

REVISION OF THE TAXONOMY OF INTERTIDAL ENCHYTRAEIDAE
(ANNELIDA, OLIGOCHAETA) OF BRITISH COLUMBIA WITH A
PRELIMINARY DISCUSSION REGARDING USE OF INTERTIDAL
SPECIES ASSOCIATIONS TO ASSESS POLLUTANT IMPACTS

by

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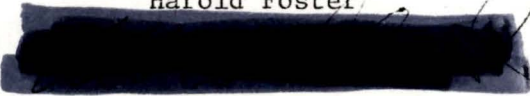
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Abstract

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A taxonomic survey of marine intertidal Enchytraeidae of British Columbia was made during 1976 to 1978. It was possible to cover a broad geographic range of British Columbia coastline. Vancouver Island was particularly well investigated.

Twenty-two species of four enchytraeid genera, Marionina, Lumbricillus, Grania and Enchytraeus, were identified using standard staining and light microscope techniques. Nine taxa, Enchytraeus bonus n. sp., Grania n. sp., Lumbricillus tsimpseanis n. sp., L. curtus n. sp., L. rupertensis n. sp., Marionina vancouverensis n. sp., M. charlottensis n. sp., M. neroutsensis n. sp., and M. trevori n. sp., are new to science. Other taxonomic descriptions were amended as required on the bases of new and type material. The generic positions of Enchytraeus multiannulatoides Altman, 1936 and E. multiannulatus Altman, 1936 were resolved to be in Enchytraeus. Enchytraeus kincaidi Eisen, 1904 was proposed as the valid name for a taxon with synonymous names E. alaskae Eisen, 1904, E. modestus Eisen, 1904, and E. cryptosetosus Tynen, 1969. The generic position for Grania paucispina (Eisen,

1904) suggested by Erséus and Lasserre (1976) was confirmed. Synonymies of Lumbricillus georgiensis Tynen, 1969 and L. ritteri Eisen (in part), 1904 to L. pagenstecheri (Ratzel, 1869) sensu Nielsen and Christensen, 1959 and of L. ritteri Eisen (in part), 1904, Enchytraeus pugetensis Altman, 1931 and Lumbricillus vancouverensis Tynen to L. annulatus Eisen, 1904 were proposed. The original description for Lumbricillus eiseni Cernosvitov, 1937 nomen novum pro Marionina americana Eisen, 1904 was found to be consistent with Nielsen and Christensen's (1959) diagnosis for Marionina and Marionina americana Eisen, 1904 was re-erected as the valid taxon name.

A key to the authenticated British Columbia intertidal enchytraeid taxa was constructed.

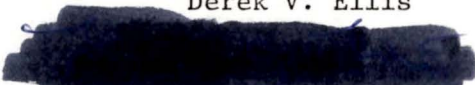
New and undescribed intertidal enchytraeid species found at Kitimat and Port Alice indicate that further studies are required to describe completely this group in British Columbia.

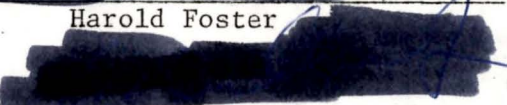
A survey of the intertidal enchytraeid species made in Neroutsos Inlet showed that marked species composition changes occurred at sites near the Port Alice pulp mill effluent into the inlet. Lumbricillus lineatus was found to have its habit distribution limited to perturbed areas very near the mill effluent. Such limited distributions of this species to perturbed areas were also noted at the Port Edward pulp mill near Prince Rupert and at Ocean Falls.

Identification to species of individual enchytraeid oligochaetes rather than enumeration of the total of unidentified individuals or of the total number of species present yielded most information regarding perturbation of communities. The additional information obtained exceeded in 'value' the additional effort required for specific identifications.

Scanning electron microscopy was preliminarily investigated as a tool of morphological description. The use of the S.E.M. with fractured specimens, to observe internal organs, may resolve many problems for future taxonomic investigators.


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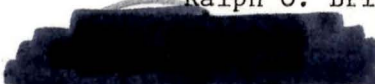

A. R. Dobell

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1. INTRODUCTION

Enchytraeidae are small, segmented, hermaphroditic annelids of class Oligochaeta. Of the twenty-two (Holmquist, 1968 and Brinkhurst and Jamieson, 1971) genera included in Enchytraeidae four, Enchytraeus Henle, 1837, Marionina Michaelsen, 1889, Grania Southern, 1913 and Lumbricillus Örsted, 1844, are known to occur frequently and in some abundance in marine and brackish benthic habitats. Grania species are known from subtidal, rarely from intertidal, habitats. Enchytraeus, Marionina and Lumbricillus species are often found to be the numerically dominant organisms in productive areas near the waterline (Giere, 1975).

Adaptations, such as nutritional specialization, for very particular niches of the intertidal ^{zone} must be highly refined within Lumbricillus which is frequently represented in intertidal habitats by several sympatric species. Factors which directly alter the type or numbers of niches available in any habitat will result in changes in the numbers and distributions of the enchytraeid species but without a taxonomic background allowing discrimination of the species present at a given time and place the complete changes incurred by environmental factors on a community are not determinable. X

At least one British Columbia study (Levings, Pomeroy and Prange, 1975) has indicated that intertidal enchytraeid oligochaete populations were noticeably altered in relative abundance and absolute numbers by perturbative environmental factors effective in the vicinity of marine effluents from pulp mills.

1.1 Objectives

In this study an attempt was made to establish a taxonomic basis that would allow the complete description of enchytraeid populations in natural and human-polluted habitats along the British Columbia coastline. A preliminary study of intertidal enchytraeid populations at various distances from the Port Alice, British Columbia pulp mill was done to determine whether reliable species identifications, utilizing the taxonomic basis established, could provide additional environmental impact information for environmental monitoring studies of an appropriate 'value' relative to the additional labour and costs incurred by identifications to that taxonomic level.

1.2 Literature Reviews

Comprehensive enchytraeid literature

Of the existing, available taxonomic literature the most complete recent review of the Enchytraeidae is by Nielsen and Christensen (1959, with supplements in 1961 and 1963). This work deals in depth with European species and consideration of species with other distributions is limited to revisions of their generic status. Justifications for the generic relocations are generally not discussed with regard to the individual species relocated and are, in some cases, obscure. Many of the intertidal taxa recorded from this area (California to Alaska) (Eisen, 1904 and Altman, 1931 and 1936) were transferred to genus Marionina even though the existing descriptions were so inadequate that the genera of the concerned species were indeterminable.

Brinkhurst and Jamieson (1971) found further shortcomings in the Nielsen and Christensen (1959) review. Objections were raised by them

to the failure to strictly apply International Code of Zoological Nomenclature (I.C.Z.N.) articles regarding validity of generic names.

Supplementary taxonomic information, including for genera type species and for species complete synonymies, location of type material when known, and type localities, was not consistently given by Nielsen and Christensen (1959, 1961 and 1963).

The 1959 review, in spite of these shortcomings, provides the most valuable recent assemblage of complete descriptions that can be used both as a basis for comparison with descriptions of North American taxa and as a basis for generic recognition. The generic definitions of Nielsen and Christensen (1959, 1961 and 1963) preempt those in Černosvitov's (1937a) System der Enchytraeiden and have in one or two instances been themselves revised (Holmquist, 1968).

Černosvitov in his later years began a bibliography of all known enchytraeid species but the manuscript was not completed before his death in 1945 and has remained unused for many years. Sections of this manuscript about Mesenchytraeus Eisen, 1878 (= Analycus Levinsen, 1883 ? see Brinkhurst and Jamieson, 1971 pp. 655-656), Lumbricillus (as Pachydrilus (Pachydrilus)) and Marionina (as Pachydrilus (Marionina)) were obtained from the British Museum (Natural History). From the sections obtained it could be determined that after publication of the Nielsen and Christensen review the significance to the taxonomy of Enchytraeidae of the manuscript was reduced. The Černosvitov manuscript served as a source of descriptions and/or figures not readily available and in some instances (eg. Enchytraeus pugetensis Altman, 1931) of poorly defined species provided a better analysis of taxonomic

rank possibilities than did the Nielsen and Christensen reviews (1959, 1961 and 1963). It would be most valuable to examine the entire manuscript in the preparation of a complete familial revision.

Subsequent to these works, Grania was reestablished by Kennedy (1966) and has since been variously revised by Lasserre (1966, 1967 and 1971a) and Erséus and Lasserre (1976).

As indicated, Brinkhurst and Jamieson (1971) in Aquatic Oligochaeta of the World superficially reviewed the genera of Enchytraeidae, including with the generic descriptions the identities of the type species. Other recent taxonomic materials have primary concern with only one or a few species and are discussed as necessary to clarify the status of British Columbia taxa.

Enchytraeidae of coastal British Columbia

Original contributions to the information resource about marine and estuarine enchytraeids in British Columbia have been made by Eisen (1904), Altman (1931 and 1936) and Tynen (1969a).

Eisen described ten new species, including three varieties, of marine enchytraeid from Alaska and northern British Columbia as well as one species of Grania from California. Several of Eisen's descriptions require revision, based as possible on types and recent material.

More recently Altman (1931) described Enchytraeus pugetensis and (1936) Enchytraeus multiannulatus from the seashore near Seattle, Washington. Inadequacies in Altman's descriptions resulted in the transfer of these species to Marionina (Nielsen and Christensen, 1959). Altman (1936) also reported finding Enchytraeus albidus Henle, 1837, a cosmopolitan species, in a salt marsh of the Naselle River, Washington.

Tynen (1969a) described six new species of intertidal Enchytraeidae of two genera, Lumbricillus and Enchytraeus, from the shores of Vancouver Island, British Columbia. Tynen's descriptions conform, for the most part, to modern taxonomic standards for enchytraeids as initiated by Nielsen and Christensen (1959) and to the I.C.Z.N. criteria.

