stekhoven, 1935

Siphonolaimus De Man, 1893

Solenolaimus Cobb, 1894

Family Linhomoeidae Filipjev, 1918

Subfamily Desmolaiminae G. Schneider, 1926

Desmolaimus De Man, 1880

D. zeelandicus De Man, 1880

syn. D. fennicus G. Schneider, 1926

Wieser, 1959 (syn. D. elongatus, Allgen, 1935)

A second Desmolaimus sp. could be distinguished in the December samples from Belcarra Park but no attempt was made to identify it further.

Linhomoella Cobb, 1920

Metalinhomoeus De Man, 1907

M. setosus Chitwood, 1951

Wieser, 1959, Washington

Length:3.58mm, esoph.:193u, tail:200u

Terschellingia De Man, 1888

T. longicaudata De Man, 1907

Subfamily Eleutherolaiminae, Gerlach and Riemann, 1973

Eleutherolaimus Filipjev, 1922

Length:5.86mm, esoph.:233u, tail:313u,
spicule l:65u, gubernaculum:30u.

This species resembles *E. stenosoma* (De Man, 1907) Filipjev, 1922, reported by Wieser (1959) and Allgén (1947). However, based on its larger size and spicule shape it is probably an undescribed species.

Subfamily Linhomoeinae Filipjev, 1920

Didelta Cobb, 1920

Linhomoeus Bastian, 1965

Length:2.70mm, esoph.:233u, tail:173u,
spicule l.:60u, gubernaculum:35u, 12 cervical setae

Paralinhomoeus De Man, 1907

P. buculentus (Wieser, 1956) Gerlach, 1963

Wieser, 1959, Washington

Paralinhomoeus sp.

amily Monhysteridae De Man, 1876

Subfamily Monhysterinae De Man, 1876

Cylindrotheristus Wieser, 1956

C. ecphygmatus (Wieser, 1959)

syn. *Theristus* (*Cylindrotheristus*) *ecphygmatus*

Wieser, 1959, Washington

C. resimus (Wieser, 1959)

syn. *Theristus* (*Cylindrotheristus*) *resimus* Wieser, 1959

Murphy, 1966, Chile

Diplolaimella Allgén, 1929

Mesotheristus Wieser, 1956

M. circumscriptus (Wieser, 1959)

syn. *Theristus* (*Mesotheristus*) *circumscriptus*

Wieser, 1959.

Monhystera Bastian, 1865

M. refringens Bresslau and Schuurmans-Stekhoven

in Schuurmans-Stekhoven, 1935

Paramonohystera Steiner, 1916.

Steineria Micoletzky, 1922

S. gerlachi Wieser, 1959

Wieser, 1959, Washington

Theristus Bastian, 1865

T. modicus Wieser, 1956

Theristus sp.1

This species can be distiguished by the presence of a long thin tail and the lack of prominent lips characteristic of Theristus sp.

Theristus sp.2

This species is shorter and has charateristic stoma and tail of Theristus sp.

Subfamily Rhynchonematinae De Coninck, 1965

Rhynchonema Cobb, 1920

Family Sphaerolaimidae Filipjev, 1918

Sphaerolaimus Bastian, 1865

Total l.	2.50mm	2.80mm	1.96mm	1.90mm	2.30mm
esoph l.	496u	493u	392u	408u	429u
l to vulva	1.74mm	1.96mm			
tail l.	249u	318u	223u	227u	244u
Max. width	131u	128u	83u	96u	86u
Stoma l.	54u	46u	42u	38u	48u
Spicule arc			48u	52u	64u

Amphid of adults is in mid-buccal cavity region but in juveniles it occurs below buccal cavity. my specimen do not resemble *S. penicillus* var. *pugetensis* Wieser, 1959, the only species of this genus recorded from Washington.

Order Desmodoridae De Coninck, 1965

Family Aponchiidae Gerlach, 1963

Aponchium Cobb, 1920

Family Desmodoridae Filipjev, 1922

Subfamily Microlaiminae Micoletzky, 1922

Microlaimus De Man, 1880

M. dentatus Allgén, 1935

Wieser, 1959, Washington

M. texianus Chitwood, 1951

Family Monoposthiidae Filipjev, 1934

Monoposthia De Man, 1869

M. costata (Bastian, 1865) De Man 1889

syn. *Spiliphera costata* Bastian, 1865

syn. *Monoposthia costata* subsp *mediterranea* Schulz, 1935

syn. *Monoposthia apiculata* Cobb, 1930

syn. *Monoposthia chinensis* Steiner, 1921

syn. *Monoposthia constricta* Ditlevsen, 1918

syn. *Monoposthia loricata* Kreis, 1929

syn. *Monoposthia metamediterranea* nom nov pro *Monopisthia mediterranea* Stekhoven, 1950

syn. *Monoposthia mediterranea* Stekoven, 1950

syn. *Monoposthia minor* Schulz, 1932

syn. *Monoposthia similis* Schulz, 1932

Wieser, 1959, Washington

Allgén, 1947, 1951, Central America

Murphy, 1961, Oregon

Family Richtersiidae Kreis, 1929

Richtersia Steiner, 1916

Order Chromadorida Filipjev, 1934

Family Comesomatidae Filipjev, 1918

Subfamily Sabatieriinae Filipjev, 1934

Sabatieria Rouville, 1903

S. americana Timm, 1952

Wieser, 1959, Washington

S. ancudiana Wieser, 1954

S. sp.

Length	2.53mm	2.66mm	3.08mm	2.66mm
Esoph.l.	195u	208u	195u	211u
Tail l.	250u	286u	305u	237u
Length to vulva			1.49mm	1.27mm
Seta l.	12.8u	12.8u	16.0u	16.0u
Max. width	80u	67u	96u	45u
Spicule arc	100u	78u		
a	31.60	40.00	32.08	59.37
b	12.90	12.60	15.8	12.60
c	10.12	9.31	10.10	11.20

My specimens do not agree with Wieser's (1959) description of S. jubata which this species closely resembles. The spicules are more arched in my specimen and the apophyses of the gubernaculum are shorter. The greater size of these specimen suggests that this may be an undescribed species.

S. pulchra (G. Schneider, 1906) Riemann, 1970

syn. *Aphanolaimus pulcher* G. Schneider, 1906

syn. *Parasabatieria vulgaris* de Man, 1907

syn. *Sabatieria vulgaris* de Coninck and Schuurmans-Stekhoven, 1933

syn. *Parasabatieria clavicauda* Filipjev, 1918

syn. *Sabatieria clavicauda* (Filipjev, 1918) Paramonov, 1929

syn. *Parasabatieria punctata* Kreis, 1924

syn. *Sabatieria punctata* (Kreis, 1924) Schuurmans-Stekhoven, 1935

Family Chromadoridae Filipjev, 1917

Subfamily Chromadorinae Filpjev, 1917

Chromadorina Filipjev, 1918

C. germanica (Bütschlii, 1874) Wieser, 1954

Wieser, 1959, Washington

Nelson et al., 1971, British Columbia

Subfamily Euchromadorinae Gerlach and Riemann, 1973

Euchromadora De Man, 1886

Subfamily Hypodontolaiminae De Coninck, 1965

Denticulella Cobb, 1933

Innocuonema Inglis, 1969
I. clivosum (Wieser, 1959) Inglis, 1969
syn. *Graphonema clivosum* Wieser, 1959
Wieser, 1959, Washington

Neochromadora Micoletzky, 1924
N. appiana Wieser, 1959
Wieser, 1959, Washington

Spilophorella Filipjev, 1917
S. paradoxa (De Man, 1888) Filipjev, 1917
Allgen, 1947, Central America
Wieser, 1959, Washington

Family Cyatholaimidae Filipjev, 1918
Subfamily Neotonchinae Wieser and Hopper, 1966
Neotonchus Cobb, 1933

Subfamily Pomponematinae Gerlach and Riemann, 1973
Pomponema Cobb, 1917

Subfamily Paracanthonchinae De Coninck, 1965
Acanthonchus Cobb, 1920
A. (*Seuratiella*) Ditlevsen, 1921

Paracanthonchus Micoletzky, 1924

Paracanthonchus sp.1- at Iona Island

This species can be distinguished by the presence of 4 preanal supplements, short stout body shape, and the closely spaced row of lateral modified punctations.

Paracanthonchus sp.2- at Belcarra Park

This species has a long tail and 4 minute preanal supplements.

Subfamily Cyatholaiminae Filipjev, 1918

Cyatholaimus Bastian, 1865

Marylynnia n. sp. (see description in next section)

Marylynnia quadriseta (Wieser, 1954) Hopper, 1977

syn. Longicyatholaimus quadriseta Wieser, 1954

syn. Marilynia quadriseta (Wieser, 1954) Hopper, 1972

Family Choniolaimidae Stekhoven and Adam, 1931

Halichoanolaimus De Man, 1886

Order Enoplida Filipjev, 1929

Family Tripylida De Man, 1876

Subfamily Tripylidinae De Man, 1876

Tripyla Bastian, 1865

Family Tripyloididae Filipjev, 1918

Bathylaimus Cobb, 1894

B. tarsioides Wieser, 1959

Length	1.51mm	1.47mm	1.71mm	1.65mm
Esoph	300u	225u	266u	400u
Tail	86u	113u	126u	
Max. width	53u	46u	86u	
Stoma l.	25.6u	22.4u	25.6u	22.4u
Spicule l.	35.2u	35.2u		
L. to vulva			680u	1120u

Wieser, 1959, Washington

Bathylaimus sp.

Paratripyloides Stekhoven, 1950

Tripyloides De Man, 1886

T. gracilis (Ditlevsen, 1918) Filipjev, 1927

Family Trefusiidae Gerlach, 1966

Subfamily Trefusiinae Gerlach, 1966

Cytolaimium Cobb, 1920

Rhabdocoma Cobb, 1920

Family Oxystominidae Chitwood, 1935 (Filipjev, 1918)

Subfamily Oxystomininae Chitwood, 1935 (Filipjev, 1918)

Oxystomina Filipjev, 1918

Subfamily Halalaiminae De Coninck, 1965

Halalaimus De Man, 1888

subgenus Halalaimus De Man, 1888

Family Lauratonematidae Gerlach, 1953

Lauratonema Gerlach, 1953

L. pugiunculus Wieser, 1959

Length:1.70mm, esoph.:138u, tail:147u,

Max. width:51u

a=33.13, b=12.30, c=11.50

Wieser, 1959, Washington

Family Anticomidae Filipjev, 1918

Anticoma Bastian, 1865

A. pellucida Bastian, 1865

Family Enoplidae Dujardin, 1845

Subfamily Oxyonchinae De Coninck, 1965

Oxyonchus Filipjev, 1927

Mesacanthion Filipjev, 1927

Subfamily Enoplinae Dujardin, 1845

Enoplus Dujardin, 1845

E. anisospiculus Nelson *et al.* 1972

Nelson *et al.*, 1972, British Columbia

Family Anoplostomatidae Gerlach and Riemann, 1973

Anoplostoma Bütschli, 1874

Family Oncholaimidae Filipjev, 1916

Subfamily Oncholaimellinae De Coninck, 1965

Viscosia De Man, 1890

Viscosia sp.1

This species can be distinguished by it's long thin tail and short indistinct cephalic setae.

Viscosia sp.2

This species has a short tail and longer, prominent cephalic setae.

Subfamily Oncholaiminae Filipjev, 1916

Oncholaimus Dujardin, 1845

O. apostematus Wieser, 1959

Timm and Hackney, 1969, California

Wieser, 1959, Washington

O. brachycercus De Man, 1889

Wieser, 1959, Washington

O. skawensis Ditlevsen, 1921

Chitwood, 1960, California

Nelson *et al*.,1972, British Columbia

Bollerup and Burr, 1971, British Columbia

O. vesicarius (Wieser, 1959) Rachor, 1969

Nelson *et al*.,1971, British Columbia

Burr and Webster, 1971, British Columbia

Wieser, 1959, Washington

syn. *Oncholaimium vesicarium* Wieser,1959

Family Enchelidiidae Filipjev, 1918

Subfamily Eurystomininae Chitwood 1945 (Filipjev, 1936)

Belbolla Andrássy, 1973

syn. *Bolbella* Cobb, 1920

Bolbellia Gerlach and Riemann, 1974

Eurystomina Filipjev, 1918

Subfamily Enchelidiinae Filipjev, 1918

Symplocostoma Bastian, 1865

Family Mononchidae Filipjev, 1934

Mononchus Bastian, 1865

syn. *Dioncholaimus* Kreis, 1932

Family Prodorylaimidae Andrássy, 1969

Prodorylaimium sp.

This species could not be placed with *Prodorylaimus rionensis* Gerlach,1954 because preanal supplements of this species begin before the spicules and are continuous. My specimens differ from the two described species of *Prodorylaimium* by the presence of more numerous (16-17) preanal supplements, the shorter distance between the anus and the last supplement and the shorter tail. This may therefore be an undescribed species. (personal comm., Andrássy to B. Hopper).

2) Description of Marylynnia n. sp.

The order Chromadorida is represented, in my collection, by species from all of its families, namely, the Comesomatidae, Cyatholaimidae, Choanolaimidae and Desmodoridae. The cyatholaimids are represented in my collection by four species, Marylynnia quadriseta Wieser, Paracanthonchus sp.1, Paracanthonchus sp. 2, and Marylynnia n. sp.. M. quadriseta and Paracanthonchus sp.2 were prominent in the Belcarra Park sediments and Paracanthonchus sp.1 was present at Iona Island. Marylynnia n.sp. was recorded from the subtidal sediments in Burrard Inlet.

On initial observation, all these cyatholaimids appeared to be very similar in having a prominent dorsal tooth and multispiral amphid and they were identified as Marylynnia sp. However, the genus Paracanthonchus can be separated from the genus Marylynnia by the presence of tuboid supplements rather than the cup-shaped supplements characteristic of the genus Marylynnia. Furtheremore, members of the genus Marylynnia have well-developed cuticular pores.

The genus Marylynnia Hopper, 1977, is distinguished from Longicyatholaimus, Micoletzky,1924 by the prominent dorsal tooth, a shorter tail and the orientation of its pore slits in a transverse plane. The pores of Longicyatholaimus sp. are also larger in size than those of Marilynia sp. Since these pores and punctations are present in the Cyatholaimids, Chromadorids and a few other free-living marine nematodes, these features will be used here to help distinguish *Marylynnia* n.sp. from others.

Taxonomic Description

With charactristics of genus *Marylynnia* Hopper, 1977, as given in Hopper, 1972. Cuticle thickened at anterior end, with prominent cuticular punctations. Annulations not distinct until mid-esophageal region. 25-36 lateral modified punctations (LMP's) in cluster starting about 50um behind head. No discernible pattern within cluster, but placement of LMP's similar in all the specimens examined (n=10). A row of 10-12 LMP's in preanal-caudal region of both sexes. The male has no further LMP's but the female has short rows with 3-4 pores a short distance anterior and posterior to the vulva. In both sexes there are 10 cephalic setae (6+4) of unequal length, spiral amphids with 4 coils. The dorsal tooth is prominent and there are 2 pairs subventral teeth. Females didelphic. Male and female tail conoid with posterior half attenuated.

In the following quantitative description, all values are in micrometers unless otherwise specified and the means for each sex are based on five specimens. Wherever possible each value is presented as the mean±s.d. and the range included in parentheses. The data on *M. complexus* are based on 1 female paratype USNM #43418 and 2 male paratypes USNM #43410 and #43412.