Marionina subterranea (Knöllner, 1935) is known from an intertidal habitat in California according to Cook and Brinkhurst (1975: in Light's Manual, 3rd edition).

On the basis of these records (Table 1) members of genera Enchytraeus, Lumbricillus, Marionina and Grania were expected to occur in the intertidal habitat of British Columbia. The numbers of species that might be found in each genus were uncertain due to the unresolved taxonomic status of many of the species; however, at the initiation of this survey, 25 intertidal and subtidal enchytraeid taxa were described from the north-east Pacific coast.

Nurminen (1973a) assembled from the literature a comprehensive record of the distributions of enchytraeids in northern areas of Asia, Europe and North America. All the studied areas harboured essentially similar faunas, with the possible exception of the Pacific coast of North America. Nurminen supposed that similar fauna might exist on the Pacific north-east and north-west coasts, a situation already known for the aquatic oligochaete family Tubificidae (Brinkhurst and Jamieson, 1971), but the knowledge of both areas was too limited to draw any conclusions.

Intertidal species of Lumbricillus known from Japan (Yamaguchi, 1937), from Kamchatka (Michaelsen, 1929), from the Kurile Islands (Shurova, 1974) and from the far-eastern seas of the U.S.S.R.

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Table 1: Intertidal Enchytraeidae: ¹ species recorded
California to Alaska. ¹ (nomenclature
aff. Nielsen and Christensen, (1959)

species	author, area record	occurrence
<u>Enchytraeus</u> Henle, 1837		
³ <u>alaskae</u> Eisen, 1904	Eisen, 1904	Muir Inlet, Alaska
³ <u>albidus</u> Henle, 1837	Altman, 1936	cosmopolitan
³ <u>cryptosetosus</u> Tynen, 1969	Tynen, 1969a	Vancouver I., B. C.
^{2,3} <u>kincaidi</u> Eisen, 1904	Eisen, 1904	Popof I., Alaska
<u>Grania</u> Southern, 1913		
^{2,4} <u>paucispina</u> (Eisen, 1904)	Eisen, 1904	Santa Barbara, California
<u>Lumbricillus</u> Orsted, 1844		Orca
^{2,3} <u>annulatus</u> Eisen, 1904	Eisen, 1904	Prince William Snd., and Meltakatl, Alaska
<u>belli</u> Tynen, 1969	Tynen, 1969a	Kurile Islands, U.S.S.R. (Shurova, 1974)
³ <u>eiseni</u> Cernosvitov, 1937 (nomen novum pro <u>Marionina americana</u> Eisen, 1904 non Ude, 1896)	Eisen, 1904	Vancouver I., B. C. Port Clarence, Alaska
<u>franciscanus</u> var. <u>borealis</u> Eisen, 1904	Eisen, 1904	St. Paul Island, Alaska
f. var. <u>unalaskae</u> Eisen, 1904	Eisen, 1904	Unalaska Island, Alaska
³ <u>georgiensis</u> Tynen, 1969	Tynen, 1969a	Vancouver I., B.C.
<u>merriami</u> Eisen, 1904	Eisen, 1904	Metlakatla and Popof I., Alaska
m. var. <u>elongatus</u> Eisen, 1904	Eisen, 1904	Metlakatla, Alaska
² <u>mirabilis</u> Tynen, 1969	Tynen, 1969a	Vancouver I., B. C. Kurile I., U.S.S.R. (Shurova, 1974)
² <u>qualicumensis</u> Tynen, 1969	Tynen, 1969a	Vancouver I., B. C.
³ <u>ritteri</u> Eisen, 1904	Eisen, 1904	Farragut Bay, Alaska
³ <u>vancouverensis</u> Tynen, 1969	Tynen, 1969a	Vancouver I., B. C.

Table 1. (Cont.) Intertidal Enchytraeidae; species recorded
California to Alaska¹ (nomenclature
aff. Nielsen and Christensen, (1959).

species	author, area record	occurrence
<u>Marionina</u> Michaelsen, 1889		
<u>alaskae</u> Eisen, 1904	Eisen, 1904	Port Clarence, Alaska
<u>citrina</u> (Eisen, 1904)	Eisen, 1904	Lowe Inlet, B. C.
<u>metlakatlensis</u> (Eisen, 1904)	Eisen, 1904	Metlakatla, Alaska
³ <u>modesta</u> (Eisen, 1904)	Eisen, 1904	Orca, Prince William Snd., Alaska
^{2,3} <u>multiannulatus</u> (Altman, 1936)	Altman, 1936	Seattle, Washington
³ <u>pugetensis</u> (Altman, 1936)	Altman, 1936	Puget Snd., Washington
<u>saxicola</u> (Eisen, 1904)	Eisen, 1904	Lowe Inlet, B. C.
² <u>subterranea</u> (Knollner, 1935)	Mesick: in Cook & Brink- hurst, 1975	Half Moon Bay, California; North Carolina; Massachu- setts; Denmark; Sweden; Finland; Tunisia, Algeria.

notes:

¹Much of this information was compiled by Tynen (1975). "A check-
list and bibliography of the North American Enchytraeidae
(Annelida, Oligochaeta)".

²Species found in collection considered herein.

³Species for which taxonomic revisions are herein proposed.

⁴Taxonomic status as proposed by Erséus and Lasserre (1976).

(Shurova, 1977) would not be completely unexpected elements of intertidal enchytraeid faunae of the north-east Pacific coast.

The range of intertidal habitats that have been examined along the British Columbia coast is unknown. Eisen (1904), who apparently covered the broadest geographic spectrum of intertidal areas, gave very limited location and habitat data with his published species descriptions. Tynen (1969a) and Altman (1931 and 1936) restricted most of their collecting to upper intertidal habitats of coarse sand and gravel beaches. Altman (1936) also collected in at least one salt marsh where he found specimens of Enchytraeus albidus. A much broader habitat range than this has been reported for enchytraeid species (Lasserre, 1971b) and it is known for sandy beaches that species with different salinity preferences and tolerances are found at different intertidal elevations (Jansson, 1968 and Tynen, 1969b).

Enchytraeidae and marine effluents

It is recognized that oligochaetes of various families, including Enchytraeidae, are frequent and abundant components of estuarine and seashore faunae. Increasing numbers of species are also being recovered from shallow subtidal to deep sea habitats. However, it is only rarely that identification of the species is undertaken in general or ecologically oriented benthic intertidal surveys.

Brinkhurst (1965, 1968, 1974, etc.) has pointed out, with particular regard to Tubificidae, specific changes in communities, observed through field studies, that may occur in response to organic effluents or to other industrial effluents. In such polluted situations the abundance of worms relative to other organisms and/or the relative abundances of

various species of the worms may be indicative of the degree of 'pollution'. Infaunal benthic organisms with low translocational mobilities, such as tubificids or enchytraeids, reflect conditions of a specific location and when they are present in high numbers can be used to monitor biological availabilities of effluent contaminants deposited in the sediments (Chapman, Churchland, Thomson and Michnowsky, 1979-- in press).

Levings, et al (1975) reported aberrant intertidal benthic communities consisting of only, or dominated by, enchytraeid ("probably") oligochaetes from British Columbia estuarine locations in Wainwright Basin near Prince Rupert, and in Neroutsos Inlet near Port Alice. All of these locations were adjacent to waters receiving pulp mill effluents. Similar, aberrant faunae were not recorded from other habitats investigated by Levings, et al (1975). Another record of this condition adjacent to the mill area at Port Alice is found in Stoll and Vandermeulen (1977). In their report the predominant intertidal animals at all near-mill stations were identified as enchytraeids (actually including both enchytraeid and tubificid oligochaetes: personal observation).

Broad tolerance ranges to various environmental factors such as salinities (Tynen, 1969b and Lasserre, 1975) and probably to contaminants in industrial effluents (Chapman, et al, 1979--in press and Ireland, 1977) allows exploitation by enchytraeids of reduced competition and enhanced food supply in organically polluted coastal waters. Enchytraeids are thought to feed upon the organisms involved in the decomposition of the organic pollutants such as fungi and bacteria since they are known to select plant remains rich in fungal material in terrestrial habitats (Dash and Cragg, 1972).

Detailed physiological studies of enchytraeids with respect to their tolerance of pollutants in pulp mill and other effluents have not been done. The problem of ecophysiological tolerances even under normal environmental conditions is a complicated and unresolved issue for several oligochaete species including the cosmopolitan intertidal enchytraeid Lumbricillus lineatus (Müller, 1774). Recent studies by Giere (1977a) of conspecific disjunct oligochaete populations in addition indicated that markedly different physiological tolerance ranges are characteristic for allopatric populations.

2. BRITISH COLUMBIA TAXONOMIC SURVEY

A survey of British Columbia Enchytraeidae was undertaken to elucidate the taxonomy of the intertidal species.

2.1 Methods

Sampling

A. Spatial design

Marine intertidal Enchytraeidae were collected from as broad a geographical range of the British Columbia intertidal as possible. The general locations from which samples were obtained are shown in Figure 1. Locations of sample sites were determined with the aid of detailed navigational charts, obvious landmarks and tide tables for the regions. Accuracy of locating samples depended to a large extent on the scale of existing charts. Occasionally maps and aerial photographs were used as additional presampling information sources. Longitudes and latitudes of sample sites were determined from field charts with calipers and parallel rules. Sample site locations are given in Appendix 1.

B. Habitats sampled

Major habitats sampled were discriminated as estuaries vs. others and within estuaries as enriched by pulp mill effluents or not enriched; beaches vs. mudflats and others and within beaches as exposed (west coast) vs. non-exposed. Pulp mill enriched estuaries and other estuaries were also distinguished as southern or northern. The discrimination of sample localities according to major habitat is shown in Table 2. Within the major habitats, at most locations, high, mid, and low intertidal subhabitats were sampled (Appendix 1). Field

Figure 1. Chart of Coastal British Columbia with general sampling locations indicated

- | | |
|---------------------|-------------------------------|
| 1. Clover Point | 19. Cluxewe River |
| 2. Ashlee Bay | 20. San Juan River |
| 3. Mount Douglas | 21. Moyeha River |
| 4. Patricia Bay | 22. Sydney River |
| 5. Tsehum Harbour | 23. Tasish River |
| 6. Portage Inlet | 24. Brooks Peninsula, estuary |
| 7. Fraser River | 25. Klaskish River |
| 8. Squamish River | 26. Stranby River |
| 9. Tsable River | 27. Port Alberni |
| 10. Salmon River | 28. Port Alice |
| 11. Tsitika River | 29. Jordon River |
| 12. Kingcome River | 30. Long Beach |
| 13. Chemainus River | 31. Brooks Peninsula, beach |
| 14. Powell River | 32. Shuttleworth Bight, beach |
| 15. Elk Falls | 33. Ocean Falls |
| 16. Burrard Inlet | 34. Kitimat |
| 17. Qualicum Beach | 35. Prince Rupert |
| 18. Miracle Beach | |

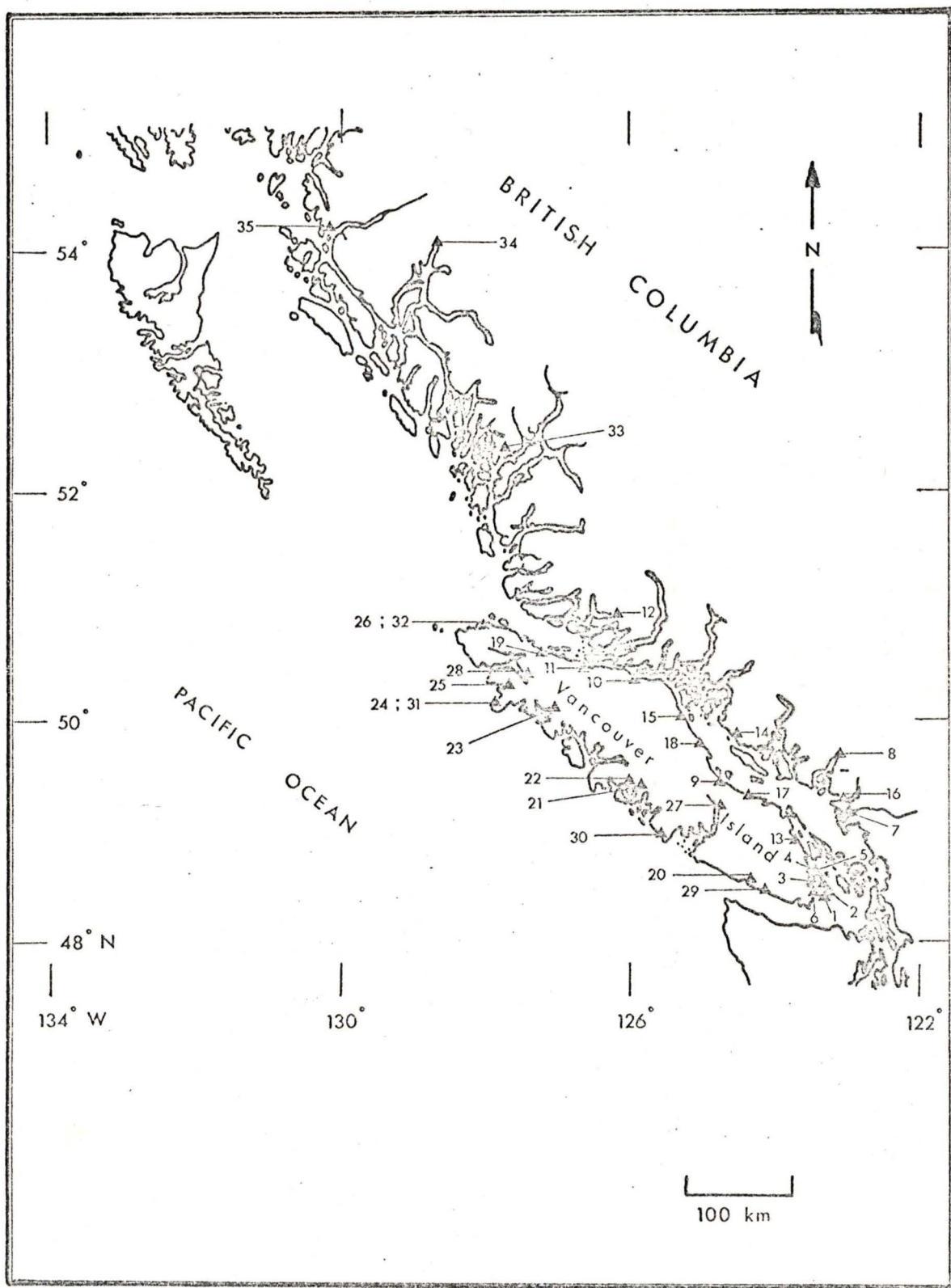


Table 2. Discrimination of sample localities according to major habitat.
 Station numbers correspond to those given in Figure 1.

Station Numbers	Estuaries				Others		
	Major Habitat				Beaches	Mudflats	
	<u>with pulp mill</u>	<u>without pulp mill</u>	<u>exposed</u>	<u>unexposed</u>			
	<u>North</u>	<u>South</u>	<u>North</u>	<u>South</u>			
	33	13		5	29	1	6
	34	14		7	30	2	
	35	15		8	31*	3	
				9	32*	4	
				10		16	
				11		17	
				12*		18	
				20		19*	
				21			
				22			
				23			
				24			
				25			
				26*			
				27			
				28			

* These stations are north of Tsitika-Neroutsos (see Habitat Distributions)

records of habitat details made at each sample site are given in Appendix 1. Visual assessments of sediment constituents i.e. fine mud-silt, coarse sand-stone, etc.; of algal abundance and taxonomic group; and of other organic constituents of the substrates such as wood chips or wood fibre were consistently recorded. Other physical site characteristics including intertidal elevation estimations were made. Accuracy of tidal elevation estimation was dependent principally on the proximity of a continuous recording tidal reference station and on the degree of predictability at the sample location with respect to the reference station (Canadian Tide and Current Tables, 1976 and 1977, V.5 and V.6).

C. Collecting techniques

Unless otherwise indicated in Appendix 1 samples obtained were non-quantitative. Samples were dug with a hand trowel and placed immediately into a storage container. Sediments to a depth of at least 10 cm were obtained. Samples to this depth should capture a significant portion of the enchytraeid population (Giere, 1975 and Jansson, 1968) and be representative for most of the species present in the sediments (Lasserre, 1971b). Samples were fixed within four hours after collection in a solution of 10% formalin in seawater.

D. Extraction techniques

Formalinized, non-quantitative samples were filtered on nylon screens with a mesh size of 500 μm and the specimens then sorted out by hand.

Whenever possible, enchytraeids were sorted immediately from unpreserved, unscreened samples. Specimens from Qualicum Beach, Miracle

Beach, Ashlee Bay, and in part Port Alice were processed live.

Collating taxonomic information

A. Literature assembly

A number of more recent bibliographies (Tynen, 1975, Nielsen and Christensen, 1959, 1961 and 1963 and Reynolds and Cook, 1976) were used to assemble a complete list of intertidal species known from the coast of British Columbia. Searches of Zoological Records, Scientific Citation Index and Biological Abstracts aided in establishing the literature locations of original species descriptions. A computer search of Biosis Previews to January 26, 1978 confirmed that most of the recent relevant material had been assembled through manual searches and from Dr. R. O. Brinkhurst.

B. Locating type specimens

Nomenclatura Oligochaetologica (Reynolds and Cook, 1976) was invaluable for determining the locations of much type material.

Syntype material of Lumbricillus georgiensis Tynen, L. vancouverensis Tynen, L. mirabilis Tynen, L. belli Tynen and Enchytraeus cryptosetosus Tynen were obtained from the Canadian National Museum of Natural Sciences (NMNS). Specimens identified by Luther C. Altman of Enchytraeus multiannulatus Altman, E. multiannulatoides Altman, E. pugetensis, Altman and E. kincaidi Eisen were examined at Thomas Burke Memorial Museum, University of Washington (UWMS). Syntypes of Lumbricillus annulatus Eisen, L. ritteri Eisen, L. merriami Eisen, Enchytraeus alaskae Eisen, E. modestus Eisen and E. kincaidi were borrowed from the United States National Museum, Smithsonian Institution, Invertebrate Section (USNM).

Other type materials of relevant species were located at California Academy of Science, Department of Invertebrate Zoology (CASF), Molslaboratoriet, Femmoller (MLFD), Museum National d'Histoire Naturelle, Laboratoire de Zoologie (Vers) (MNHN) and Naturhistoriska Riksmuseet, Sektionen for Evertebratzoologi (NHRS) but were not seen.