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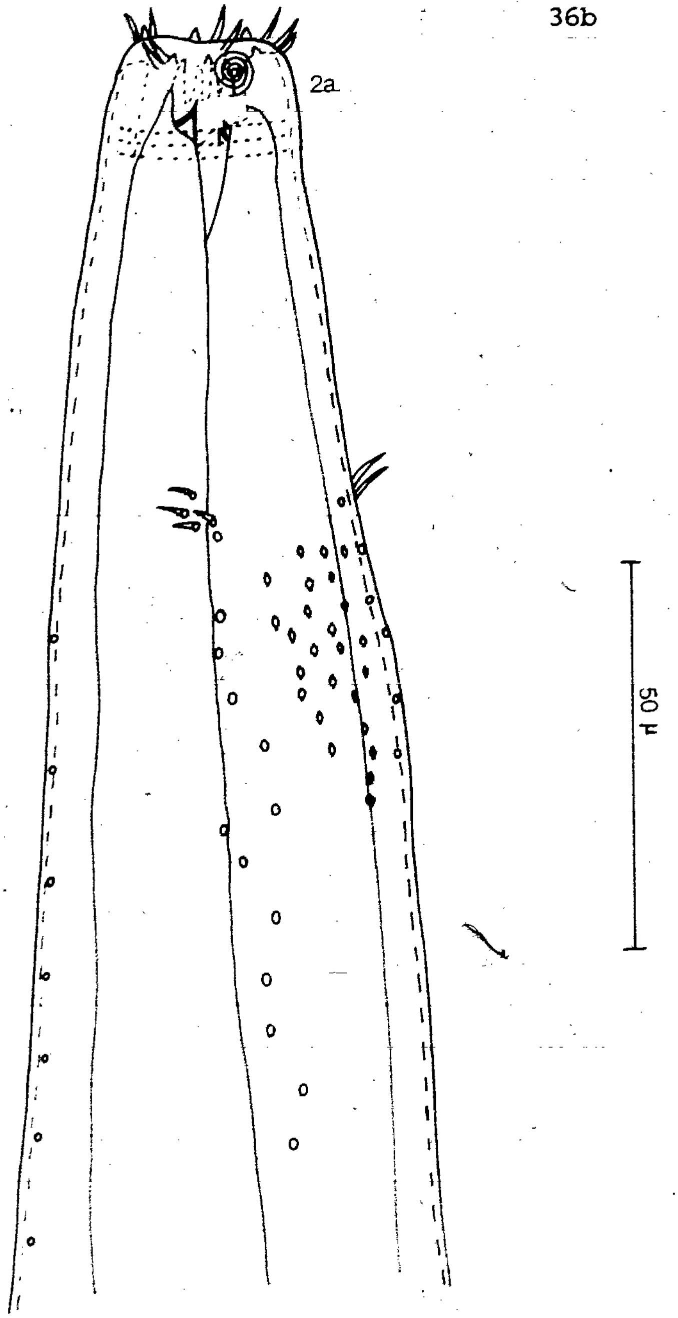
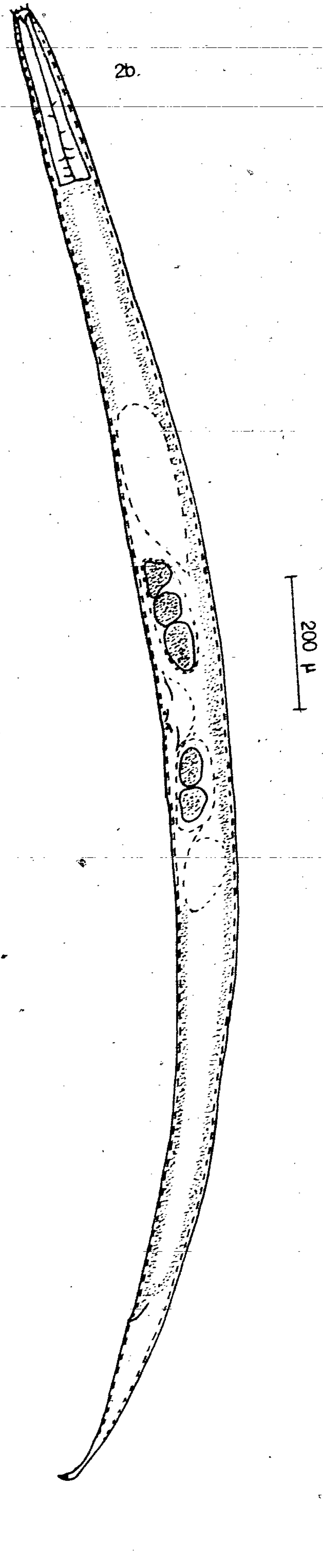
Fig.2. *Marylynnia* n. sp. 2a. Lateral view of female showing body shape. 2b. Lateral view of head showing amphid, dorsal tooth and paired subventral teeth.

2a



2b.



Female (fig. 2)

Length:2.17±0.13(2.04-2.31) mm

Maximum width:84.5±6.0(76.7-92.3)

Esophageal length:300.7±22.6(277-327)

Distance anterior end to amphid:2.0±0.9(1.3-2.6) (n=2)

Width at amphid:25.7±1.7(24.7-28.6)

Head diameter at anterior extremity:25.4±0.9(24.7-26.0) (n=2)

Amphid width:9.6±1.5(7.8-11.7)

Amphid width/body width at amphid:0.37±0.05(0.3-0.42)

No. cephalic setae:10(6+4)

Length cephalic setae:6.2±0.6(5.2-6.5)

Length anterior end to vulva:1.01±0.06(0.94-1.07)

Tail length:236.6±18.1(214-263)

a=12.8±0.4 b=7.2±0.6 c=9.2±0.89

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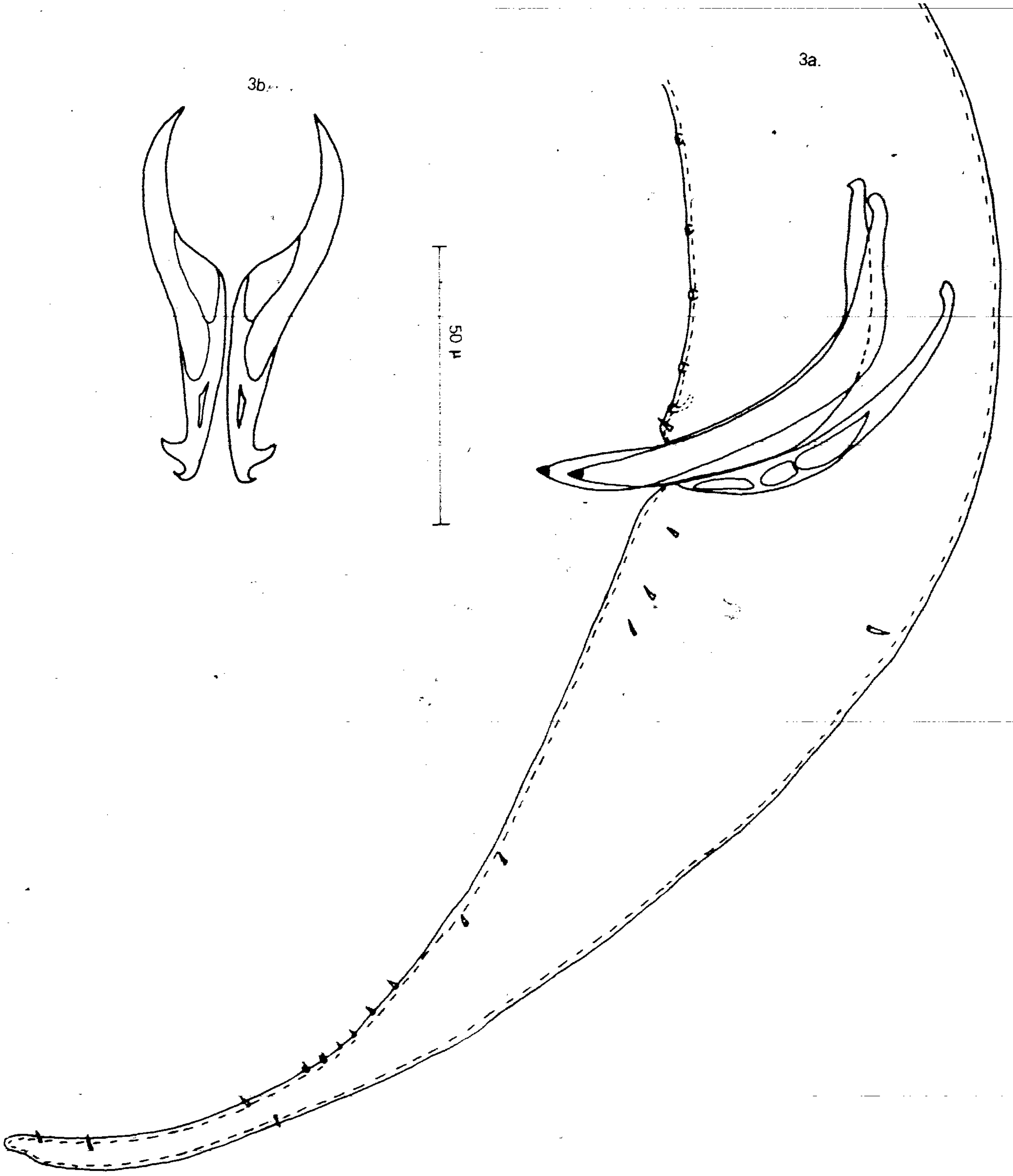
Fig. 3. Marylynnia n. sp.3a. Spicular apparatus of male

3b. Gubernaculum of male


3b.
3a.
50 µ

Male (Fig. 3)

Length:2.16±0.16(1.96-2.42) mm

Maximum width:65.0±3.2(59.6-67.6)

Esophageal length:292±28(256-327)

Distance anterior end to amphid:3.9±3.7(1.3-6.5) (n=2)

Width at amphid:25.2±1.7(23.4-27.3)

Head diameter at anterior extremity:24.7±1.6(23.4-26.0)(n=2)

Amphid width:11.4±0.6(10.4-11.7)

Amphid width/body width at amphid:0.45±0.03(0.43-0.5)

Length cephalic setae:6.5±0.9(5.2-7.8)

Spicule arc:114.0±6.7(91.0-106.0)

Spicule chord:95.0±6.5(91.0-106.0)

Tail length:210.0±29.9(166-250)

Gubernaculum:93.0±1.4(92.0-94.0) (n=2)

a=16.7±1.7 b=7.5±0.6 c=10.5±0.8

5 cup-shaped preanal supplements present.

Diagnosis

Marylynnia n.sp. is most closely related to M. complexus (Warwick, 1971) Hopper, 1977 because they both have a cluster of LMP's in the mid-esophageal region. However, it is distinguished from M. complexus by having the characteristic cluster of LMP's limited to the mid-esophageal region and larger in size here than elsewhere on the body. M. complexus, however, has 54-58 LMP's in the mid-esophageal region starting 49.4±9.0(39.0-54.6)um behind the head and extending for 120.9±11.1(110.5-132.6)um. There are also 13-16 LMP's on the tail arranged close together. M. complexus has 6-10 very small hypodermal pores in the esophageal region, 9 in the vulvar region and 2 on the tail.

3) The Taxonomic Importance of Hypodermal Pores and Punctations

The 'pores' referred to here appear, under light microscopy, as circles of varying sizes and shapes amongst the punctations which appear as dots in several chromadorids. Little attention has been given to the type and number of pores in relation to species identification. One reason for this lack of utilization in taxonomy could be the difficulty of distinguishing the different types at the normal resolution of the light microscope. The lack of complete data on the pores has minimized their inclusion in standard taxonomic descriptions. Hence, their value in taxonomy has not been fully realized.

Since the earliest record of pores by Bastian in 1865, several taxonomic papers have recorded the presence of pores. Bastian (1865) recorded their presence in various nematode species and the differences he noted suggest that the number of pores varies with species. Chitwood and Chitwood (1950) described pores, in both the Enoplida and Chromadorida, as the openings of two sublateral rows of unicellular glands situated in the lateral chords. They also noted that these glands occur only in the Aphasmidea. Such pores are not confined to the Cyatholaimidae but have been described also from the Eurystominidae (Hopper,1970) and the Desmodoridae (Hopper and Cefalu, 1970). Schuurmans-Stekhoven and Teunissen (1938) recorded the distribution and number of pores in _Plectus granulosus_. However, the

Cyatholaimidae is the only family of marine nematodes in which hypodermal pores have been consistently recorded and in which their structure has been the subject of investigation.

Inglis (1963) was the first person to describe cuticular pore structures in detail and he compared them to the 'campaniform-type' organs which act as proprioceptors in insects. He described two types of pores: an ovoid type with a transverse sheet of cuticle (type-1) and a circular type with a raised central dome (type-2). Since then the two types of pores have been referred to as hypodermal pores and lateral modified punctations (LMP's) respectively by several authors. Hypodermal pores, which appear as pores with a transverse slit, occur in up to 12 longitudinal rows around the circumference of the body. The most prominent are the two sublateral rows situated in the region of the lateral chords. Normally, the hypodermal pores in these rows are spaced uniformly throughout the body length. There are fewer longitudinal rows of LMP's each of which appear as pores placed between two punctations, and generally, only a single row of LMP's are present in each lateral aspect. However, their distribution within this row is highly variable between species. Warwick (1971) refers to these two types of pores as type-a and type-b respectively.

Although the presence of the two types of pores has been confirmed by several authors, a different interpretation of pore structure resulted from the ultrastructure studies of Wright and Hope

(1968): They describe the pore as a complex consisting of: a shallow depression in the outer cuticle, a slit-like pore extending through the deeper cuticular layers into an underlying hypodermal cell, and a ring or collar-like development of dense material in the middle cuticle layer. They introduced the term 'pore complex' for the type-1 pore described by Inglis because several components of the cuticle contribute to the image of a circle with transverse bar that is seen on the cuticle surface with a light microscope.

The function of the pore complex is not clear. Chitwood and Chitwood (1950) used the term 'lateral hypodermal glands' to describe the structures beneath these pores in the Enoplida and Chromadorida. De Man(1889) drew glands in some of his figures of *Para canthonchus ocellatus* Bastian and showed their relationship to pores. Schuurmans-Stekhoven (1935) refers to pores in relation to 'skin glands'. Nevertheless, only the term hypodermal has been retained by Wright and Hope because the pores are not restricted to a lateral position and their function as glandular openings has not been demonstrated.

Although various authors have noted the presence of hypodermal pore complexes and various names have been assigned to them, the possible taxonomic significance of their kinds and numbers has been ignored except in the one paper by Hopper (1972). In distinguishing the species of a Calanoid copepod, *Eucalanus*, Fleminger (1973) showed that the distribution pattern and number of integumental organs, which

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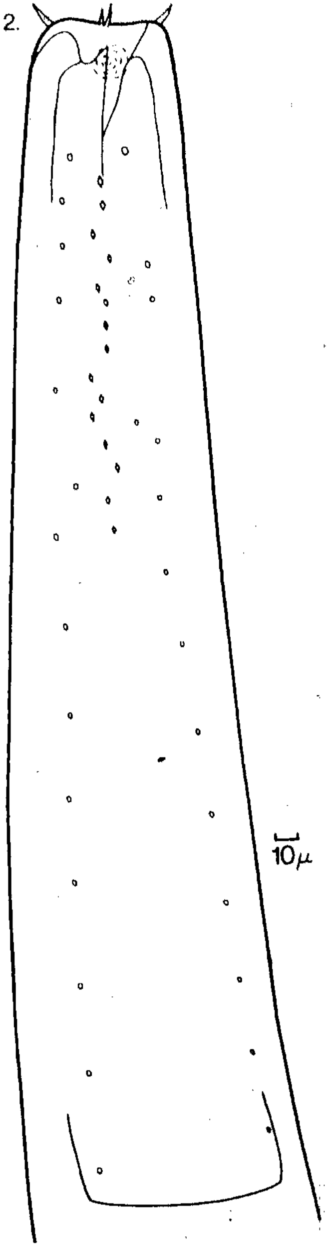
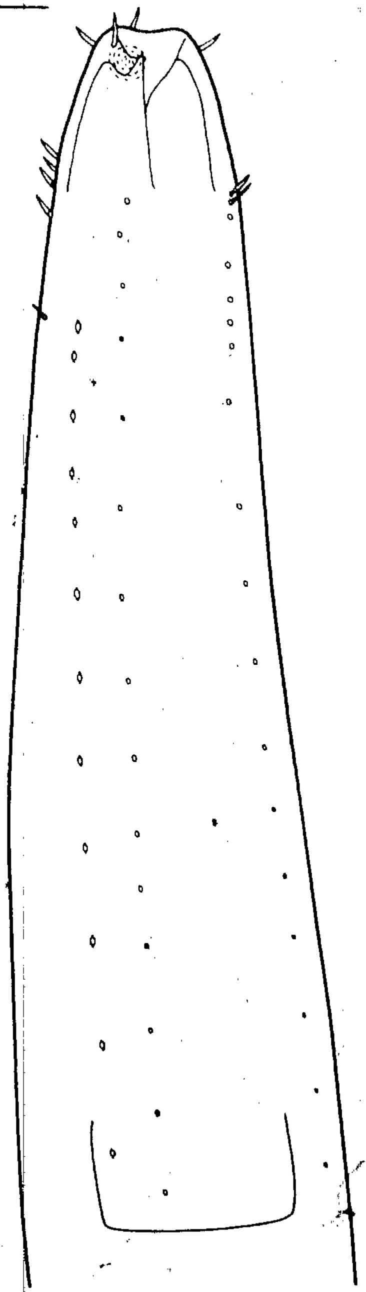
Fig. 4. Pore patterns of three cyatholaimid species: *Marylynnia* n. sp., *Paracanthonchus* sp. 2 and *M. quadriseta*

Marylynnia n. sp.

Paracanthonchus sp. 2.



M. quadriseta



include sensillae and glandular pores, are of taxonomic significance. The distribution of hypodermal pore complexes and modified punctations may be equally important in the taxonomy of some nematode groups. The importance of such meristic or countable characters has been emphasized in taxonomy (Mayr,1969), because in statistical usage, they are discrete variables and the fact that they can only take on certain values makes them taxonomically more reliable.

The pore patterns for each of the three cyatholaimid species in my collection are very distinctive (fig.2). The arrangement of the hypodermal pore complexes on the cuticle in each of the three species is constant among adults and juveniles and conforms with the general description given above. The LMP's show greater interspecific variations in their cuticular arrangement than do the hypodermal pores. However, the arrangement is consistent within a species. In the following discussion only Para canthonchus sp.2, Marylynnia quadriseta and Marylynnia n. sp. will be considered.

Marylynnia n.sp. has a cluster of LMP's behind the head extending for about 100u with 25-35 units in the cluster. There is no discernible pattern within the cluster, although the placement of the LMP's is similar in all specimens examined. A row of 10-12 LMP's occurs in the preanal-caudal region of both sexes. The male lacks further LMP's but the female has short rows containing 3 to 4 pores located a short distance anterior and posterior to the vulvar region.