Taxonomic procedures

A. Identification priorities

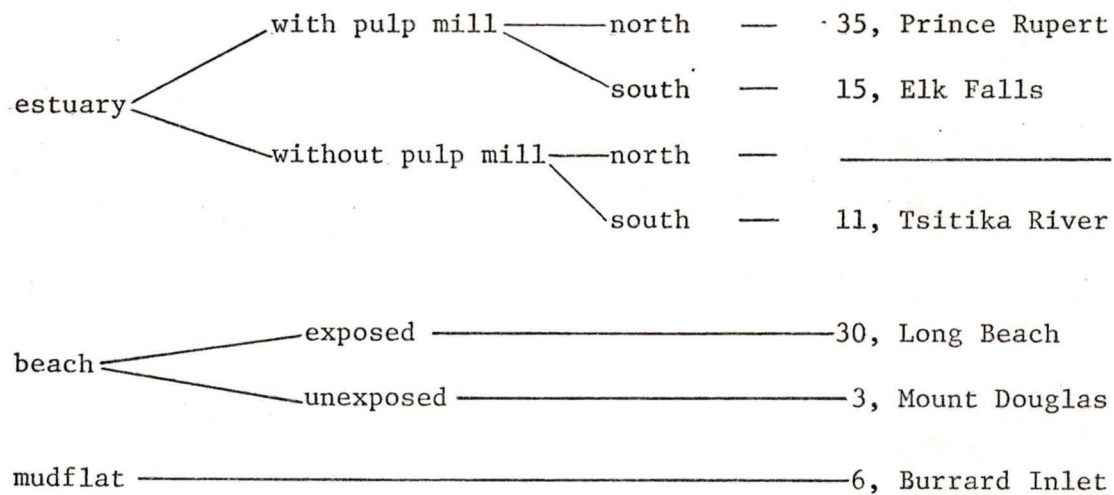
Approximately eight thousand enchytraeid specimens were obtained for the collection under consideration. With a rather poor taxonomic basis from which to begin, it was not considered possible, within reasonable time constraints allowed for this study, to identify all the mature specimens.

Utilizing a working hypothesis that different complexes of enchytraeid species would be associated with the different major habitats discriminated, mature specimens from stations chosen with regard to region, habitat type and number of mature specimens were identified (Table 3). A northern coast pulp estuary, Prince Rupert - Appendix 1, a southern Strait of Georgia pulp estuary, Elk Falls, a southern undisturbed estuary, Tsitika, a protected beach of the inner coast, Mount Douglas, an outer coast, exposed beach, Long Beach and a mudflat in Burrard Inlet were the representative stations selected. The dates of sampling for each of these stations are given in Appendix 1; they all fall within the summer months mid-June to early September.

Secondarily, specimens from areas of particular interest, Miracle Beach, one of the type habitats for Tynen's (1969a) species, and Port Alice, for a more detailed study of shoreline oligochaete

Table 3. Stations chosen for initial identifications.

Stations are designated by numbers and names, corresponding to Figure 1.



The first part of the document is a letter from the Secretary of the State to the President of the United States, dated January 1, 1865.

The letter is addressed to the President and is signed by the Secretary of the State. It contains the following text: "I have the honor to acknowledge the receipt of your letter of the 29th inst. and in reply to inform you that the same has been forwarded to the proper authorities for their consideration."

The second part of the document is a report from the Secretary of the State to the President, dated January 1, 1865. The report contains the following text: "I have the honor to inform you that the same has been forwarded to the proper authorities for their consideration."

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communities in the vicinity of pulp mill effluents, were identified. All identifications made to date are shown in Appendix 1.

B. Identification procedures and species records

For taxonomic purposes, only mature specimens were examined. Only in very well studied and thoroughly characterized communities is it possible to identify, with some probability of being correct, immature enchytraeids to the specific, and in cases even generic, taxonomic level. The prominent clitellum that characterizes a mature enchytraeid is shown in Figure 2.

Light microscope and drawings

Using light microscopy techniques modified after Erséus (1974), Erséus and Lasserre (1976) and Cook and Brinkhurst (1973) morphological taxonomic studies were done on fixed material. These techniques involved staining whole organisms in Grenacher's alcoholic borax carmine then dehydrating in an ethanol series followed by clearing in xylene and mounting in Canada balsam; and, as required, dissecting out taxonomically important structures from specimens in the mounting medium. Details of specimen preparation for light microscopy are given in Appendix 2.

Observations of permanently mounted specimens and cleared specimens mounted temporarily in xylene, were made using a Nikon microscope model S-Ke II with a built-in Koehler illuminating system, phase contrast capabilities, and a trinocular eyepiece. An attached Reichert drawing tube was utilized for making permanent illustrated records (tracings) of the mounted specimens. Magnifications for tracings were 100x, 200x,

400x and 1000x (with oil). Most details could be discerned at magnifications of 200x or 400x.

Light microscope and photographs

For photographic records live specimens were observed under a compound microscope with attached camera and micro-flash apparatus.

The specimens, after the technique of Nielsen and Christensen (1959), were placed in a drop of seawater on a slide and covered with a coverslip of a weight suitable to the specimen's size and robustness. To slow the organism's movements, water was gradually withdrawn from under the coverslip with an absorbent tissue.

During observation, photographs, as a permanent record of the live specimens, were made. Photographs were taken with an Olympus PM-6 camera mounted on a Zeiss Universal-R microscope. To obtain correct film exposures at the very high shutter speeds required to eliminate animal movements, a Zeiss micro-flash attachment that triggered the camera shutter was used in combination with neutral density filters. Magnifications for photographs were 100x and 160x, rarely 400x.

Photographic records of living specimens complement but do not replace scale drawings or tracings of fixed specimens. Light microscope photography at higher magnifications cannot show the three dimensional attributes of organs and organ systems as shown by drawings.

Scanning electron microscope

Specimens of some species were studied in a JEOL JSM-35 scanning electron microscope using the emissive mode of operation at accelerating

voltage of 10 kv. Images were recorded photographically on Kodak Verichrome Pan film VP-120. Standard dehydration, critical point drying and gold coating methods were used in specimen preparation. Details are given in Appendix 3.

In comparison of scanning electron microscope output with other microscope output, the outstanding feature of the S.E.M. micrographs was the remarkable depth of field. In both magnification and resolution the S.E.M. had ranges intermediate between those of the light microscope and the transmission electron microscope.

C. Taxonomic features

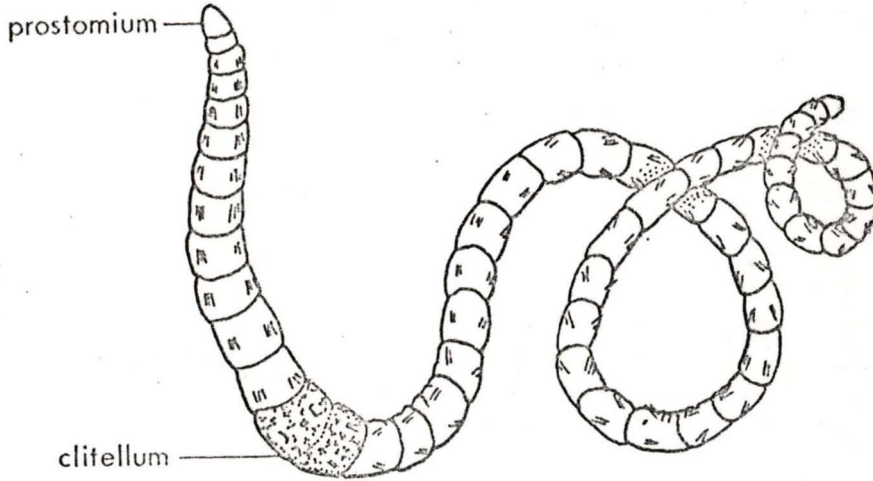
The most important morphological characteristics used for distinguishing enchytraeid species were the structures of the various sex organs including spermathecae, seminal vesicles and testes, and the male duct (Fig. 3). For the respective genera other, additional characteristics were also taxonomically significant due to their conservative, intraspecific natures. Single characters generally were not diagnostic at either the generic or specific levels (Lasserre, 1971b).

Taxonomic criteria established by Nielsen and Christensen (1959) were adhered to and descriptions made were consistent with the format that they used. For a complete description of a specimen, the following characters were recorded:

1. morphological: length,
number of segments (Fig. 3),
arrangement of cutaneous glands,
setal shape (Fig. 2),
setal distribution,
position of head pore,

Figure 2. Generalized mature Enchytraeidae and some taxonomically important setal characteristics.