Table 1. Hypodermal pores and modified punctations in Cyatholaimids*

	I ♂	I ♀	II ♂	II ♀	III ♂	III ♀
Distance behind head of first pore (u)	64.7±3.6	68.1±3.0	22.6±4.7	21.6±3.9	31.3±8.3	30.8±5.3
No. of hypodermal pores in esophageal region	49.8±4.5	49.8±5.8	40.2±4.7	41.6±4.1	22.0±5.0	21.2±3.9
No. of LMP's in esophageal region	32.6±3.4	30.0±3.7	10.4±0.9	14.0±3.2	11.6±1.1	12.8±1.1
No. of hypodermal pores in vulvar region		4.9±1.2		9.5±1.4		9.4±1.1
No. of LMP's in vulvar region		3.8±0.4		4.2±0.8		
No. of hypodermal pores on tail	8.1±1.5	8.1±1.7	17.4±3.0	16.4±2.9	10.4±1.5	10.2±2.2
No. of LMP's on tail	7.4±1.9	7.2±1.8	8.8±1.8	7.6±0.6	4.2±0.5	4.6±0.9

* As viewed from lateral surface

n=5

I=*Marylynnia* n. sp.
II=*Paracanthonchus* sp. 2
III=*M. quadriseta*

Paracanthonchus sp.2 has a row of 15-20 anteriorly placed LMP's extending about one-third the esophageal length. 8-10 LMP's occur in the caudal region and none were found elsewhere on the body.

In *Marylynnia quadriseta* the LMP's are not clustered at the anterior end. Instead, two rows of hypodermal pores occur laterally starting 46-73u from the anterior end, while the LMP'S start one-third of the way down the esophageal region and continue the length of the body.

All three species of the above mentioned cyatholaimids had pores and modified punctations arranged in varying densities over all the body and therefore data were collected (Table 1) so as to differentiate between the species on the basis of their pores. The following observations were made: (i) The distance behind the head of the first hypodermal pore was constant for a given species. (ii) The number of hypodermal pores and LMP's in the esophageal region was constant for a given species. (iii) The number of pores and LMP's in the tail region were constant for a given species but often difficult to ascertain because the tails of fixed nematodes were frequently curled. (iv) Counting all the pores and LMP's over the entire body is very time consuming, hence the number of pores and LMP's in a row were counted (a) from the base of the esophagus to the anterior end, (b) 15.5um on either side of the vulva and (c) on the tail. (v) Varying patterns of distribution may sometimes require other measurements to be made in order to differentiate between some species.

Hopper (1972) defined Marylynnia sp. as having a greater number of hypodermal pore complexes and LMP's than Longicyatholaimus sp. However, it is not yet possible to correlate occurrence and arrangement of pores so as to provide a general statement about the pore complexes of a taxonomic group, because historically not all authors have included pores in taxonomic descriptions. Also, when the presence of pores is recorded there is often no detail as to their type, number and distribution. Although male Cyatholaimids can normally be distinguished on the basis of the shape and size of genital armature, problems often arise in identifying female and juvenile cyatholaimids. Under such circumstances, it would be valuable to be able to use data on pore distribution which, although variable in numbers between individuals is consistent in the placement and arrangement of pores within species.

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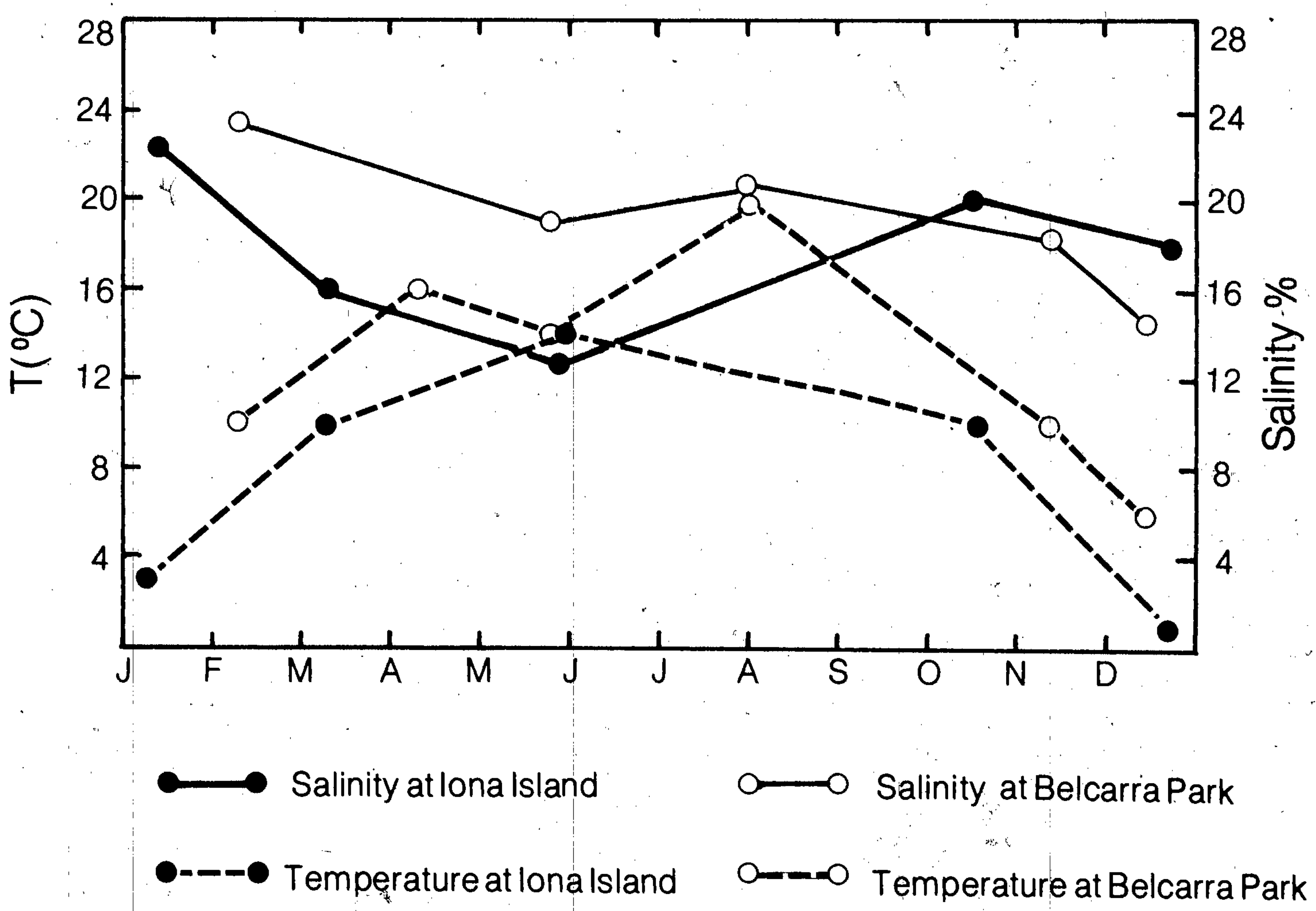
Fig. 5. Temperature and salinity at Iona Island and Belcarra Park during 1977


T(°C)
28
24
20
16
12
8
4
Salinity ‰
J
F
M
A
M
J
J
A
S
O
N
D
Salinity at Iona Island
Temperature at Iona Island
Salinity at Belcarra Park
Temperature at Belcarra Park

ECOLOGY

1) Observations on Environmental Parameters

a) Temperature and Salinity

The surface water temperature and salinity measurements are presented in Fig 5. At both the Iona Island and Belcarra Park sites the surface water temperature increased during the summer from the lowest temperature that was detected during the winter months of December and January (Fig. 2). The maximum temperature recorded at Belcarra Park was 20.5 C and the minimum was 7.0 C. The temperatures at Iona Island are relatively lower and the recorded range was 1.5-15.0 C. The lower temperatures at Iona Island may be attributed to the exposure of the site and especially to the strong winds that are associated with the passage of active frontal disturbances through this area. It may also be a factor of runoff temperatures. On the other hand, Belcarra Park is sheltered from these winds because of its more inland location and proximity to the mountains.

The salinity at both sites was higher in the winter and lowest in the summer (Fig. 5). The salinity at Iona Island is slightly lower than that at Belcarra Park, probably because it is influenced by the Fraser River. However, Belcarra Park receives more precipitation than does Iona Island due to its proximity to the mountains.

Table 2. Grain size composition of sediments at two sites at different sampling times (figures represent g/25g sediment)

	Grain Size	Jan. 11	Mar. 7	April 7	May 31	Oct. 15	Dec. 20
Iona Island	0.063	1.1	1.1	1.5	2.0	10.0	6.3
	0.063-0.105	4.6	5.1	2.8	2.8	2.0	6.1
	0.105-0.250	14.2	12.2	7.6	12.7	8.3	10.6
	0.250-0.500	2.6	3.8	9.6	4.4	2.3	1.0
	0.500-1.000	1.5	2.2	3.0	2.2	1.2	0.5
	1.000-2.000	0.2	0.1	0.2	0.3	0.1	0.1
	2.000						
		April 17	May 20	Aug. 1	Nov. 10	Dec. 12	
Belcarra Park	0.063	1.4	1.9	3.8	3.9	3.0	
	0.063-0.105	1.0	1.9	2.3	1.3	1.3	
	0.105-0.250	7.7	7.9	9.8	4.8	4.9	
	0.250-0.500	7.9	3.8	4.8	4.0	4.5	
	0.500-1.000	4.4	2.3	1.6	2.5	3.7	
	1.000-2.000	1.7	2.2	1.9	2.1	3.2	
	2.000	0.6	4.7	0.9	6.1	4.5	

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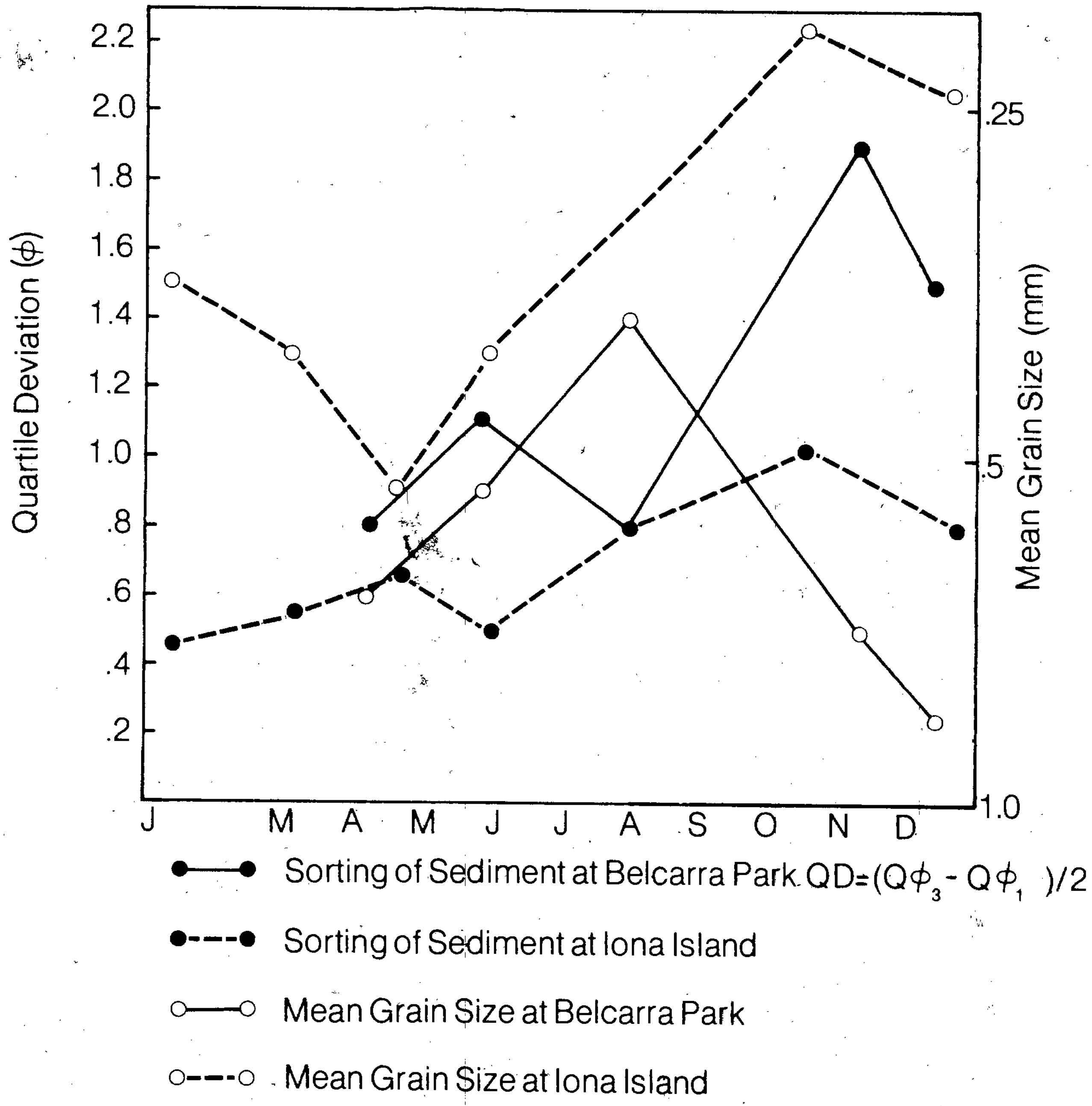
Fig. 6. Mean grain size and sorting of sediments at Iona Island and Belcarra Park during 1977


Quartile Deviation (ϕ)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
Mean Grain Size (mm)
.25
.5
1.0
J
M
A
M
J
J
A
S
O
N
D
Sorting of Sediment at Belcarra Park QD=($Q\phi_3 - Q\phi_1$)/2
Sorting of Sediment at Iona Island
Mean Grain Size at Belcarra Park
Mean Grain Size at Iona Island

b) Sediment grain size.

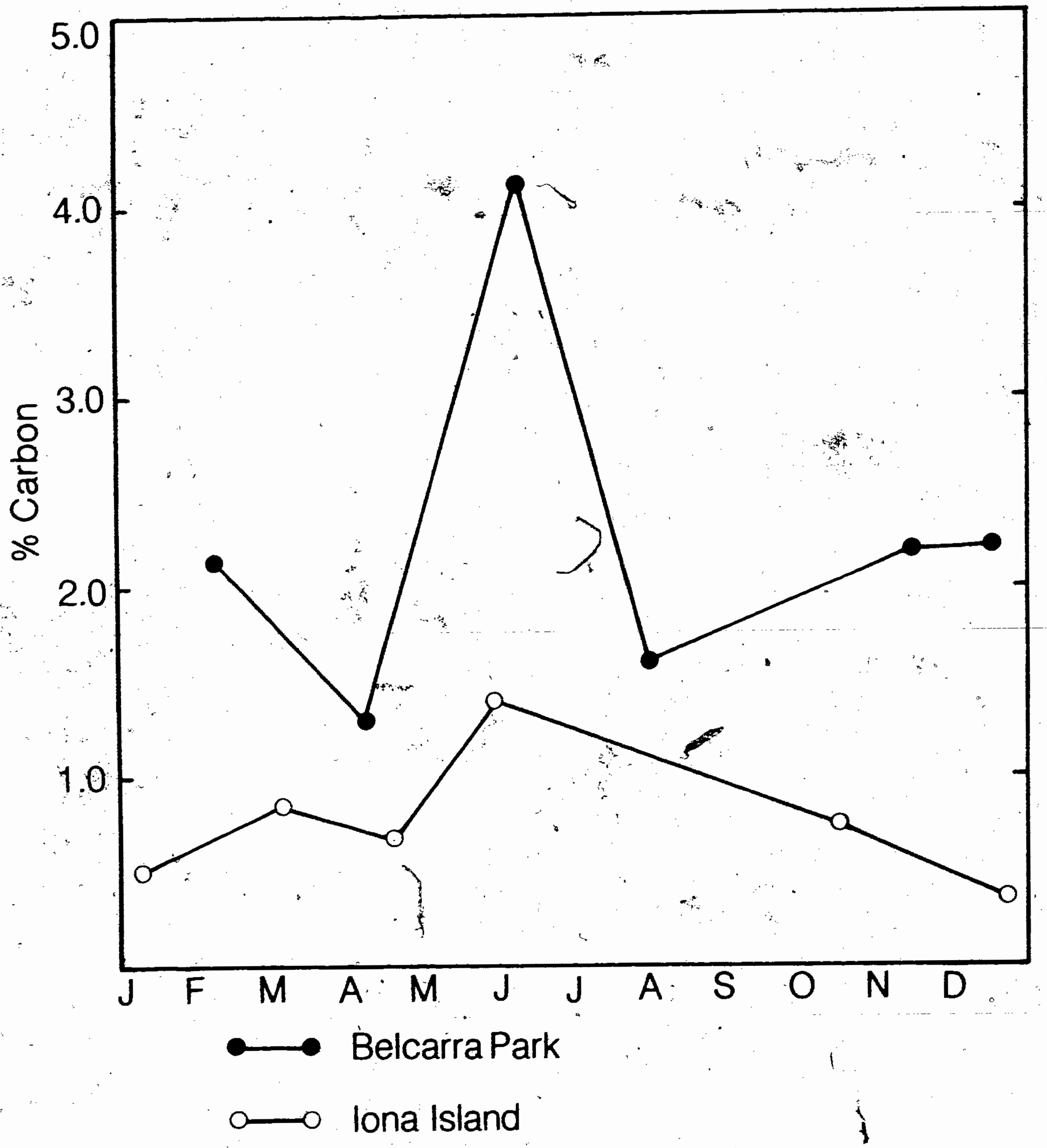
The general grain size distribution of the sediment at both sites is presented in Fig. 6, and a more detailed analysis of the grain sizes in Table 2. The mean grain size of the Belcarra Park sediments (730u) was much greater than that at Iona Island (350u). The amount of the silt-clay fraction was higher at Belcarra Park in the earlier samples but is greater at Iona Island in the October-December samples (Table 2). The greater mean size of the Belcarra Park sediment may be attributed to the presence of coarse gravels at this site.