GENERALIZED ENCHYTRAEID



SETAL SHAPES



with ental hook
straight

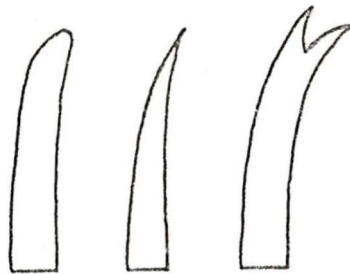


curved



with nodulus
sigmoid

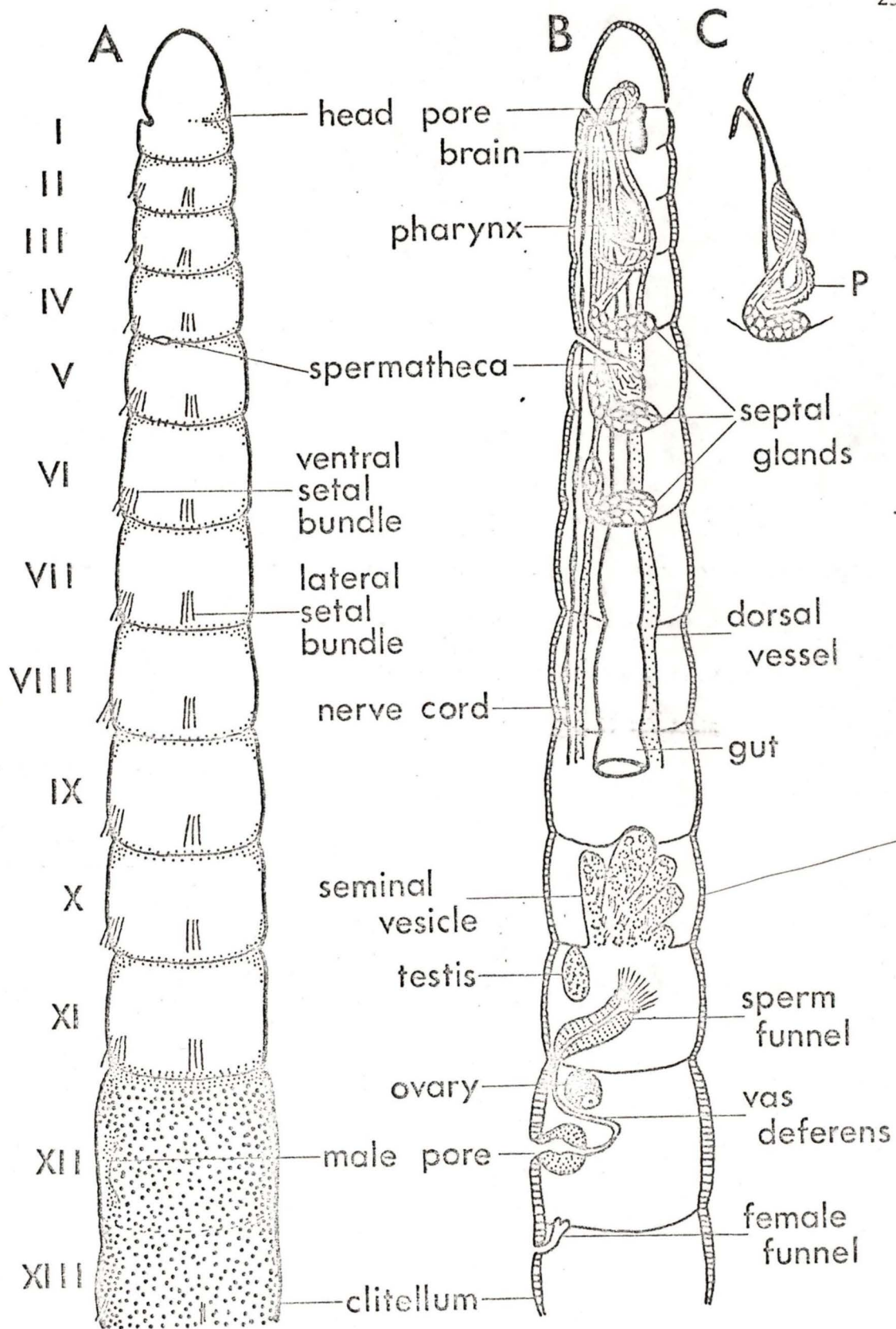
ENTAL TIPS



round pointed

simple bifid

Figure 3. Schematic longitudinal views of a mature enchytraeid.
A. external; B. internal, with lumbricilline seminal vesicles; and C. pharynx with enchytraeine peptonephridia (P).



extent of clitellum,
arrangement of gland cells of clitellum,
brain shape,
peptonephridia (Fig. 3), presence or absence
and shape,
presence or absence of gut diverticula and
number,
morphology of septal glands,
spermathecal morphology,
morphology of seminal vesicles and testes,
relative dimensions of sperm funnel,
relative dimensions and shape of sperm funnel
collar,
extent and other details about vas deferens,
penial bulb formation and relative size,
segment of origin of dorsal blood vessel,
blood colour,
shape of nephridia,
colour and relative size of chloragocytes and
first segment present on gut,
lymphocytes, nucleate or anucleate and general
shape and size,
ventral copulatory glands presence and position,
number of eggs present at one time; and

2. non-morphological: habitat, general sediment characteristics and
intertidal disposition.

The positions of the various structures and some attribute states are shown in Figures 2 and 3. For a species to be completely described it was necessary to examine many specimens in order to allow for intra-specific variability.

Enchytraeus Henle, 1837

Enchytraeus species were immediately distinguishable from species of the other three marine genera considered because they possessed paired, unbranched peptonephridia (Fig. 3). Setae in the species of this genus are straight or slightly curved, without noduli; numbers of setae per bundle are variable.

To distinguish species within the genus, setal distributions, relative dimensions of the sperm funnel, occasionally also shape, and spermathecal morphology, in particular the arrangement of glands around the ectal duct and the number and arrangement of ampullar diverticula were useful as preliminary characteristics. All characteristics as listed, were considered for species identifications but those of the spermathecae were usually of ultimate consideration in decision-making.

Grania Southern, 1913

Grania species were easily distinguished from species of the other three genera on account of their long, thin body dimensions and their unique setal distribution, each bundle containing at most one straight seta. Setae are entirely absent in at least the three most anterior segments and dorso-lateral setal bundles commence in segments posterior to the first ventral bundles.

For species discrimination the exact origins or range of origins of dorsal and ventral setal bundles and the spermathecal morphology including distribution of spermatozoa are most significant (Erséus and Lasserre, 1976). For Grania, in contrast to the other three genera, there are never glands along the ectal ducts of the spermathecae. Grania paucispina Eisen has some small glands at the ectal orifice.

Lumbricillus Örsted, 1844

A key morphological characteristic distinguishing Lumbricillus species from those of genera Enchytraeus, Marionina and Grania is the presence in Lumbricillus of well-developed, lobed seminal vesicles (Fig. 3). For some other characteristics Lumbricillus is quite heterogeneous. Setae range from almost straight to very sigmoid, noduli are never present, and setal numbers per bundle are highly variable.

The ultimate characteristic for distinguishing the species of Lumbricillus was the morphology of the spermathecae; however, other conservative characteristics were always considered. These characteristics included relative dimensions of sperm funnels, setal shape and distribution, and, within a range of forms, septal gland morphology.

Marionina Michaelsen, 1839

Marionina as diagnosed by Nielsen and Christensen (1959) is still a rather heterogeneous taxon. "The natural entities [new genera included] will become more apparent when more species have been described" (Nielsen and Christensen, 1959).

Marine species recorded from the considered collection were determined to belong to Marionina, rather than to one of the other three genera found, if they possessed an unlobed seminal vesicle or seminal vesicles were lacking and spermatozoa were free in the coelom, and peptonephridia were absent and setal bundles, where present, consisted of more than a single seta. Other common characteristics of Marionina include nephridia with the anteseptale consisting of the funnel plus a portion of the nephridial canal and straight or sigmoid setae without noduli, usually few per bundle.

For distinguishing species the distribution and shape of setae, the morphology of septal glands, apparently quite conservative in Marionina (Lasserre, 1971b), presence or absence of seminal vesicles and, finally, the details of the morphology of the spermathecae were very important.

D. Determination of taxonomic status

It cannot be stressed too often that it was considered very important in these taxonomic investigations to consider as wide a range of taxonomic information as available. Such a range of information included habitat, distributional and behavioural data.

The recognition of taxa as new or known was based on species-character tables constructed for each of the four genera. From these tables could be extracted species or species groups similar to a taxon described from British Columbia. Detailed comparisons of those taxa extracted to the described taxon were then made using original descriptions and revised descriptions of relevant taxa.

Phenetic differences and similarities between the British Columbia taxon and other similar taxa were attributed with different importances or 'weights'. Relative importance attributed to morphological differences were consistent with what could be discerned from the literature about the respective conservatism of the different morphological characters in the four genera and with the variability observed in British Columbia populations of a taxon.

In some instances, taxa found in British Columbia were not well represented numerically and the conservatism of observed characteristics within the British Columbia populations could not be assessed. In these cases, the degree of difference between a British Columbia taxon and similar other world taxa was critically assessed in terms of the conservatism of the differing characteristics. Geographical and habitat separations of taxa, probably barriers to genetic exchange, were considered taxonomically significant.

Thus an 'aberrant' individual sympatric with and morphologically similar to another British Columbia taxon, but for which, due to its unique known existence, conservatism of the 'aberrant' characteristics could not be determined was not designated as a new species even though it was valuable to note its presence.

Traditionally, objections are raised to the erection of new species on the basis of individual specimens but the quantity and quality of differences merit more critical assessment than would be allowed by such an overriding objection. Numerical taxonomic analyses at the species level consider individuals and could easily discriminate sufficiently different individuals at similarity values well below the similarity of

individuals determined to be specifically equivalent.

Tables illustrating distinguishing characteristics between the British Columbia taxa and similar taxa-groups extracted from the generic tables were constructed once the rank of a described taxon had been resolved, e.g. Table 4.

2.2 Taxonomic Results and DiscussionEnchytraeus Henle, 1837Enchytraeus (partim): Michaelsen, 1889, p.34Pachydrilus (partim) Claparede, 1861, p.75Halodrilus Verrill, 1873, p.623Neoenchytraeus (partim) Eisen, 1878, p.74Archienchytraeus Michaelsen, 1885, p.273Parenchytraeus Hesse, 1893, p.1-3Diagnosis of the genus.

The following diagnosis of Enchytraeus by Nielsen and Christensen (1959) is the most complete and homogeneous to date.

Type species: Enchytraeus albidus Henle, 1837.

"Setae straight, without nodulus, occasionally missing on some segments. Head pore at O/I. Dorsal pores absent. Brain rounded posteriorly. Gradual transition between oesophagus and intestine. Paired, unbranched peptonephridia present. Oesophageal appendages absent. Intestinal diverticula absent. Dorsal vessel arising in or behind the clitellar region. Blood colourless or faintly yellowish. Three pairs of primary septal glands [secondary glands sometimes present]. Interstitial tissue of nephridia well developed; anteseptale consisting of funnel only; the efferent duct usually of postero-ventral origin. Seminal vesicle present and usually well developed. Vas deferens long sometimes extending backwards to XXI. Penial bulb present. Male pore without atrial glands. Spermatheca simple, communicating with the oesophagus. The ectal duct usually with glands. Small to large species occupying marine, limnic and

terrestrial habitats " (Nielsen and Christensen, 1959, p.89).