The sediments at Iona Island are well sorted when compared with those of Belcarra Park. By the scale of Folk and Ward (1957) the Iona Island sediments (Q.D.range:0.5-1.15) are in the range of well sorted to moderately sorted while the Belcarra Park sediments (Q.D.range: 0.8-1.9) are moderately sorted to poorly sorted (Fig.6).

c) Organic carbon.

The amount of organic carbon associated with the sediments is higher at Belcarra Park than at Iona Island (Fig.4). The peak carbon content seen at Belcarra Park in May-June is associated with the presence of a large amount of visible detritus and a substantial diatom population. No measurements on the nitrogen content of the sediments could be obtained as it was present only in trace amounts.

Fig. 7. Per cent organic carbon associated with sediments at Iona Island and Belcarra Park during 1977


% Carbon
5.0
4.0
3.0
2.0
1.0
J
F
M
A
M
J
J
A
S
O
N
D
Belcarra Park
Iona Island

d) Redox layer.

No measurements were made on the redox potential, however, the redox layer was visible at a depth of 1.5 to 3.0 cm at Iona Island and 2.0 to 3.0 cm at Belcarra Park. At both sites the redox layer was lower in the winter months.

e) Summary

Iona Island has well-sorted sediments that result from its greater exposure. These factors also cause the lower average temperatures of the sandflat, while its proximity to the river lowers the salinity of this site.

Belcarra Park is more wave sheltered and has a poorly sorted sediment with a somewhat higher temperature and salinity. It also has more organic carbon associated with the sediments which may be due partially to the vegetation in the vicinity of this site.

2) The Nematode Fauna

The raw data for the nematodes collected at each site is presented in Appendies 3-6. The nematode fauna at the two sites is characterized by the presence of different morphological forms. The nematode fauna at Belcarra Park is characterized by a large number of linhomoeids, which are primarily epigrowth feeders and presumably feed on diatoms and algae. The large number of phytobenthos observed at this site in the summer together with the greater amount of organic carbon associated with the sediments provides the necessary food for this group of nematodes. On the other hand, the Iona Island fauna is composed primarily of *Sabatieria pulchra*, *Paracanthonchus* sp.1, and *Tripyloides gracilis* all of which are non-selective deposit feeders.

The nematode fauna at Stanley Park (appendix 5) was very similar to that at Belcarra Park and so it was abandoned as a site of regular sampling. The fauna at the Maple Wood mud flats and Steveston marsh (appendix 6) is similar to that at Iona Island. Although *Sabatieria* sp. and *Marylynnia* sp. are predominent at Maple Wood mud flats, *Chromadorina* sp., *Desmolaimus* sp. and *Theristus* sp. are also present. However, Steveston marsh sediments mostly contained *S. pulchra*.

A unique fauna was found in the sediments at the end of Indian Arm (Appendix 6). The usual fauna of a sandy beach, such as

Table 3. Number and depth of nematodes at the Belcarra Park and Iona Island sites sampled at different times over one year. Each value is the mean of three replicate sampes±s.e.

		Feb. 8	April 7	May 20	Aug. 1	Nov. 10	Dec. 10
Belcarra Park	0-2cm	510±253	422±135	380±235	852±715	232±155	362±74
	2-4cm	256±187	257±181	109±47	305±355	228±177	160±81
	4-6cm	70±48	126±25	85±45	43±41	105±130	37±16
	Total	816±482	805±276	573±321	1199±1074	407±427	560±111

		Jan. 11	Mar. 7	April 19	May 31	Oct. 15	Dec. 20
Iona Island	0-2cm	31±12	43±41	59±26	109±23	193±74	197±50
	2-4cm	23±4	15±11	14±3	54±45	76±34	75±77
	4-6cm	11±10	9±7	8±4	12±9	26±5	15±19
	Total	64±17	67±52	81±32	175±69	295±108	287±42

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Fig. 8. Per cent distribution of nematodes in three sediment layers during 1977 at Iona Island

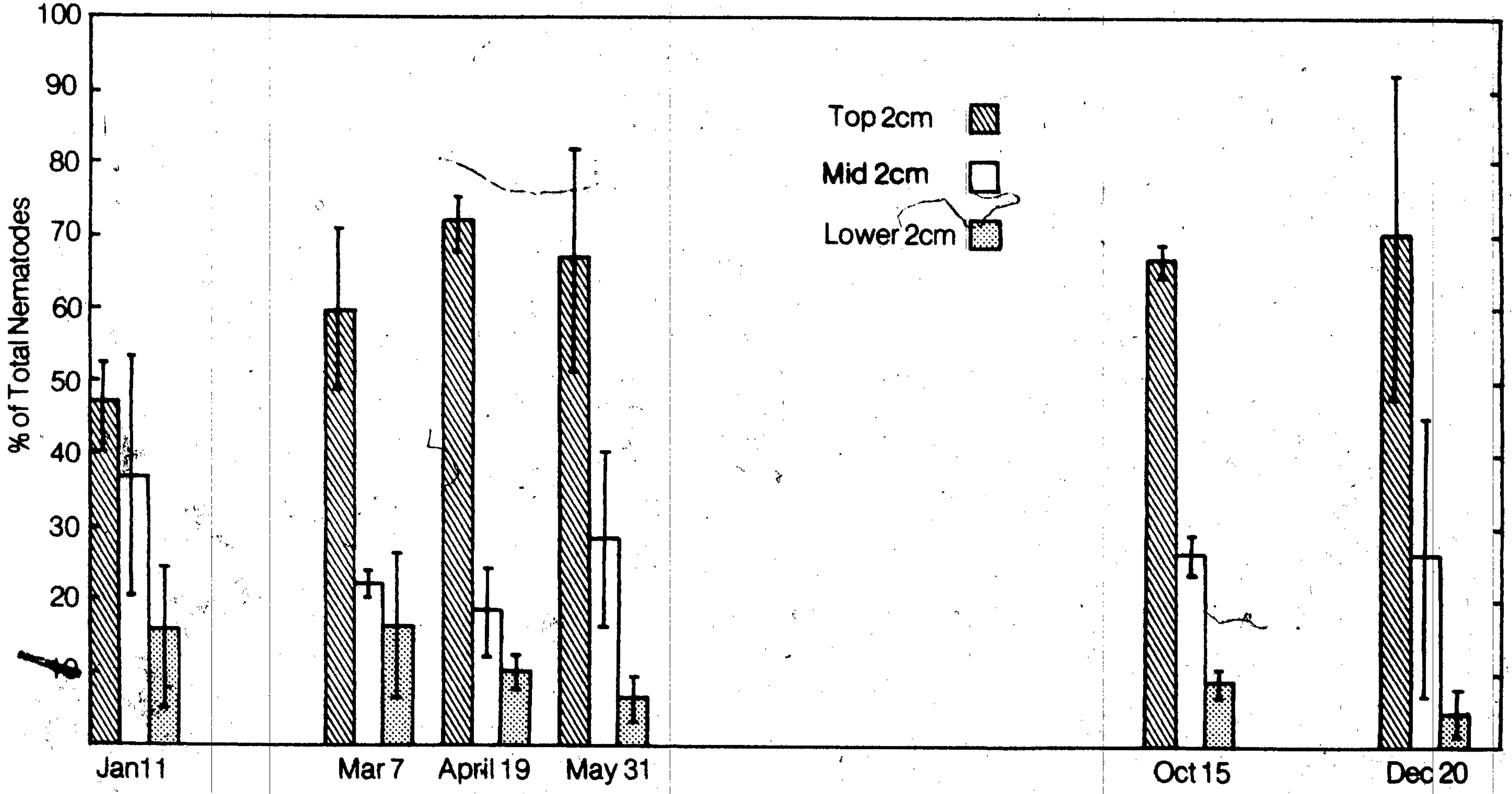
% of Total Nematodes
100
90
80
70
60
50
40
30
20
10
Top 2cm ▨
Mid 2cm ☐
Lower 2cm ▩
Jan11
Mar 7
April 19
May 31
Oct 15
Dec 20

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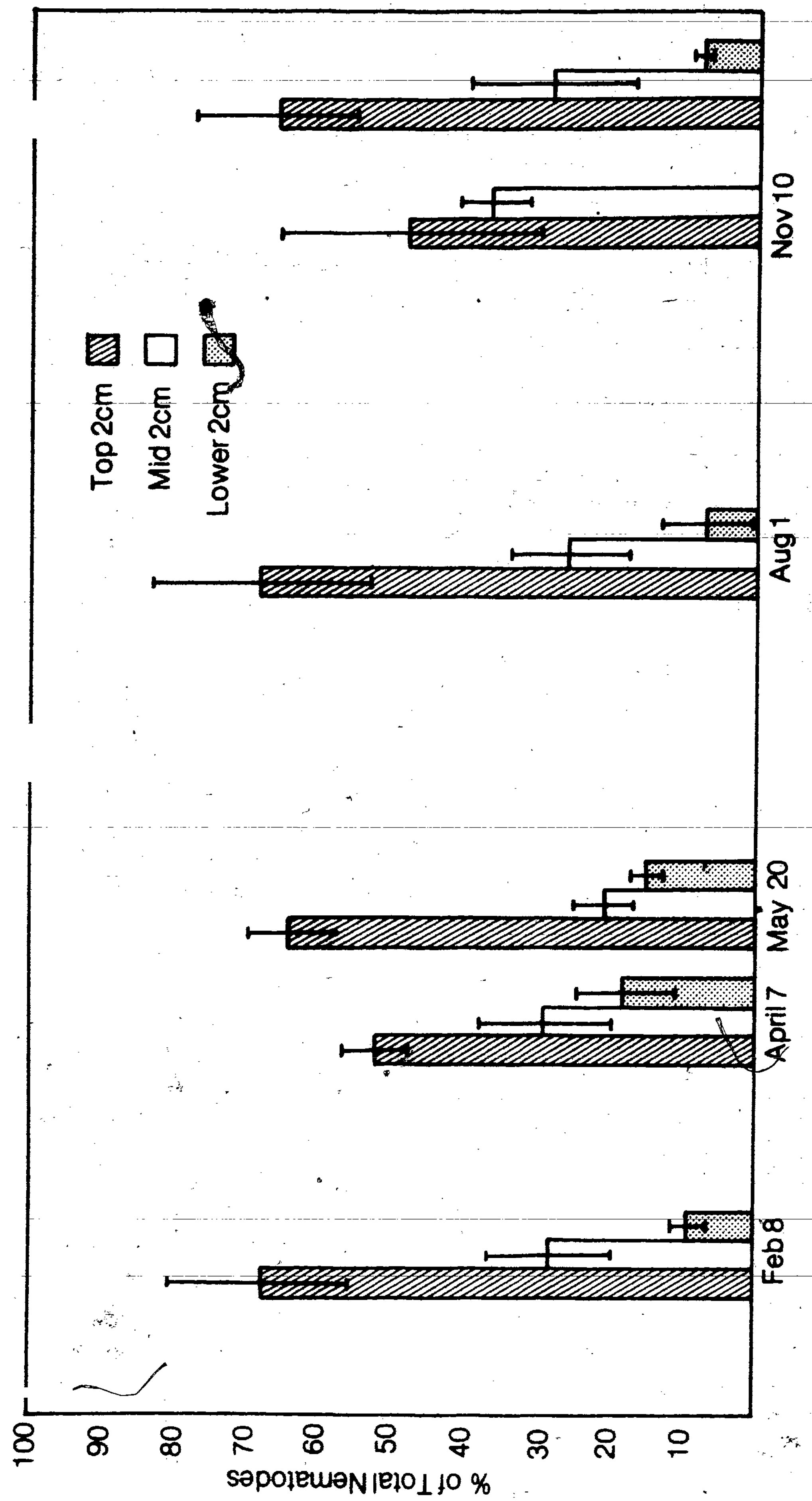
Fig. 9. Per cent distribution of nematodes in three sediment layers during 1977 at Belcarra Park


% of Total Nematodes
100
90
80
70
60
50
40
30
20
10
Feb 8
April 7
May 20
Aug 1
Nov 10
Top 2cm
Mid 2cm
Lower 2cm

Parascolaimus sp. and *Marylynnia* sp. was found associated with fresh water species, such as *Tripyla* sp., and terrestrial species, such as the dorylaimids and tylenchids.

Although *Sabatieria* sp. has not been further identified to species in the February and April samples, the total *Sabatieria* sp. population is lower in summer than in winter. *Sabatieria pulchra* is the dominant species in the fauna throughout the year at Iona Island.

The total numbers of nematodes at Belcarra Park is much higher than at Iona Island at each sampling time ($P<0.001$) (Table 3), and the greatest numbers at Belcarra Park occur in August. The numbers of nematodes at Iona Island, however, show a continuous increase throughout the year. The maximum nematode density occurred at Belcarra Park in August with 1,199/118cc nematodes in the upper 6cm of the sediment or 1.19×10^{6} /m^{2}. The lowest density occurred in January at Iona Island with 64/118cc nematodes in the upper 6cm of the sediment or 6.4×10^{3}/m^{2}.

At both sites most of the nematodes were found in the upper 2cm ($P<0.001$) of the sediment and relatively few nematodes below 4cm. (Table 3). To assist in comparing the nematode fauna for the two sites, the total number of nematodes found in the three depths of the sediment have been expressed as a percentage (Figs. 8,9). At both sites, less than 15% of the nematodes were below 4cm. and more than

Table 4. Number of nematode species at three depths at Belcarra Park and Iona Island at different sampling times over one year. Each value is the mean of three replicate samples

		Feb. 8	April 7	May 20	Aug. 1	Nov. 10	Dec. 12
Belcarra Park	0-2cm	21	31	30	36	29	27
	2-4cm	12	25	22	26	22	12
	4-6cm	10	22	23	15	12	19
		Jan.11	Mar. 7	April 19	May 31	Oct. 15	Dec. 20
Iona Island	0-2cm	8	6	11	14	7	10
	2-4cm	3	3	5	10	2	3
	4-6cm	3	2	4	5	2	2

half of them occurred above 2cm. Although the numbers of nematodes at at each site varied over time (P<0.001), there was no significant change in the numbers of nematodes at each depth over time.

The number of nematode species (Table 4) at Belcarra Park was significantly higher than at Iona Island (P<.001) and increased considerably during the summer at both sites (P<.001). No significant difference was noted in the number of nematode species at each depth over time or between sites, but considerably fewer species were found in the lower depths of the sediment (P<.001), especially at Iona Island.

Those species that comprised more than 10% of a sample were regarded as the dominant species and were further investigated for their seasonal fluctuations, as fluctuations of the rarer species will have little effect on seasonal population fluctuations, the mean number of these abundant species and their prevalence in the fauna are presented in Tables 5 and 6. Their frequency distribution and their age structure, expressed as the number of males, females and, juveniles is given in Figures 10 to 16.