According to Nielsen and Christensen (1959, p.89) secondary septal glands were absent in genus Enchytraeus. However, their description of E. minutus (1961) was the first in which the presence of secondary septal glands (in V and VI)* was indicated. In E. buchholzi Vejdovsky, 1879 morphologically similar structures to those of E. minutus are called ventral lobes (Nielsen and Christensen, 1959, p. 93). It would seem to be only a matter of opinion whether the ventral parts of the septal glands have acquired "such high degree of independence" (Nielsen and Christensen, 1959, p.20) from the primary septal glands that they should be called secondary septal glands. For E. bonus n.sp., described later, the parts of the septal glands referred to as ventral lobes are certainly not as independent as those termed secondary glands in the locally recorded species of Grania (eg. Grania n. sp., from Vancouver-see the following taxonomic section).

* note: Kasprzak (1973, f.38) illustrated E. minutus with secondary septal glands in IV and V.

A. Amended descriptions

The following descriptions of known taxa are modified, when necessary, on the basis of the British Columbia material.

Enchytraeus kincaidi Eisen, 1904 Figures 4-10, Plate 1,
Table 4

Enchytraeus kincaidi Eisen, 1904, pp. 66-68.

text fig. 37-38, pl. XVIII f. 2-4.

E. kincaidi: Cernosvitov, 1937a, p. 291.

E. kincaidi: Nielsen and Christensen, 1959, p. 90.

Enchytraeus alaskae Eisen, 1904, pp. 68-70. text fig.

39-40, pl. I f. 19, pl. XIX f. 4-6, pl. XX f. 1-2.

E. alaskae: Cernosvitov, 1937a, p. 291.

Enchytraeus modestus Eisen, 1904, pp. 63-64, f. 33,

pl. XIV f.2-3.

E. modestus: Cernosvitov, 1937a, p. 293.

Marionina modesta: Nielsen and Christensen, 1959, p. 109.

Enchytraeus cryptosetosus Tynen, 1969a, pp. 387-388,

f. 10, pl. 1 f. 12&16.

Syntype material of all the synonymous species, E. kincaidi, E. alaskae, E. modestus and E. cryptosetosus were obtained from their two repositories. Pertinent observations made on the syntype specimens are given below.

USNM syntype series 5163 of E. kincaidi Eisen consisted of four whole specimens. Two of the four specimens were mature, the other two had incompletely developed male reproductive organs and no spermathecae.

Contrary to Eisen's (1904, pp.67-68) description, the peptonephridia of the specimens were typically enchytraeine, paired and unbranched; chloragogen cells were present surrounding the gut and dorsal blood vessel, in large number from VII; the vas deferens of the mature specimens were clearly distinguishable extending posteriorly into XIII; and four complete setae were observed in only one lateral bundle of a single syntype specimen.

The two mature syntype specimens had, respectively, 62 and 61 segments. The spermathecae of these specimens were as illustrated by Eisen (and the same as Tynen's species E. cryptosetosus).

The syntype material for E. alaskae Eisen, USNM 21104, was labelled as Enchytraeus alaskana Eisen; location: Garford Island, Meier Inlet. The spelling of both the name of the species and the location of collection differ slightly from the written description (Eisen, 1904).

The four whole syntype specimens obtained were not as large as Eisen (1904) indicated, with only 52 to 57 segments. All of the syntype specimens were mature, with well-developed clitella and spermatozoa in the spermathecae. The spermathecal morphology of these syntype specimens was as Eisen illustrated for E. kincaidi. The spermathecae figured by Eisen (1904, f.40a&d) for E. alaskae appear to be of an immature specimen, without spermatozoa in the ampulla of the spermatheca.

USNM 21106, was a series comprised by two specimens of the nominate E. modestus Eisen. One of these specimens was lacking the five most anterior segments and the other, unfortunately, was

not fully mature. The whole specimen possessed, however, typical enchytraeinae, paired, unbranched, peptonephridia and seminal vesicles. The spermathecae were not fully developed. They were not like the irregularly glandular structures figured by Eisen (1904) but possessed a small, distinct ectal rosette of gland cells. The ectal ducts were relatively long, the ampullae small and lop-sided and the ental ducts short but distinct. This specimen in total resembled partially mature specimens of E. kincaidi that were collected and observed during this study.

NMNS 3403, a single whole specimen of E. cryptosetosus Tynen, was examined and could not be found to differ significantly from E. kincaidi syntypes or from new material collected for this study (Table 4).

Some specimens identified as E. kincaidi Eisen are also retained at Thomas Burke Memorial Museum, University of Washington. The specimens (collection number 144) were collected by Prof. Trevor Kincaid in 1899 at Popof Island, Alaska and were identified by L.C. Altman on November 25th, 1931.

E. kincaidi Eisen has been chosen as the nominate type of the species in account of priority due to seniority over E. cryptosetosus Tynen. The name has been more stable than that of E. modestus because of a better initial description and definition of E. kincaidi. The species also was recognizably illustrated as E. kincaidi not E. alaskae.

The specimens series typifying E. alaskae has detail discrepancies with the written description, particularly important in the spelling of the species name. In addition the type locality habitat for E.

kincaidi is better defined than that for E. alaskae.

The 'supplementary' setae reported by Tynen for E. cryptosetosus are not a unique feature. Setae and replacement setae in all microdrile oligochaete families develop within epidermal follicles distal end first (Cook, 1971: in Brinkhurst and Jamieson, p. 18).

Type material. USNM 5163, syntype series of four whole specimens.

Type locality. Popof Island, Alaska, collected by Professor Trevor Kincaid, June, 1899.

Material examined. Enchytraeus kincaidi- syntypes, USNM 5163.

E. alaskae - syntypes USNM 21104.

E. modestus - syntypes, USNM 21106.

E. cryptosetosus - syntype, NMNS 3403.

More than 60 mature specimens, both living and fixed and stained, collected at locations around Vancouver Island (Ashlee Bay, Tsitika River, Elk Falls, Qualicum Beach, Miracle Beach and Port Alice - Appendix 1).

Description. Large, brownish or yellow intertidal specimens, from 15 to 20 mm long, with 44 to 62 segments. Setae straight with ental hook (Fig. 2 and 11), equal in length within a bundle.

Distribution: preclitellar lateral: (2) 3,

" ventral: 3,

postclitellar lateral: 2-3(4), and

postclitellar ventral: 2-3.

Ventral and lateral postclitellar bundles of mature specimens have three setae from XIX-XXIII to most posterior one or two segments. Replacement setae frequently present as bundles of two or three subcuticular, incomplete setae (see Tynen, 1969, f.12). Brain small relative to body size, slightly concave posteriorly, length approximately 1.8 x width (Fig. 4). Transition oesophagus to intestine gradual, no intestinal diverticula. Paired, unbranched peptonephridia present, extending from posterior of pharynx to posterior of IV. Canal regular and distinct. Three pair primary septal glands present, all with ventral lobes, all broadly united dorsally. Ventral lobes of most posterior pair massive. Chloragocytes small, not highly coloured, rarely light green or brown, present from VI dense from VII. Cells distinctly club-shaped, with a narrow attachment to the gut. Lymphocytes nucleate, granular, spindle-shaped, length about 1/2 length of posterior seta. Dorsal blood vessel arises XIV/XV to posterior XV, blood yellow in living and formalinized specimens. Nephridial anteseptale consists of small funnel, efferent duct terminal (Fig. 5), particularly long and narrow anteriorly. Clitellum extends XII-XIII, gland cells dense, deep, not in a regular pattern. Seminal vesicles large, unlobed, extending rarely into VIII, frequently into IX. Sperm funnels long and narrow, length varies in fixed specimens from 5 to 8 x width (Fig. 6),

collar regular, just less than funnel width (Fig. 7). Vas deferens irregularly coiled in XII. Penial bulb not compact, consists of one primary bulb and ten or twelve smaller, secondary bulbs (Fig. 8 and Plate 1). Spermatheca (Fig. 9) with a small rosette at ectal pore and some small scattered glands around the ectal half of duct. Duct widens gradually to form ampulla which has a single, large, diverticulum originating from ectal half. Length of duct equal or just greater than length of ampulla. Both diverticulum and ampulla proper contain spermatozoa. Diverticulum is equal in size to ampulla. Ampulla connected to gut laterally at ental end. In very mature worms, diverticulum may pinch into several ball-shaped compartments full of spermatozoa (Fig. 10). As many as sixteen eggs counted in a mature individual.

Habitat. Upper intertidal sand and shingle beach under decaying seaweeds and rocks.

Distribution. Alaska-Pribilof Islands to southern Islands. Various beaches around Vancouver Island, British Columbia. Particulars of specimens obtained at Ashlee Bay, Tsitika River, Elk Falls, Qualicum Beach, Miracle Beach and Port Alice are given in Appendix 1.

Remarks. E. kincaidi has morphological similarities to all of E. albidus Henle (Appendix 4), E. multiannulatus Altman (description following), E. capitatus von Bulow, 1957

amended Nielsen and Christensen 1959 and 1961 and three other of Eisen's 1904 species Marionina saxicola (Table 4), M. citrina and M. metlakatlensis. The first three species are clearly distinguishable from each other and E. kincaidi as illustrated by Table 4. The last three species of Eisen are all incompletely described and the type specimens of each is lost or in a condition preventing morphological observations of internal structures (Appendix 5).

E. kincaidi superficially resembles E. capitatus in spermathecal morphology, however, the ampulla and diverticula of E. kincaidi are very distinct, with spermatozoa contained in both. The compact penial bulb of E. capitatus serves to distinguish it not only from E. kincaidi but from all of the large Enchytraeus species listed in Table 4.

Variation in the shape of the ampullae of the spermathecae with degree of maturity is a common condition. It has been noted for E. albidus:

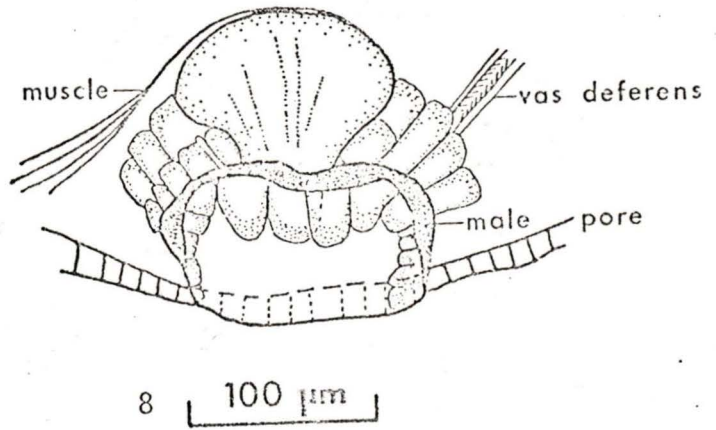
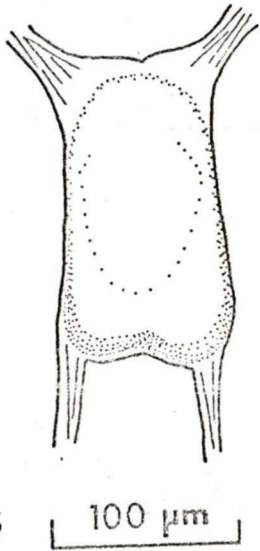
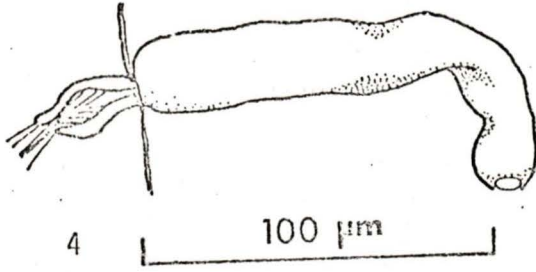
"the ampulla may be small, oval and without dilations; or it may be large and dilated either posteriorly or dorsomedially"

(Nielsen and Christensen, 1959, p. 91);

by Eisen for Marionina saxicola (Table 4); and in the present study for Enchytraeus kincaidi and E. multiannulatus.

Enchytraeus kincaidi

- Figure 4. Brain.
- Figure 5. Posterior nephridium.
- Figure 6. Sperm funnel.
- Figure 7. Enlargement of sperm collar.
- Figure 8. Penial bulb.
- Figure 9. Spermatheca.
- Figure 10. Spermatheca with compartmentalized
diverticulum.



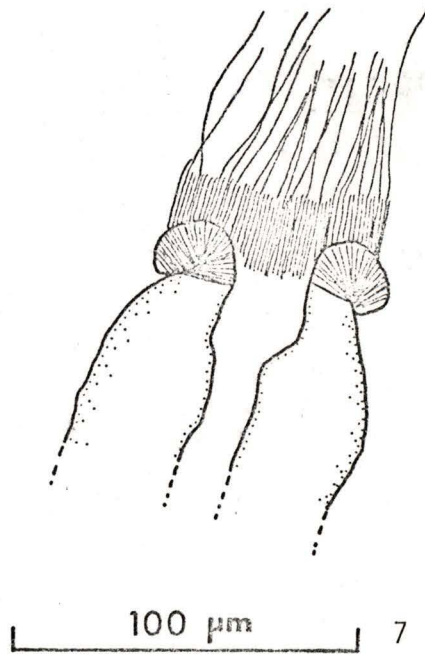
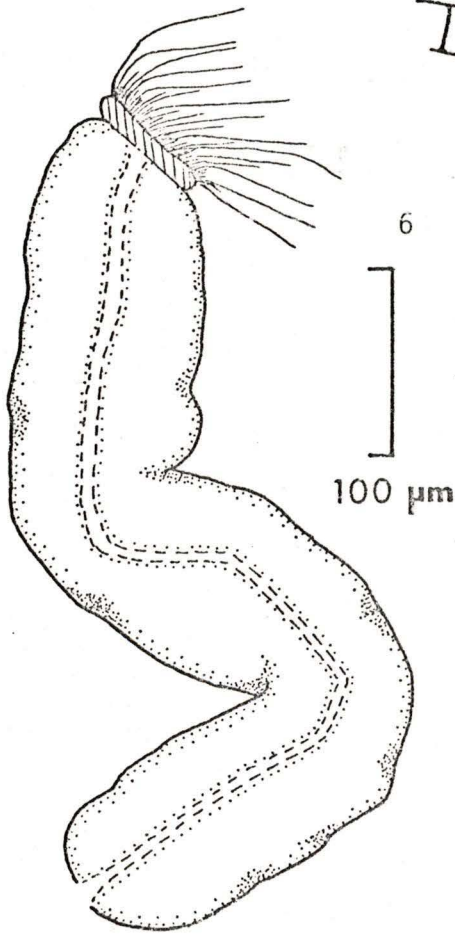
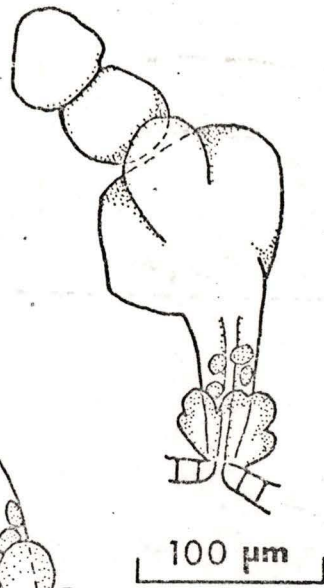
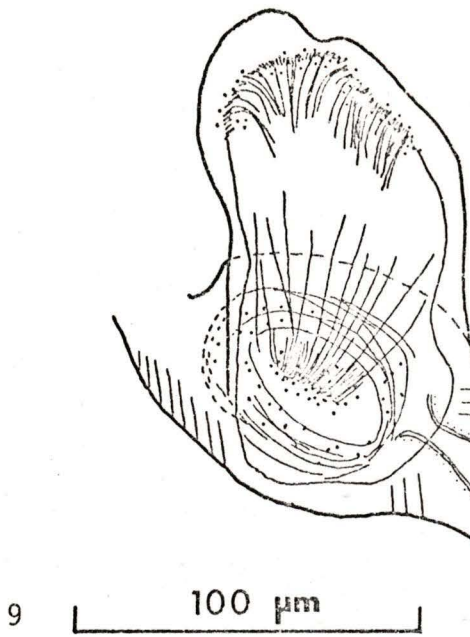


Plate 1. S.E.M. photo micrograph of male pore of
Enchytraeus kincaidi, Eisen (x620).



Enchytraeus multiannulatus Altman, 1936

Fig. 11-15, Table 4.

Enchytraeus multiannulatus Altman, 1936

pp. 29-32, pl. XII f. 108-109, pl. XIV f. 114, 117.

Marionina multiannulatus: Nielsen and

Christensen, 1959, p. 109.

Type material. UWMS.

Type locality. West Point Light, Fort Lawton, Seattle,
Washington.

Material examined. UWMS, whole mounted specimens and sectioned specimens I, II, VIII and IX 7-32. Identified by Luther Altman. Material must be considered as syntypes since no holotype was designated. British Columbia, three mature specimens from near Prince Rupert (Appendix 1).

Description. Large, robust intertidal specimens, about 15 mm long, with 46 to 52 segments (new material with 50 and 52 segments). Setae straight, with a slight ental hook (Figure 11), equal within a bundle.

Distribution: preclitellar lateral: (2)3,
 " ventral: 3
 postclitellar lateral: 2-3, and
 " ventral: 2-3.

Postclitellar lateral setae usually three from XXII or XXIII. Replacement setae in dark staining follicles, straight with a thick ental end, convergent at tips, in bundles of 2 or 3. Brain truncate or convex posteriorly, length approximately 1.75 x width (Fig. 12). Transition oesophagus to intestine gradual, no intestinal diverticula. Paired, unbranched peptonephridia present extending posterior pharynx to posterior IV, central canal regular. Three pair septal glands present, all with ventral lobes, all united dorsally. Chloragocytes present from VI, not dense, not coloured, height of cells about equal length of lymphocytes. Nucleate lymphocytes abundant, slightly granular, spindle-shaped (Fig. 11), length of lymphocytes approximately 1/2 posterior seta length. Dorsal vessel arises postclitellar in XIV, blood yellow in fixed specimens. Nephridia narrow, long, anteseptale equals funnel only, postseptale elongate, narrowing to terminal ectal duct (Fig. 13). Clitellum extends over

XII and XIII, gland cells dense, tall not regularly distributed. Seminal vesicles in XI, X and posterior IX, not lobed. Sperm funnels long and narrow, length 5 or 6 x width (Fig.14), collar width equal or just greater than funnel width, in very mature worms slightly convoluted. Vas deferens long, coiled in XII, with thick walls. Penial bulb not compact, with a number of glandular sub-bulbs (Fig. 8). Spermatheca with short, thick walled ectal duct, canal distinct (Fig. 15). Duct expands to thick walled ampulla. Ampulla with two very large diverticula originating from ectal end, one directed dorsally, the other ventrally, rarely with an additional, small diverticulum on one or both spermathecae. Ectal duct with a mass of glands along ectal part, no distinct rosette. Ampulla connected to oesophagus at V/VI. As many as two eggs present at one time.

Habitat. Upper intertidal, decaying algae.

New Record. At 3.6 m above chart datum under rotting wood fibre mat approximately 7 cm thick; near a steaming pulp mill effluent.

Distribution. Seattle, Washington.

New Record. Prince Rupert, British Columbia (Appendix 1).