Distinct periods of peak abundance characterized by a large number of juveniles could be seen for some of the species such as Neochromadora appiana, Chromadorita sp., Neotonchus sp., Linhomoeus sp.1, Linhomoeus sp.2, Araeolaimus sp., Metalinhomoeus sp.,

Table 5. Mean Number and Percent Abundance, in Parenthesis, at Belcarra Park of Dominant Nematode Species in the Upper 6cm. of Sediment over one year. ($\bar{x}$ of 3 replicates)

	Feb. 8	April 7	May 20	Aug. 1	Nov. 10	Dec. 20
Araeolaimus	11(1.2)	23(1.1)	11(1.2)	46(4.4)	8(1.8)	8(1.9)
Parascolaimus	2 (0.3)		1(0.1)			
Desmolaimus	98(13.5)	4 (0.6)	11(1.8)	44(2.8)	8(1.8)	32(7.3)
Metalinhomoeus		34(3.3)	7 (1.8)	9 (1.0)	11(2.5)	
Terschellingia	24(3.2)	78(8.4)	108(21.0)	209(15.0)	125(17.0)	39(6.4)
Eleutherolaimus	24(2.8)	12(1.8)	51(9.0)	28(3.1)	11(2.5)	3(0.5)
Paralinhomoeus		4 (0.4)	20(2.8)	30(3.9)	20(3.8)	24(4.5)
Linhomoeus I	16(3.3)	9 (1.2)	29(5.9)	1 (0.1)		1(0.1)
Paramonohystera			6 (1.7)	30(3.0)	10(2.4)	1(0.1)
Theristus I	25(3.0)	58(8.2)	29(4.4)	44(5.1)	28(6.5)	7(1.4)
Theristus II	1 (0.2)	42(5.6)	7 (0.9)	33(3.0)	29(3.8)	
T. modicus			3 (0.5)	14(1.8)	10(1.8)	4(0.7)
Sabatieria sp.	309(34.8)	21(3.1)	37(6.4)	68(8.0)	94(19.0)	147(19.0)
S. ancudiana			1 (0.1)	26(1.4)	17(2.5)	
S. americana			2 (0.4)	8 (0.5)	15(6.1)	
S. clavicauda			11(1.5)			84(15.7)
S. jubata			8 (0.4)			
Neochromadora	39(5.9)	60(8.6)	8 (1.5)	3 (0.5)	18(4.3)	46(7.9)
Chromadorita		21(2.5)	1 (0.1)	4 (0.6)	19(3.7)	5 (0.8)
Marylynnia sp.	127(21.0)					
M. quadriseta		20(2.3)	22(3.3)	39(3.1)	2 (0.5)	21(3.4)
Paracanthonchus II		31(3.3)	6 (0.8)	26(1.7)		
Paratripyloides	10(2.4)					
Tripyloides	1	5(0.6)			2 (0.5)	
Oncholaimus sp.	30(3.0)	7(10.0)	1 (0.1)	3 (0.6)	1 (0.1)	9(2.0)
Viscosia I		40(4.5)	24(4.6)	40(2.7)	18(2.1)	6(1.1)
Viscosia II		8 (1.2)	51(9.0)	44(4.8)	25(4.6)	14(2.7)
Linhomoeus II		1 (0.3)	27(5.0)	285(15.4)	21(2.7)	2(0.5)
Neotonchus		35(3.1)	1(0.2)	11(2.9)	7(1.0)	

Table 6. Mean Number and Percent Abundance, in Parenthesis, at Iona Island of Dominant Nematode Species in the Upper 6cm. of Sediment over one year. ($\bar{x}$ of 3 replicates)

	Jan. 11	Mar. 7	April 19	May 31	Oct. 15	Dec. 20
Parascolaimus	7 (8.8)	3 (6.0)	7 (6.4)	3 (1.4)		
Paramonohystera	3 (3.3)					5 (2.0)
Theristus sp.	8 (13.9)	4 (5.5)	21(26.2)	13(6.1)		8 (2.6)
Diplolaimella				29(15.6)		
Sabatieria pulchra	22(48.0)	40(50.0)	19(27.4)	54(31.3)	253(84.0)	212(73.9)
Neochromadora	3 (5.1)	3 (4.7)	2 (2.3)	24(15.2)		
Paracanthonchus I	7(12.0)	11(22.4)	7(8.1)	14(8.5)	30(12.0)	37(13.1)
Tripyloides	2(2.6)	4(5.1)	12(15.3)	22(12.8)	4 (1.9)	16(5.3)

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Fig. 10. Frequency distribution (in numbers) and age structure of Parascolaimus sp., Paramonohystera sp., Paracanthonchus sp. 1 and Tripyloides sp. during 1977 at Iona Island. The monthly sampling times are similar for each species

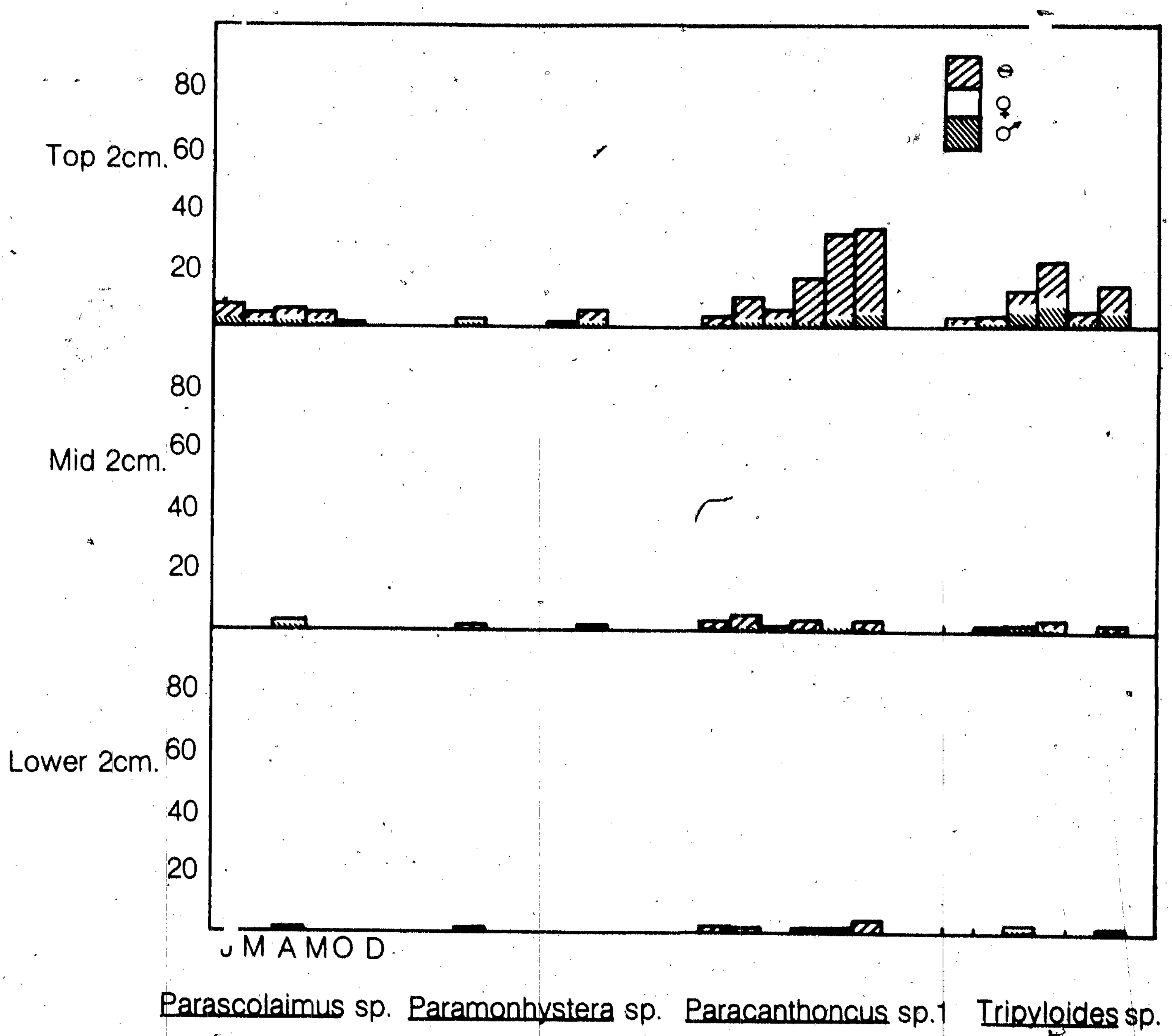
⊖
♀
♂
Top 2cm.
80
60
40
20
Mid 2cm.
80
60
40
20
Lower 2cm.
80
60
40
20
J M A M O D
Parascolaimus sp.
Paramonhystera sp.
Paracanthoncus sp.1
Tripyloides sp.

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Fig. 11. Frequency distribution (in numbers) and age structure of *Theristus* sp. I, *Diplolaimella* sp., *Sabatieria clavicauda* (=*S. pulchra*) and *Neochromadora* sp. during 1977 at Iona Island. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.

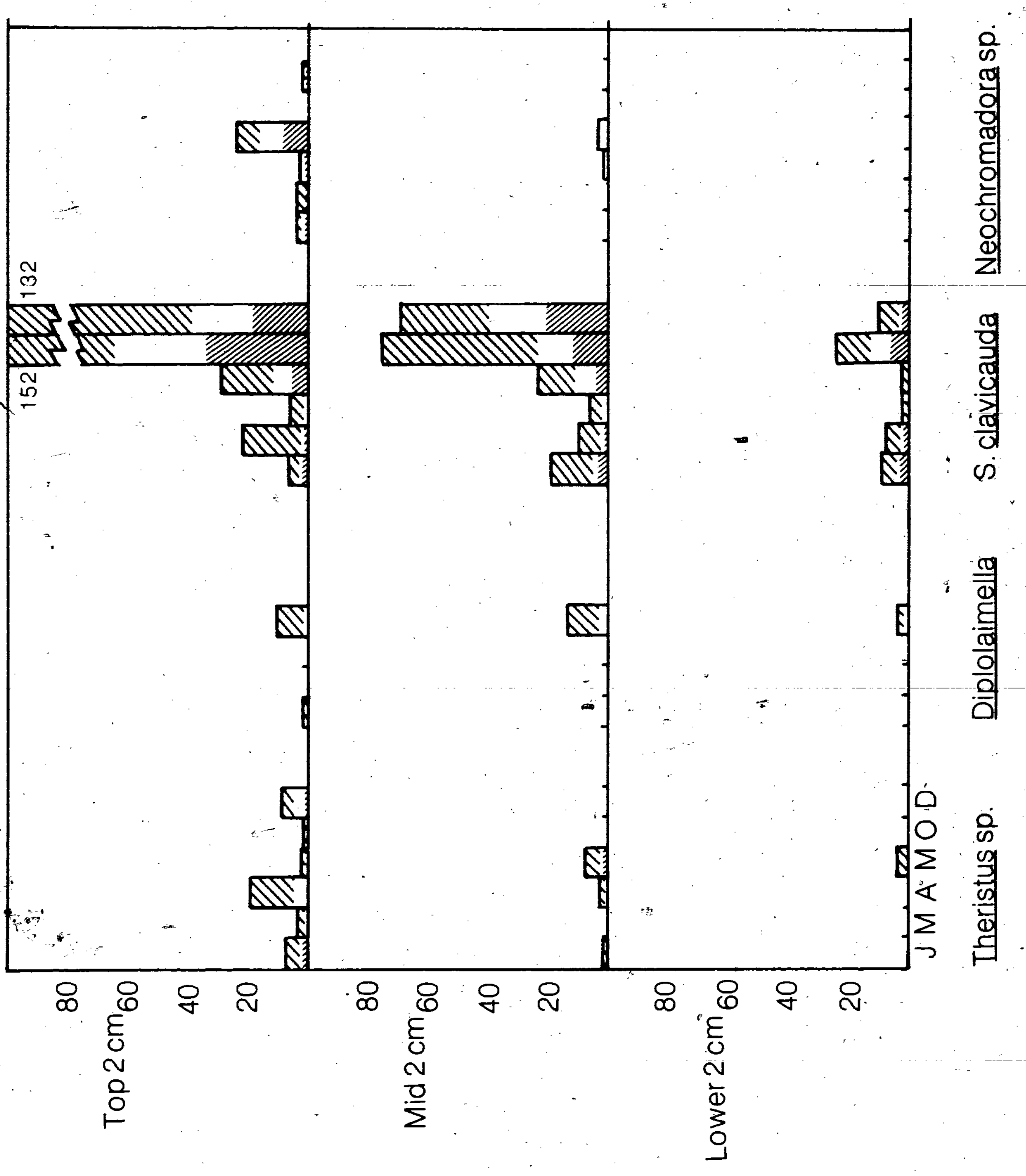
Top 2 cm
Mid 2 cm
Lower 2 cm
80
60
40
20
152
132
J M A M O D
Theristus sp.
Diplolaimella
S. clavicauda
Neochromadora sp.

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Fig. 12. Frequency distribution (in numbers) and age structure of *Araeolaimus* sp., *Metalinhomoeus* sp., *Paralinhomoeus* sp., *Linhomoeus* sp. I and *Paramonohystera* sp., during 1977 at Belcarra Park. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.

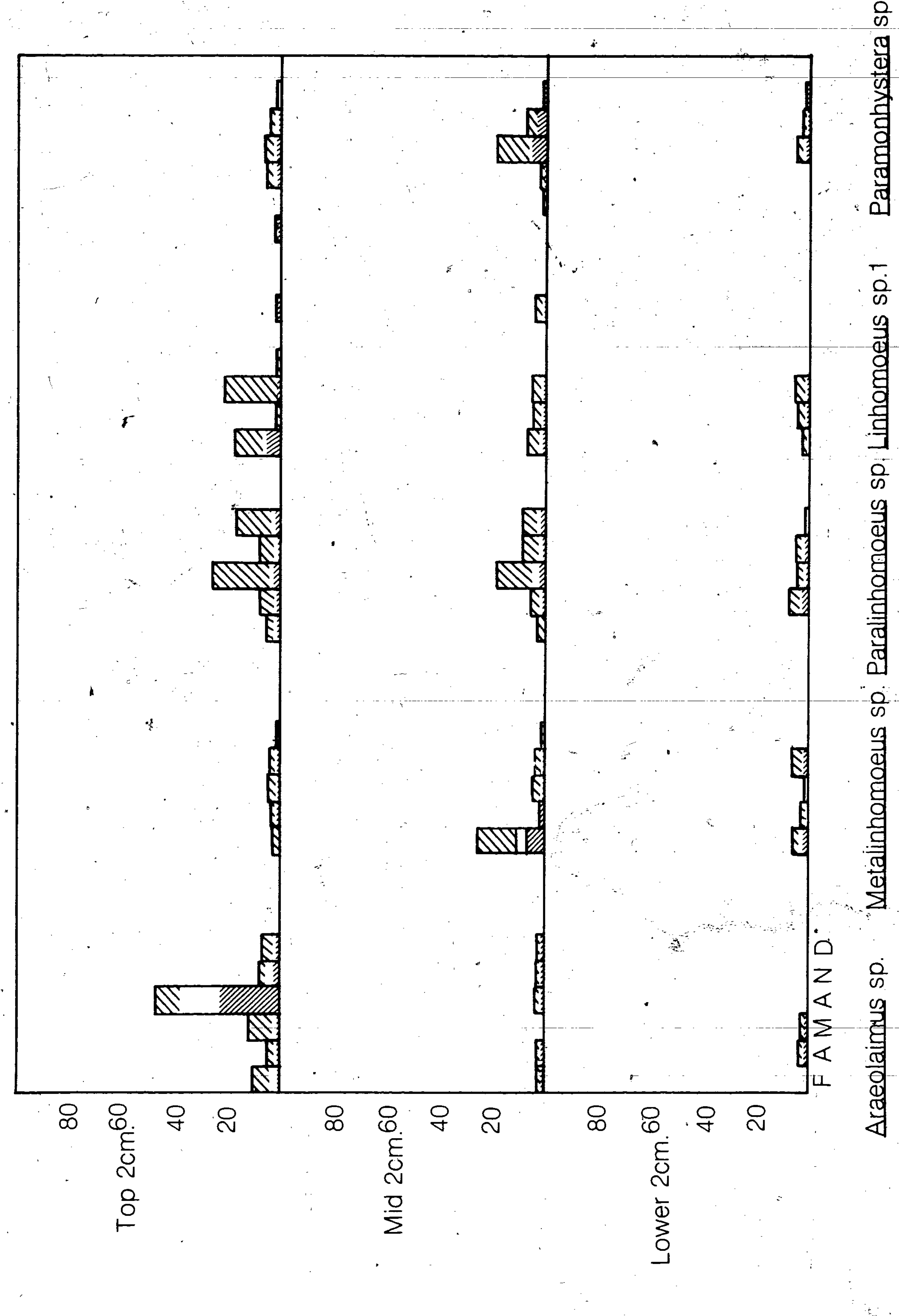
Top 2cm.
80
60
40
20
Mid 2cm.
80
60
40
20
Lower 2cm.
80
60
40
20
F A M A N D
Araeolaimus sp.
Metalinhomoeus sp.
Paralinhomoeus sp.
Linhomoeus sp.1
Paramonhystera sp.

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Fig. 13. Frequency distribution (in numbers) and age structure of Desmolaimus sp., Terschellingia sp., Eleutherolaimus sp., Theristus sp. I and Theristus sp. II during 1977 at Belcarra Park. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.

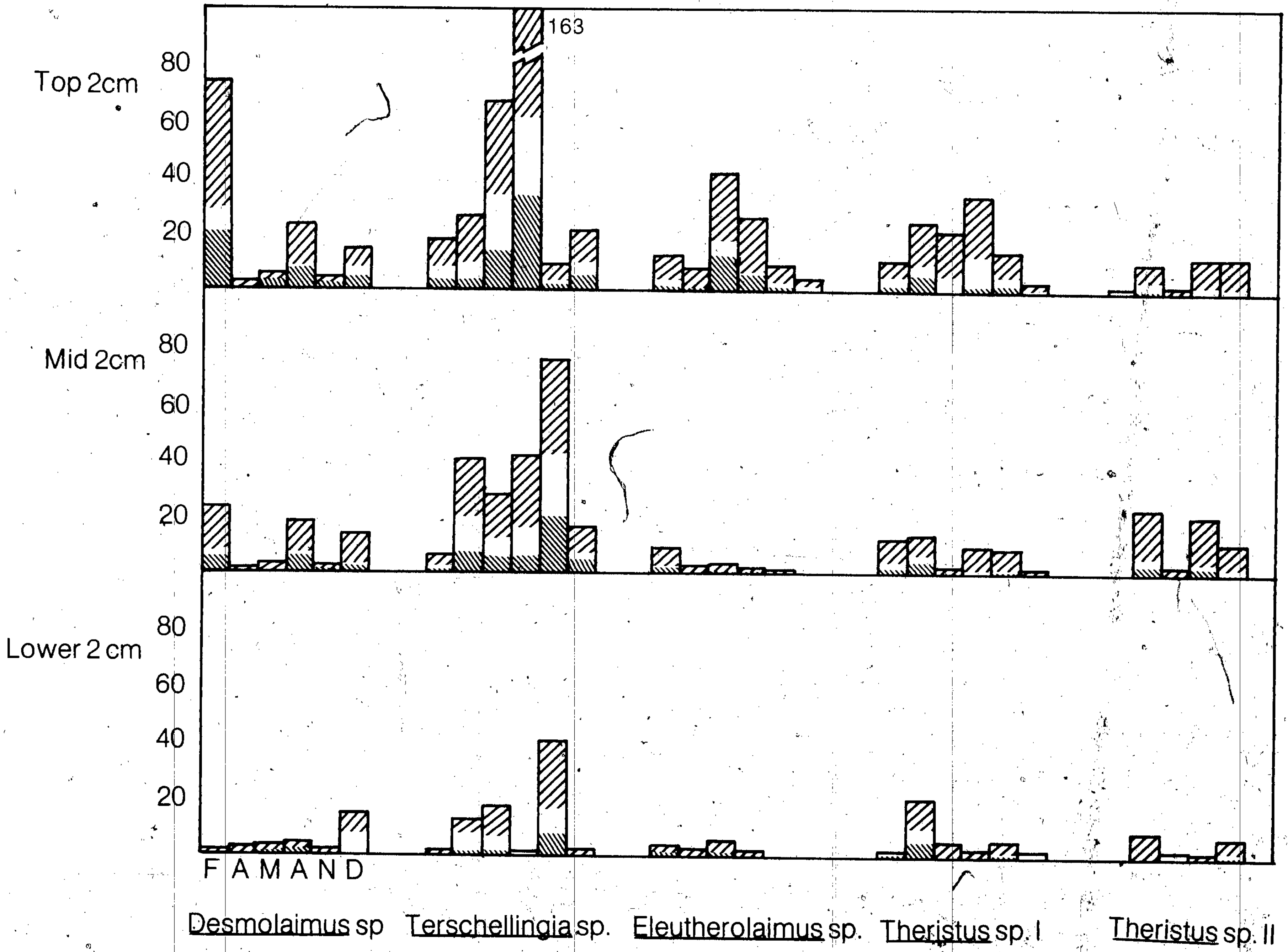
Top 2cm
Mid 2cm
Lower 2 cm
80
60
40
20
163
F A M A N D
Desmolaimus sp
Terschellingia sp.
Eleutherolaimus sp.
Theristus sp. I
Theristus sp. II

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Fig. 14. Frequency distribution (in numbers) and age structure of _Neochromadora_ sp., _Viscosia_ sp. I, _Viscosia_ sp. II, _Linhomoeus_ sp. and _Marylynnia_ sp. (=_M. quadriseta_) during 1977 at Belcarra Park. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.

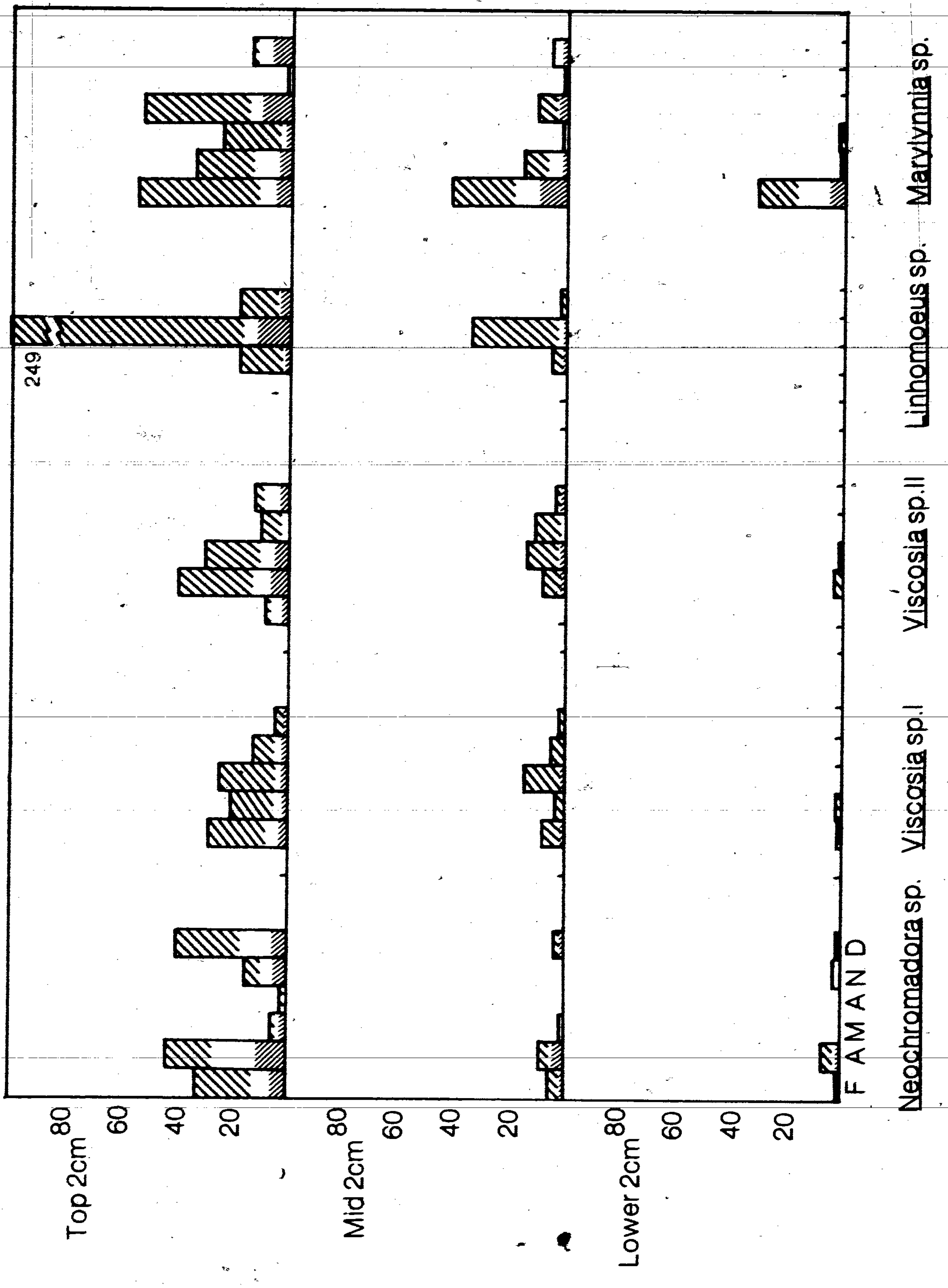
Top 2cm
Mid 2cm
Lower 2cm
80
60
40
20
249
F A M A N D
Neochromadora sp.
Viscosia sp.I
Viscosia sp.II
Linhomoeus sp.
Marylynnia sp.

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Fig. 15. Frequency distribution (in numbers) and age structure of Chromadorita sp., Paracanthonchus sp. 2, Marylynnia sp. and Neotonchus sp., during 1977 at Belcarra Park. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.

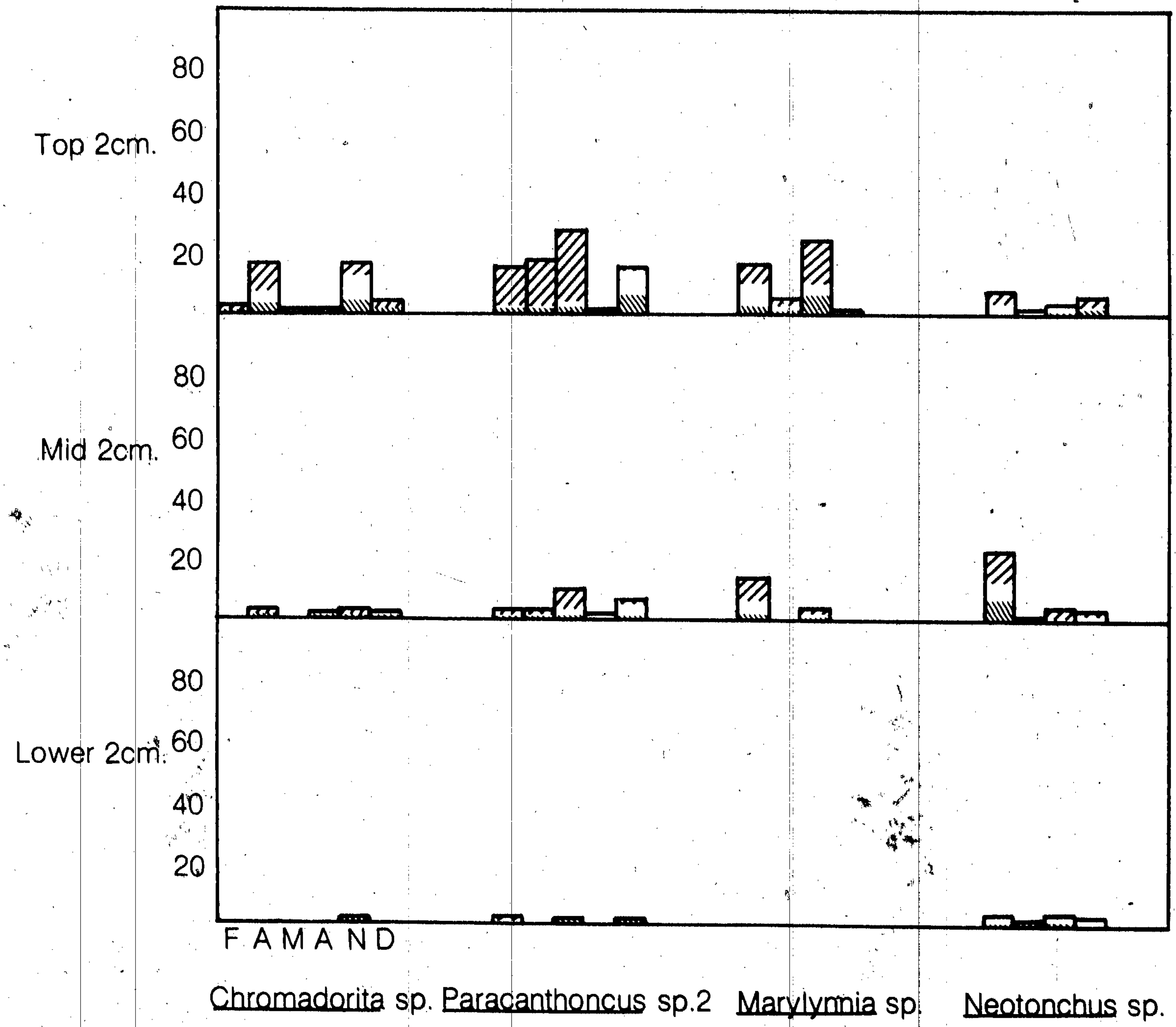
Top 2cm.
Mid 2cm.
Lower 2cm.
80
60
40
20
F A M A N D
Chromadorita sp.
Paracanthoncus sp.2
Marylynnia sp.
Neotonchus sp.

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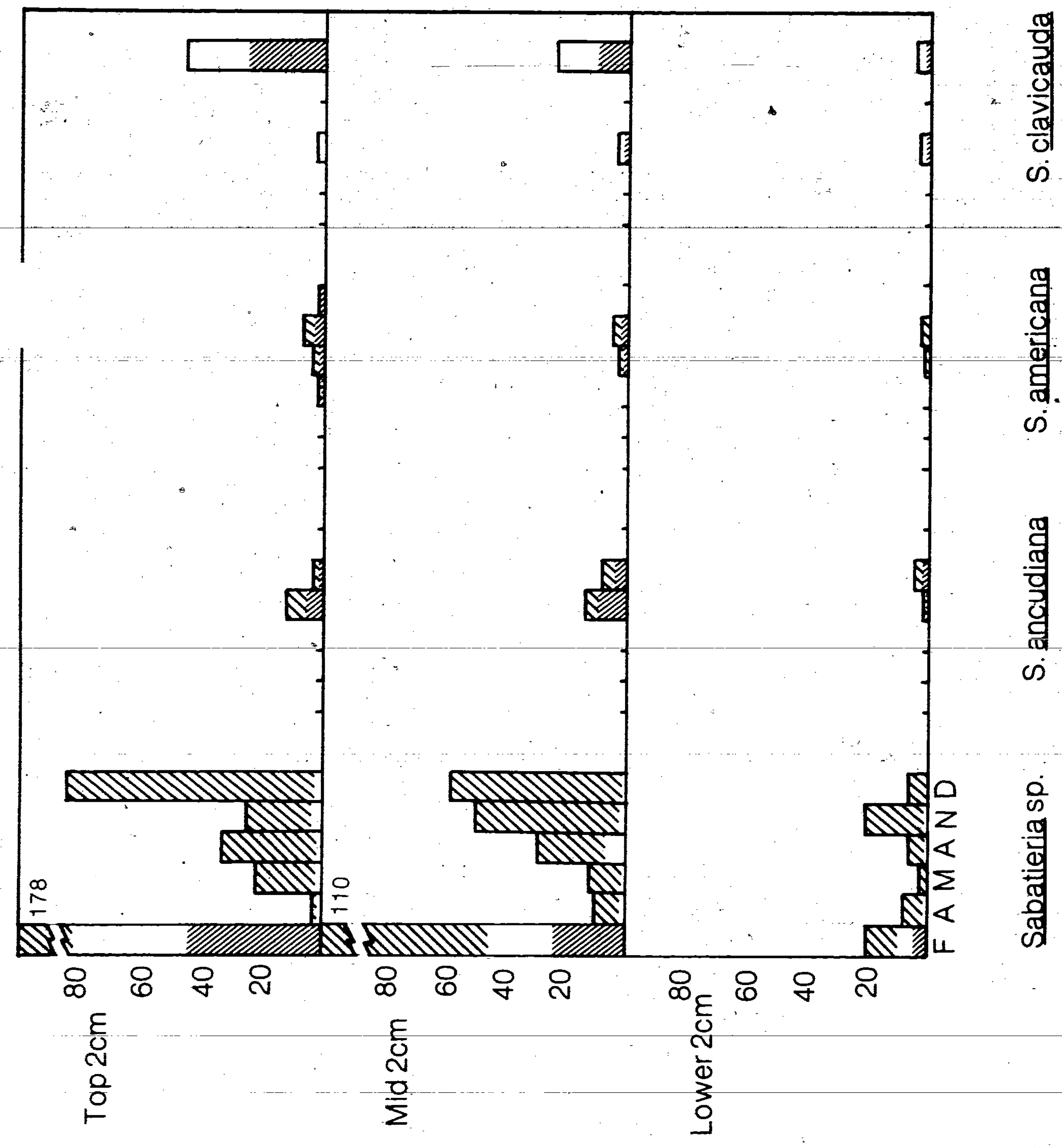
Fig. 16. Frequency distribution (in numbers) and age structure of *Sabatieria* sp., *S. ancudiana*, *S. americana* and *S. clavicauda* (=*S. pulchra*) during 1977 at Belcarra Park. The monthly sampling times are shown and are similar for each species. See figure 10 for legend.


Top 2cm
Mid 2cm
Lower 2cm
178
110
80
60
40
20
80
60
40
20
80
60
40
20
F A M A N D
Sabatieria sp.
S. *ancudiana*
S. *americana*
S. *clavicauda*

Paramonohystera sp., *Desmolaimus* sp., *Terschellingia longicaudata*, *Eleutherolaimus* sp. and *Sabatieria* sp. at Belcarra park, and *Paracanthonchus* sp. 1, *Neochromadora appiana*, and *S. clavicauda* at Iona Island (Figs.10-16). Other species that do not have periods of peak abundance but are prominent in the fauna throughout the year are *Paracanthonchus* sp.2, *Marylynnia* sp., *Viscosia* sp.1, *Viscosia* sp.2, *Theristus* sp.1, *Theristus* sp.2, at Belcarra Park and *Parascolaimus* sp., *Tripyloides gracilis* and *Theristus* sp. at Iona Island (Figs. 10-16).

3. Discussion

The similarity of the fauna at Stanley Park to that at Belcarra Park and at Maple Wood mud flats to that at Iona Island indicates that the occurrence of nematode species is not determined by the geographical location in the Inlet. Instead, it is affected by environmental factors such as sediment composition.

Iona Island and Belcarra Park have distinctly different nematode faunas that can be attributed to the different physico-chemical nature of the substrate at the two sites. The homogenous sediments of Iona Island do not support the rich community of organisms that are characteristic of the heterogenous sediments of Belcarra Park. Since the Belcarra Park and Iona Island samples were not taken at the same tide level, time of day etc. the two sites are not comparable, however, the nematode fauna characterizing the two sites will be discussed in view of the particular environmental conditions found at each site.

Although the nematode densities recorded in other studies (Tietjen, 1969; Warwick and Buchanan, 1970) vary with the particular physico-chemical nature of the site, the numbers of nematodes at Belcarra Park are of a similar order of magnitude as those found in other studies. Densities of $2.44x10^6/m^2$ were reported from an intertidal sandy beach by McIntyre and Murison (1973) while Platt

(1977a) reported 3500 nematodes /m^2 in well-sorted sediments of medium size. Ott (1972) recorded $0.5x10^6$ to $1.1x10^6$ nematodes/$m^2$from a fine sand flat in North Carolina.

A 1974 study of the littoral benthic fauna at Iona Island reported densities of $8.7x10^4$ nematodes/m^2 on the north part of the causeway (Anon.,1974). These figures appear to be very high in comparison to the present study. It is possible, however, that this area was sampled at a time when a particular species was reproducing and so a large part of the nematodes counted were juveniles. B.Harrison (pers.comm.) found significantly higher densities of harpacticoid copepods in the troughs of the sand ripples on the Iona Island sandflat. Therefore, the time and mode of sampling may contribute to the higher numbers of nematodes in this earlier report. These studies on nematode populations must be compared with caution as the size of the core samples will have an effect on the degree of patchiness that is observed and the maximum number of species in a season could be a reflection on the life cycle of a species.

Much higher nematode densities of $4x10^6/m^2$ are reported by Skoolmun and Gerlach (1977) in intertidal estuarine sandy sediments in the Weser Estuary in northern Germany. The lower nematode population densities of the Iona Island sediments is in agreement with the impoverishment of this site noted by Levings and Coustalin (1975) and may be attributed to its shallow slope, tidal level and to the well sorted sediments, which are discussed later.

The type and number of organisms that can live in the interstitial spaces are limited by the physical constraints of space and the food available to them. The number of species reported by various authors is also variable and may depend on the duration of the study because of seasonal fluctuations in the population and the particular method of sampling. In short term studies on intertidal sandy beaches, 41 species were reported by King (1960) from Florida, while Wieser (1959a) reported 106 species from Puget sound, Washington, McIntyre and Murison (1973) reported 104 species on an intertidal sandflat and Skoolmun and Gerlach (1971) found only 31 species of nematodes in studies carried out over several months in the Weser estuary.

The size and composition of the sediments is affected by numerous factors the importance of which must be considered as they affect the nematodes inhabiting them. The physical aspects of sediment granulometry has been examined by geologists (Folk, 1966, a review) and its importance to interstitial organisms is of interest to meiofauna ecologists. The Belcarra Park beach, with its poorly sorted sediments, is not well drained and thus more capillary water in the interstitial spaces enables more organisms to live here. Although the Iona Island site is always covered with water, the temperature and salinity changes that occur here may be too great for the nematodes.

The importance of the median particle diameter and silt content in determining the diversity of interstitial organisms was suggested in earlier studies by Warwick and Buchanan (1971) and Heip and Decraemer (1974) as more niches are available due to the higher spatial heterogeneity of coarser sediments. The uniformity of sand particles at Iona Island results in greater uniformity of interstitial spaces.

The influence of sediment granulometry on the faunal diversity of nematode populations has been recognized in several studies (Wieser, 1959b; Warwick and Buchanan, 1971a; Ward, 1973b; Heip and Decraemer, 1974). Ward (1975b) found the standard deviations of nematode lengths to be much lower in well sorted sediments. While the Iona Island fauna was composed of nematodes of median length such as the monhysterids, *Paracanthonchus* sp.1, and *Tripyloides*, the Belcarra Park fauna consisted of nematodes with a variation of lengths and morphological types such as the very long linhomoeids and oncholaimids. Homogenous sediments therefore inhibit the occurrence of variation in nematode sizes by offering homogenous interstitial spaces.

Some species of interstitial organisms may be limited in distribution because of their inability to colonize sediments composed of various grades of sand (Boaden, 1962). The angularity of the sand grains also affects the ability of nematodes to inhabit some sediments (Conrad, 1976), as rounded sediments are packed more closely and so decrease the interstitial space. Since well-sorted sediments are subject to greater wave action (Bascom, 1964) they tend to be less angular and so support fewer organisms.

The availability of food for the nematodes will be affected by sediment composition. In a study of the microbial fauna, respiration rates were shown to be higher in mud than in sand (Cavanaugh and Peterson, 1975). The studies of Meadows and Anderson (1968), have stressed the importance of crevices and hollow surfaces on sand grains for the attachment of microorganisms to them. Since well sorted sediments have a smoother surface, they will not be as suitable for the attachment of microorganisms, because the abrasive action of waves serves to alter the texture of sand grains.

The impoverishment in nutritional terms of the Iona Island sandflat may also contribute to its lower nematode population. The dumping of dredge spoils in the the upper intertidal area of Iona Island is reported to have prohibited the development of mud algae and marsh plants (Matthews and Murray, 1966, from Levings and Coustalin, 1975). The importance of organic detritus to deposit feeding organisms has been shown in some recent studies (Newell, 1965; Tunnicliffe and Risk, 1977). These studies have shown that these organisms feed not on the detritus itself but on the organisms associated with it. Thus less available nutrients in the sediments limit the growth of microorganisms, which are the essential food for the nematodes.

Although no pattern was noted in fluctuations of total numbers of nematodes in the sediment depths, the scarcity of nematodes below 4cm is significant. Most nematodes occur in the top few centimeters of sediment but some investigators have found nematodes to occur in deeper intertidal sediments. McIntyre and Murison (1973) reported nematodes to a depth of 12 cm in the summer and up to 32cm in the winter from an intertidal sandy beach. In a Georgia salt marsh, Teal and Wieser (1966) found nematodes to a depth of 12-14cm and Wormald (1976) reported nematodes to a depth of 9cm on a sandy beach in Hong Kong. With the exception of one species, Theristus blandicolor, Skoolmun and Gerlach (1971) found all nematodes in the upper 5cm of sediments.

Most previous studies of nematodes report them as occurring mostly in the upper 6cm of the sediment (Rees,1939; Capstick,1959; Wieser and Kanwisher,1961; Tietjen,1969; Platt,1977b). Platt (1977b) found that the total number of nematodes in the deeper sediments was greater in the winter than in the summer and attributed this variation to a deeper redox layer in the winter.

Three species, Cytolaimium exile Cobb, Terschellingia longicaudata De Man and T. brevicaudata Ott, have been shown to be characteristic of a deeper sulfide layer (Ott,1972). In my study, the even distribution of some species such as T. longicaudata, Sabatieria sp. and Marylynnia quadriseta in all depths of the sediment (Figs.13,14,16)suggests that these species may have a greater tolerance for the anoxic conditions found here. On the other hand, the virtual absence of some species such as Neochromadora appiana, and Paracanthonchus sp.2 below 2 cm could be an indication of their intolerance for anoxic conditions (Figs. 14,15).

The extreme variability noted in the replicate samples at both sites is characteristic of the patchiness seen in the littoral habitat. Sibert et al. (1977) reported standard errors of up to 858 nematodes (from a mean of 1943) from a mud flat in the Cowichan River estuary, British Columbia . Although this patchiness has been recognized in studies of other meiofaunal organisms, its importance to nematodes has been recognized only recently. Gerlach (1977) has shown that dead and decaying organisms on a beach will recruit meiofaunal organisms with selective attraction for nematode species. In showing a preference for certain foods of marine nematodes, Lee et al. (1977) also provide evidence for seasonal fluctuations in the nematode fauna. They demonstrated that meiofaunal organisms, including nematodes, are segregated in their habitats by their selective feeding habits which divides up their available microflora for food.

Differences in the distribution of nematode species have been shown to be characteristic of the life history of an organism or the distribution of its food (Jansson, 1968a). Some species, such as *Marylynnia quadriseta*, *Neochromadra appiana*, *Theristus* sp. and *Viscosia* spp. do not show distinct peaks and are prominent in the fauna throughout the year. Others such as *Sabatieria* spp., *Linhomoeus* sp., *Desmolaimus* sp., and *Eleutherolaimus* sp. have periods of high and low abundance. While *Sabatieria* spp. are prominent in the winter months the linhomoeids are prevalent in the spring and summer. When the algal blooms occur.

The age class structure of a population indicates if it is reproducing throughout the year or only at certain times of the year. The seasonal fluctuations in the nematode species examined here provide only a very general picture as the results are only for one year and the time interval between samples gives an incomplete picture. Nevertheless, some trends can be seen in the changing species composition that are a result of the species life cycle and also the changing environment.

The *Sabatieria* spp. and the linhomoeids have only one generation a year while the cyatholaimids and *Viscosia* spp. have two or three generations a year. Tietjen (1969) reported one generation a year for *S. celtica*, but two generations a year for *S. falcifera* with the prevalence of these species in the winter months, and the linhomoeids in the summer. V. viscosa has been shown to have 1-2 generations a year (Skocimun and Gerlach, 1971) and V. carneyensis to have 2 generations a year (Tietjen, 1969). This being a small omnivorous species reproduces throughout the year, as in the present study. Such oncholaimids have been observed to have mucus threads which are used to trap small detritus particles, bacteria and macromolecules (Riemann and Schrage, 1978) and are therefore not dependant on a seasonal food source.

Life history studies of nematodes in laboratory cultures have shown them to vary with temperature and salinity. In general, higher temperatures result in shorter generation times and a range of 10-197 days has been recorded for Monhystera denticulata (Tietjen and Lee, 1972). Similar variations in generation times have been recorded by Hopper and Myers (1966) and by Heip et al. (1978).

Differences in the nematode fauna between Iona Island and Belcarra Park can be attributed to the different environmental conditions at the two sites. The exposed Iona Island site has well-sorted sediments while the more sheltered Belcarra Park site has poorly sorted sediments. The physico-chemical composition of the sediments and interstitial water determines the suitability of the habitat for various microorganisms that are the major food source of the nematodes.

Due to insufficient laboratory studies on the biology of free-living marine nematodes, one can only speculate as to the reasons for some of the differences in nematode distribution within the site. However, studies on nematode tolerance to specific environmental conditions and on the species preference for food can provide reasons for spatial and temporal differences in the distribution of nematode species. Such laboratory studies can also provide clues to the patchy distributions and to the large betweem sample variability that are peculiar to the microenvironments on the beach.

Conclusions

There is a difference between the nematode fauna at two intertidal sites, Iona Island and Belcarra Park near the city of Vancouver. Iona Island, a large sandflat with well-sorted sediments and little organic matter associated with the sediments has fewer nematodes and number of nematode species than Belcarra Park which has poorly sorted sediments and more organic carbon associated with the sediments. At both sites, the total number of nematodes and nematode species increased during the summer. While the epigrowth feeders such as the monhysterids and linhomoeids were most abundant in the summer, the non-selective deposit feeders, such as *Sabatieria* spp., were most abundant in the winter.

Hypodermal pores and punctations in the cuticle of the cyatholaimids are taxonomically important structures. *Marylynnia* n. sp. from this family is described.

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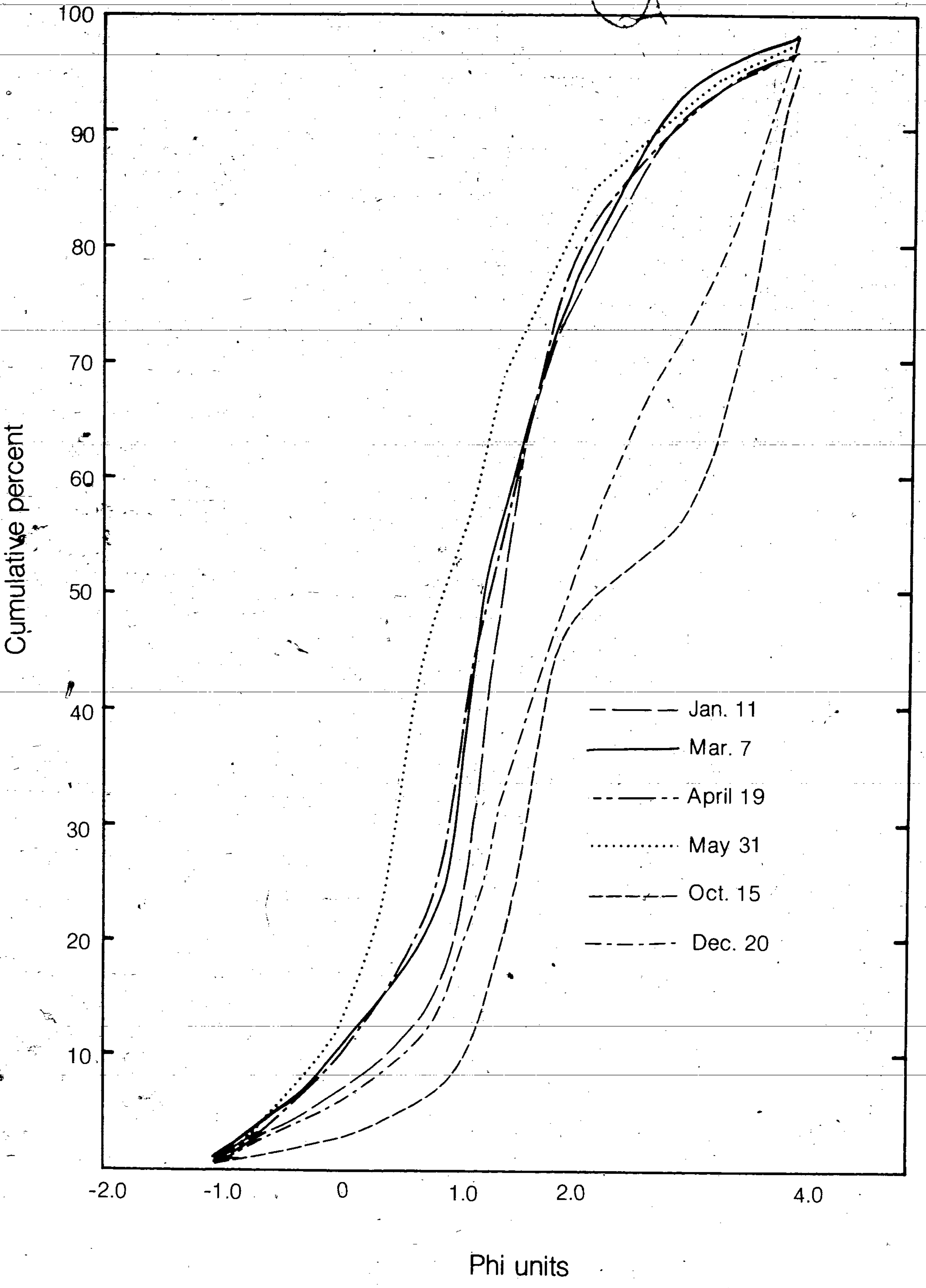
APPENDIX

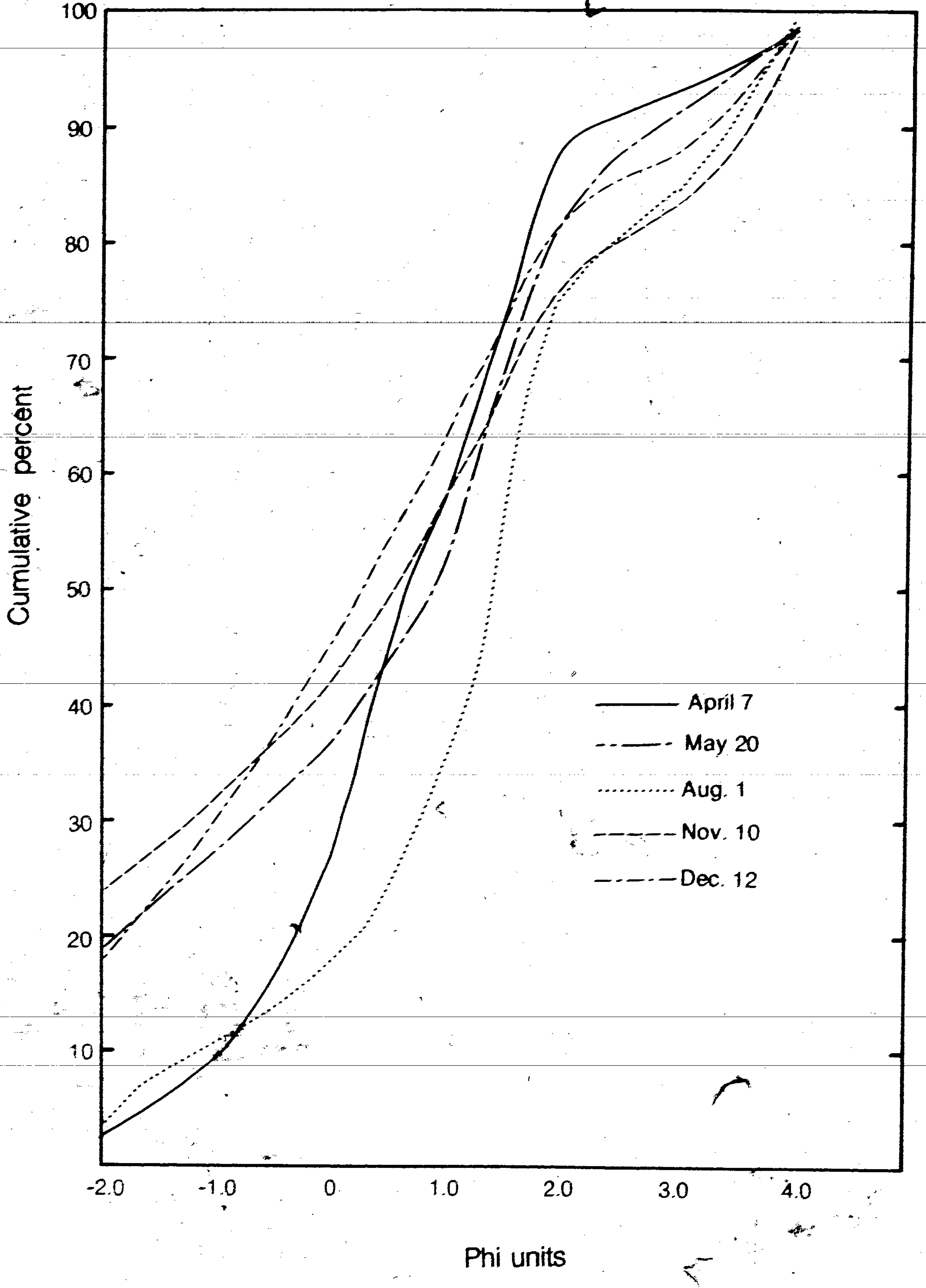
LEAF 100 OMITTED IN PAGE NUMBERING.

Appendix 1. Cumulative percent curves of sediment at Iona Island over one year at six sampling times


100
90
80
70
60
50
40
30
20
10
Cumulative percent
-2.0
-1.0
0
1.0
2.0
4.0
Phi units
Jan. 11
Mar. 7
April 19
May 31
Oct. 15
Dec. 20

LEAF 101 OMITTED IN PAGE NUMBERING.

Appendix 2. Cumulative percent curves of sediment at Belcarra Park over one year at five sampling times


100
90
80
70
60
50
40
30
20
10
Cumulative percent
-2.0
-1.0
0
1.0
2.0
3.0
4.0
Phi units
April 7
May 20
Aug. 1
Nov. 10
Dec. 12

Appendix 3. Number of nematodes at Iona Island over one year

	Sampling time and depth*																																																		
Species	31-1	31-2	31-3	32-1	32-2	32-3	40-1	40-2	40-3	41-1	41-2	41-3	42-1	42-2	42-3	49-1	49-2	49-3	50-1	50-2	50-3	51-1	51-2	51-3	55-1	55-2	55-3	56-1	56-2	56-3	57-1	57-2	57-3	62-1	62-2	62-3	63-1	63-2	63-3	64-1	64-2	64-3	71-1	71-2	71-3	72-1	72-2	72-3	73-1	73-2	73-3
Axonolaimus spinosus	2																																																		
Parascolaimus sp.	1			12			1												4						1	1																	1			1					
Linhomoeidae										3			4			8	2		8	1	1				5			2			1			1																	
Desmolaimus sp.																			1								1																								
Terschellingia longicaudata																									1	2		1	1																						
Linhomoeus sp.										1										1						1	1																								
Monhysteridae																										1																									
Diplolaimella sp.							2									4									2			1												1			3						5		
Monhystera refringens																	1	2							11	29	8	15	7		5	7	4																		
Paramonhystera sp.				2	2		1									1																																			
Theristus sp.	9	2		5			5	1	1				4			16	3		28	4		14		1	4	18	7													1									14	1	
Theristus sp. 2																												1	2	1		4	1				1			2			16			6			1		
Rhynconema sp.																	1														2	1								2											
Microlaimus dentatus																				2							1																								
Monopisthia costata																																																			
Sabatieria sp.	3	20	4	8	17	13	6	4	15	2	3	3	56	23	7	10	5			2	3				15	20	2																								
S. clavicauda																		16				8	11	2	9	25		11	11	1	11	8	3	85			43			116			147	3		61	28	17	45		2
Chromadoridae																					1				1			28	2	1	11	2	1	80	92	32	28	36	23	105	99	21	48	2		54	27	8	42	147	
Chromadorina sp.																																											3			1					
Innocuonema clivosum																3			1		2																												2		
Neochromadora appiana	4			2			4			1			3			3	1		1			1			22	1																				1					
Spilophorella paradoxa																												24	1		22	2														1			1		
Cyatholaimidae	2	4		4		3																			8															1											
Paracanthoncus sp. 1							5	3	1	6	3		11	2	1	7			9			3	1		10	4	1	6	1		1	1		5			2						1								
Tripyloides gracilis				4				2		1			8	1		12		1	19	1	1	2			31	3		11	1		11	3		20			34	1		32	1	1	31	4		25		11	35	5	1
Oxystomina sp.																												17	1		14	1		6			5			2			3			17			19	7	2
Lauratonema pugiunculus																												2			2																				
Oxyonchus sp.				1		1																						1															1								
Anoplostoma sp.																2			1																																
Oncholaimus sp.																3			1	1		1						5			2																				
O. vesicarius																			1									2												1		1									
Eurystomina sp.																																		1																	
Unidentified							2	1					3			1			2	4	2				3	1																									
																												1						2			2						1								
																																														3	1		2		

*Note that each sampling time is numbered (Collection number) and that at each sampling time there are three depths, 2,4 and 6 centimeters from the sediment surface

Appendix 4. Number of nematodes at Belcarra Park over one year

Sampling time and depth*

Species	34-1	34-2	34-3	35-1	35-2	35-3	36-1	36-2	36-3	46-1	46-2	46-3	47-1	47-2	47-3	48-1	48-2	48-3	52-1	52-2	52-3	53-1	53-2	53-3	54-1	54-2	54-3	58-1	58-2	58-3	59-1	59-2	59-3	60-1	60-2	60-3	65-1	65-2	65-3	66-1	66-2	66-3	67-1	67-2	67-3	68-1	68-2	68-3	69-1	69-2	69-3	70-1	70-2	70-3
Leptolaimus sp.							3	1		27	4				9									1	3			4	8		3			3			1	1							1	9								
Araeolaimus sp.	13	2		2			15	1		3	2	5	7	1	2			3	2			9		1	19	1	1	11	1		93	2		2	1		1			1			12	2	1	1								
A. boomerangis																												12	2		6	4	1	1			1			1			4			12	2		7	1			3	
Axonolaimus spinosus	1			1						7		1	2			3			1			1																																
Odontophora peritricha																									7	2					4						3						1	2					2			2		
Parascolaimus sp.	2		1	2			1	5		1	2	1				2						1				1																												
Paraterschellingia sp.													3															1	1		2																							
Siphonolaimus sp.	5		1									3	3	5				1						1	4			8	2		1			1			3								1									
Solenolaimus sp.																												2																										
Linhomoeidae	4			1							8						1	1			1	5	2	3	3	1	1	2	16	3	2			1	1	1	4	1	1				2					1	2				2	
Desmolaimus sp.	111	24	1	48	3	1	64	41	2	2	1		2	3	5				2	1		10	7	5	3	1	3	56	49	10	12	2		1	2	1	10	5		1				3	6	19	20	29	23	11	5	11	8	1
Metalinhomoeus setosus										3	6		1	4		5	56	16	5		2	1	2	7	2		3	10	4	3	3	2	1		2	1	3		1				4	10	15	1	2							
Terschellingia longicandata	25	8	2	9	1	2	19	5		12	25	21	6	4	5	59	92	9	30	21	2	144	53	22	27	9	17	333	90		143	26	1	14	7	2	14	69	21	5	3		7	155	100	41	40	6	21	9		1		
Eleutheeolaimus sp.	14	13	4	3	3	1	19	10	5	23	4	6	1	1	1				15	1	3	57	7	9	55	4	2	25	4	1	44	3		7			10	1		4			14	3	1	7			1				1	
Didelta sp.											1																	5	1																									
Linhomoeus sp.	14	6		11	1	1	11	16	1	2		11	1	7	2		5	1	2	10	6	13			45	5	7	3																		1	3							
Paralinhomoeus buculentus																8	5					20	14	17	1	3	6	33	52	8	40	3		3	3	1	14	8	1	2	3		6	11	14	12	2		16	6		20	13	3
Paralinhomoeus sp.													2	1					7	6		12	4	1	34	10	7	631	96	5	109	6		7	1		41						13	6	2					1	2		1	1
Monhysteridae											2	7	4			1	1	1					1	1	1														1		2		1			46	9	5	42	4	2	6	2	1
Cylindrotheristus resimus																																																				1		1
Diplolaimella sp.		2	1	2			3		2		5			3	1						3				3							1																						
Mesotheristus circumscriptus																				1				1																														
Monhystera refringens	5	4	1	7		1	4	14	8						5										1																													
Paramonhystera sp.							2								1							15	2					14	52	11	2			3	7	1	4	19	6				1				1	1	1			1		
Steineria gerlachi	3	1		2						3	1	3					1		1			3			19	3		1	1		5	1		1				1					1		1									
Theristus sp.	7			3	1		20	35	9	38	10	24	31	6	30	3	24	7	3		2	33	1	8	27	7	5	24	24	5	83	5		7	5	1	22	6		10	1		12	20	14	1	3		7	3	2	3		1
T. modicus																									4	1	2	14	1	1	22			3	1	1	14			2			6	4	3	3	2		3	2		2		
T. sp. 1				2						1	3	3	21	29	21	11	37	1				7	5	3		3	2	19	49	2	12	7	1	2	5	1	30	25	2				3	9	17									
T. sp. 2												2		1						1		6			12	1		2			1			1	1																			
Sphaerolaimus sp.				6			2			6		2	6	3	2	7	1		3		1	7			6	1		4			15			3	1	2	2			1						3			1			1		
Aponchium sp.															1																																							
Microlaimus dentatus													12			45	5	12			1	4	1	2	6	1	4	48	32	3	8			4	1	2	15			1	1		6	2						2				
M. texianus										3														5																						4		1	1	5	1		1	
Monopisthia costata										13						15	1					2						1						1			8						4	2		2			1			1		
Sabatieria sp.	373	269	23	72	8	13	89	54	25																																													
S. americana										2	4	3	5	21	19	2	5	2	7	4	2	21	6	1	39	25	5	41	44	10	47	36	3	12	6	5	47	68	24	13	11		17	68	35	59	58	4	88	9		105	104	14
S. ancudiana																			1						6			8	4	2	5	4					8	8	1	8	6	1	4	5	5	7								
S. sp.																					1		1					26	36	5	5	4		1			10	12	2	1			1	13	12									
S. pulchra																			2			1	1		16	3	3	1			5	1					1						1	1	1									
Chromadoridae																						9	9	12		3											1									38	28	5	47	1		83	44	5
Chromadorina germanica		2					3					4		2	1			1							1	1		2				1					3			1	1		3	2		11	2		4	1				
Euchromadora sp.										8			1												1			9			6	1			1		4	1			1		13	5	2	11	1		6	1				
Denticulella sp.										31			4																																									
Innocuonema clivosum																1																																						
Neochromadora appiana	29	7	3	26			45	7	1	23			8			18	15				1	2			2			4	7		3						15	1		5			26	6	3	5	2		3			2	2	
Spilophorella paradoxa										99	3	14	15	21	6	19	2		4			5	2		9	1	2	2			4	1		2			7			8			33	1	5	70	7	1	43	2		10	3	2
Neotonchus sp.													9	[illegible]		36	3					2	2	1	1	3	5	12	1	1	6	2		4	2		14	6	1	1			1	7		1			1	1		1		
Pomponema sp.																27	70	8				1		1		1				5	5	6	2	4	6	4	14	4						1	3					1				
Cyatholaimidae																2	21	2																																				
Acanthonchus sp.										2			24	1	5	1	2	1	1			5		1	18	17	5	5	5		4																							
Paracanthonchus sp. 2	18	13		84	2	3	147	107	7																			3	6	1	6									1				2		31	15	1	11	2		1		2
Cyatholaimus sp.	4			1						1		2	19	1		28	7	9	2	2		2		1	51	5	3	25	25	2	14	4		1		1		2																
Marylynnia quadriseta															3								1																				1				1							
Halichoanolaimus sp.	1								1				13	10	1	38	30	2	1						16			41	2		52	3	1											1										
Bathylaimus sp.										2	3	2					1			1	3	2		2			1	1																										
Paratripyloides sp.										6	15		1	9		7		1																																				
Tripyloides gracilis	1							1		5	4	2				2	1																				3						1	3							3	2		
Cytolaimium sp.																					1			1					2																									
Rhabdocoma sp.																1	12	4				3	4	5					6						2		6	1					1				1		1	2				
Oxystomina sp.	2									4	1	2	5	1	1	1									3			11	2		9												1					1						
Halalaimus sp.														7															1	1	2	1		2				1								1								
Anticoma pellucida													1			24		1																			1						1											
Mesacanthion sp.													1																		1																							
Viscosia sp. 1													11			106	24	2	8	3	1	19	3	1	32	2	3	28	37	1	44	8		1			5	2					31	13	3	4			3			7	3	
Viscosia sp. 2																23			14	2	2	23	7	1	80	16	8	24	23	4	55	15		9	1	1	5	20	1	4	1		11	13	3	2	2		12	1		18	6	
Oncholaimus sp.	83	7		22	2	2	60	6	1	51	7	16	55	33	12	9		5				1			1			6			2						1				2					1			9			1	1	
O. skawensis				1												17																																						
O. vesicarius				1		1	5			3																																	1			6			7			1	1	
Belbolla sp.												1																																										
Eurystomine sp.													1			1					1		1	3			1	2	8	2							15	5					3	4	1									
Symplocostoma sp.										4		1	2				1																																					
Unidentified	7	7		19		1	30	11	3	26	11	11	19	10	6	37	25	7	2			16	1	4	4	2	2	15	17	4	22	1		4	1	4	11	2			1		1	5	2	5	2		11			8	2	1
Rhabditis marina															1																															4	1		17	2	1	1	1	

*Note that each sampling time is numbered (Collection number))and that at each sampling time there are three depths, 2,4 and 6 centimeters from the sediment surface

Appendix 5. Number of nematodes at Stanley Park

	Sampling time and depth*																	
Coll. No.	28-1	28-2	28-3	29-1	29-2	29-3	30-1	30-2	30-3	43-1	43-2	43-3	44-1	44-2	44-3	45-1	45-2	45-3
Leptolaimus					1					5	2		7				3	1
Araeolaimus				93	1		4	4		2	1		5	1				
Axonolaimus	7	2																
Odontophora										66	3	2	9	3		3	1	1
Parascolaimus	22			21	3	1	3	2					5	1				
Siphonolaimus										4			2			1		
Desmolaimus				23	2		51	53	8	23	14	8	42	14	4	12	4	1
Terschellingia					10	2	7	7		16	23	9	8	14	4	33	42	20
Eleutherolaimus	24	9	1	14	36	3	12	7		220	46	10	308	15	1		29	10
Linhomoeus										48	26	9	47	14	1	13	1	1
Monhysterid								2					16					
Diplolaimella	2			3				17		2		15						
Steineria				6	7	1	22	5	1									
Theristus I	28	11	1	7	1		11	2		5	4		4	2				
Theristus II	3	4		2	4		4	1			3		9	3				
Sphaerolaimus										7	4	1	17			7		
Monoposthia	8			1	1							1						
Sabatieria	8	78	12	19	53	15	73	107	59	84	62	25	61	64	17	51	19	9
Chromadorid							2											
Chromadorina	1			6			4			4	1		5			4	1	
Neochromadora				4			2			6	1		9			22		1
Cyathplaimid	17	31	5	4	10	13	10	4	1									
Marylynnia	1									411	208	100	107	32	8	155	60	19
Cyatholaimus													1					
Tripyloides	1			2									3					
Oxystomina				1	1		3			5	1		5	1		2	1	
Oxyonchus											1		1	1				
Oncholaimus	9	6		23	8	2	5		1	36	9	1	79	3	2	9	3	
O. skawensis	3			1	1													
O. vesicarius	2			12			4		2				3					
Unidentified						7				22	8			4		7	4	2

*Note that each sampling time is numbered (Collection number) and that at each sampling time there are three depth, 2,4 and 6 centimeters from sediment surface

Appendix 6. Number of nematodes at Indian Arm (37, 38), Maple Wood mud flats (33) and at Stevenson marsh (66)

Genera	37-1	37-2	37-3	38-1	38-2	38-3	33-1	33-2	33-3	66
Leptolaimus		13		3	7	2				
Odontophora					1					
Parascolaimus	4			65	20		8	2		
Siphonolaimus						1				
Desmolaimus							10	1	1	
Terschellingia								4		
Linhomoeus										4
Diplolaimella		3	2			3				
Theristus I	11			27	12		12	6		
Theristus II							5			
Richtersia				1						
Sabatieria pulchra							129	78	6	273
Chromadorid						6				
Chromadorina	1						56	4	1	
Neochromadora				3	1					
Cyatholaimid	1	1								
Marylynnia	3			34	15	4	108	11		3
Tripyla				49	17					
Tripyloides	1						4	1		4
Oxystomina							1			
Lauratonema	3	1								
Enoplus				66	61	6				
Oncholaimus	36	34	2	13	19	10				
O. vesicarius				1						
Mononchus	4			16	19	10				
Desmoscolecid							1			
Tylenchid				5	8					
Prodorylaimium				11	8	6				
Unidentified	3	2		15	1	3	9	1		1

Appendix 7. Three-level, nested ANOVA calculated on log n+1 transformed total number of Nematodes

Source Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F	Significance
Time	4	0.5	0.1	0.79	n.s.
Site	1	9.6	9.6	62.4	***
Depth	2	10.8	5.4	35.0	***
Time-Site	4	2.7	0.7	4.4	***
Time-Depth	8	0.7	0.1	0.6	n.s.
Site-Depth	2	0.1	0.1	0.4	n.s.
Time-Site-Depth	8	0.5	0.1	0.4	n.s.

Appendix 8. Three-level, nested ANOVA calculated on number of nematode species.

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F	Significance
Time	4	863.9	216.0	11.9	***
Site	1	5198.3	5198.3	285.4	***
Depth	2	1298.4	649.2	35.7	***
Time-Site	4	217.0	54.3	3.0	***
Time-Depth	8	52.6	6.6	0.4	n.s.
Site-Depth	2	106.4	53.2	2.9	n.s.
Time-Site-Depth	8	168.2	21.0	1.2	n.s.