Enchytraeus multiannulatus

Figure 11. a) Posterior setal bundle

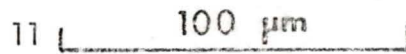
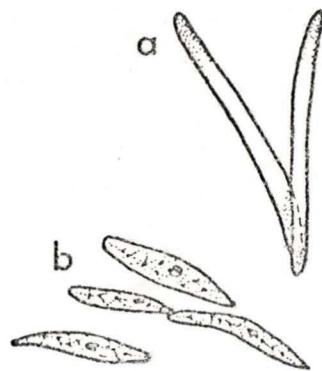
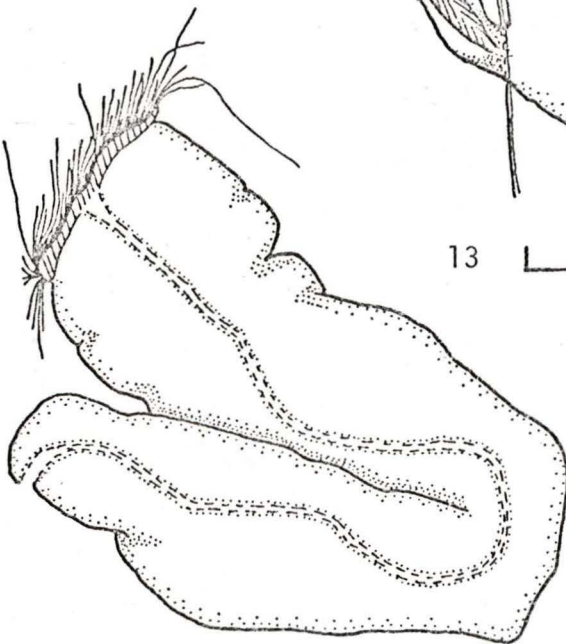
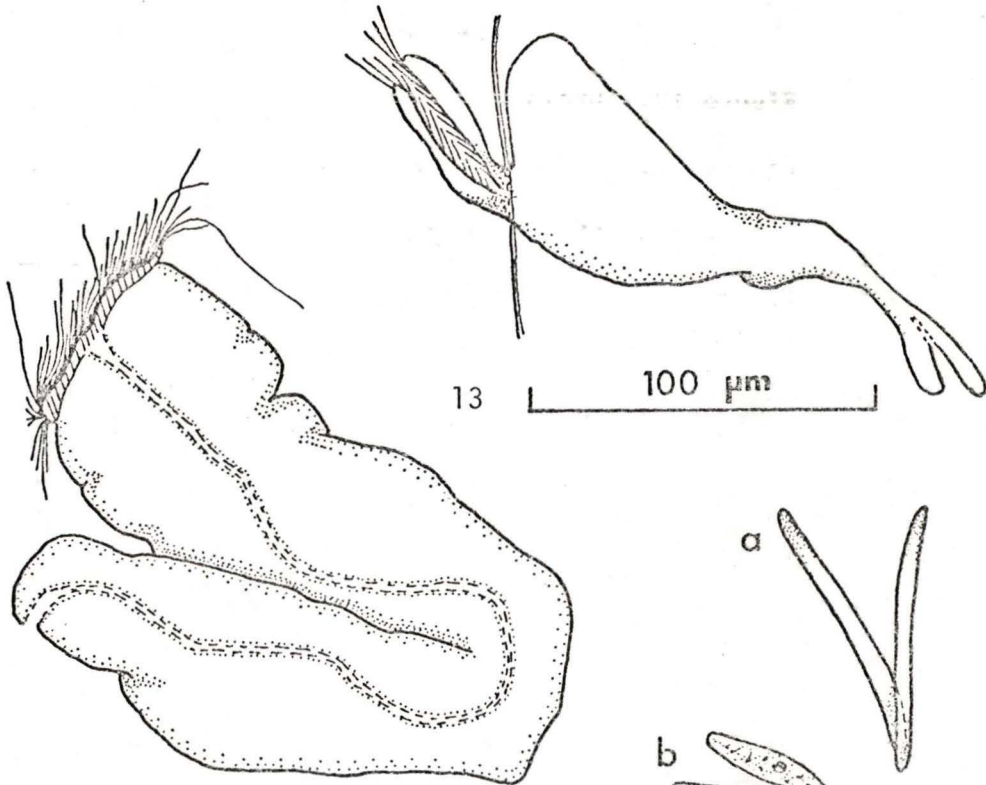
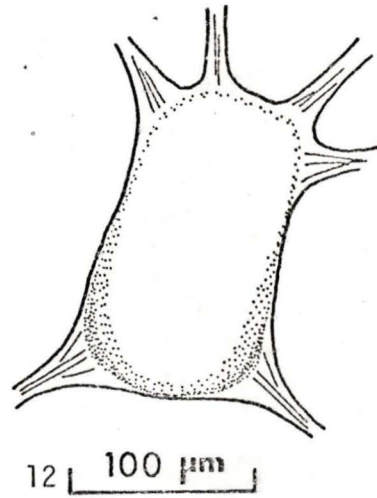
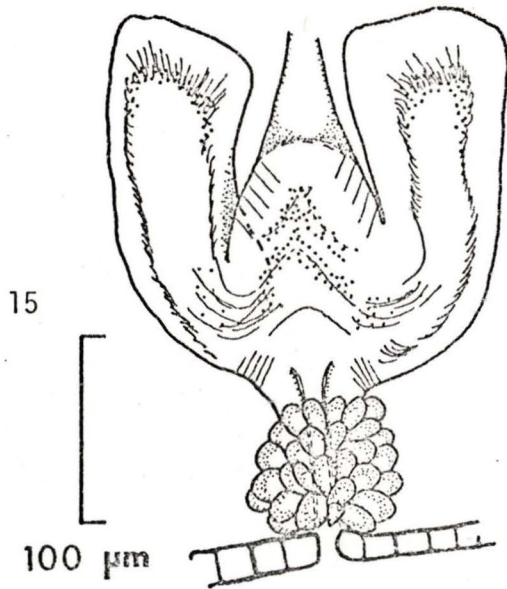
b) Lymphocytes.

Figure 12. Brain.

Figure 13. Posterior nephridium.

Figure 14. Sperm funnel.

Figure 15. Spermatheca.



Remarks. The species Enchytraeus multiannulatus was transferred to genus Marionina by Nielsen and Christensen (1959) because peptonephridia were not stated to be present by Altman (1936).

Specimens identified by Altman as E. multiannulatus were examined in order to resolve the generic status of this species.

A pair of well developed, spongy looking, unbranched peptonephridia, originating just posterior to the pharynx and extending to the posterior of IV were found in all specimens examined. The seminal vesicles were massive, unlobed and extended forward through X and usually IX. Penial bulbs, nephridia, and spermathecae were as described by Altman (1936).

Contrary to Altman's description only two or three fully developed setae were found in ventral bundles, three anteriorly and 2 or 3 posteriorly. Immature setae without ental hooks were frequently found associated with posterior ventral bundles.

E. multiannulatus differs most obviously from E. kincaidi and the other species listed in Table 4 in number of ampullar diverticula and in the arrangement of glands around the ectal duct of the spermatheca. Another consistent, but slight morphological difference between E. multiannulatus and E. kincaidi is in the ratio of length to width of their sperm funnels.

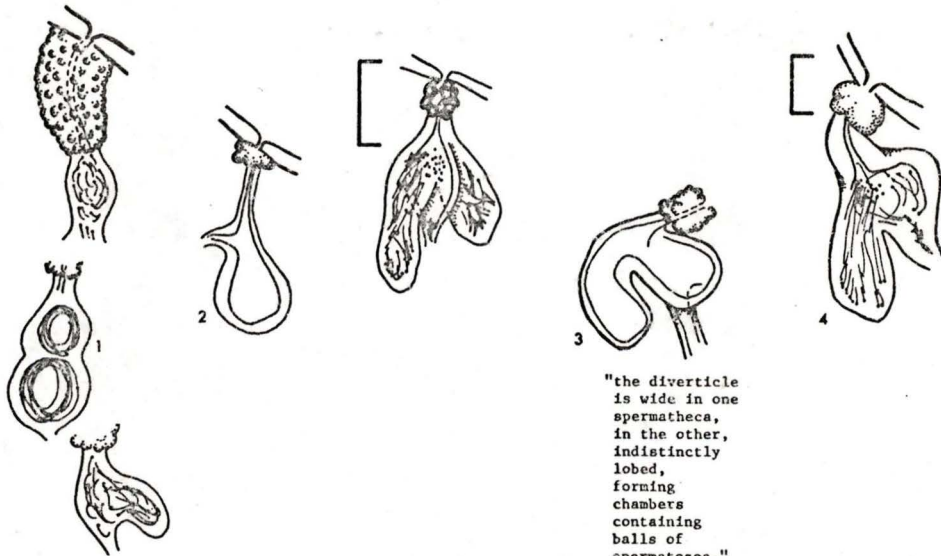
Table 4. Characteristics of some large, intertidal *Enchytraeus* species.

Spermathecae either redrawn from 1. Nielsen and Christensen, 1959; 2. Nielsen and Christensen, 1961; 3. Eisen, 1904; or drawn from 4. *Enchytraeus kincaidi* Eisen, a syntype from series 5163 (USNM); or recent British Columbia material.

SPECIES

CHARACTER	<u>albidus</u> Henle	<u>capitatus</u> v. Bulow amend Nielsen and Christensen	<u>multiannulatus</u> (Altman) amended	<u>saxicola</u> Eisen	<u>kincaidi</u> Eisen
length (mm)	20-35	10-20	15-20	15-20	15-25
no. segments	46-65	37-57	46-52	63*	44-67
setal shape	straight or curved	straight with ental hook	straight with ental hook	straight	straight with ental hook
setal lateral distrib. ventral	2-4:2-3 3-5:2-4	2-4:2 to XX,3 2-4:2 to XX,3	(2)3:2 to XXII or XXII,3 3:2-3	3:(2)3 3(4):(2)3	(2)3(4):2 to XIX-XXIII,3 3(4):2 to XIX-XXIII,3
clitellum	XII-XIII	XII-XIII	XII-XIII	XII-XIII	XII-XIII
origin of dorsal vessel	XIV-XVIII	XV-XVI	XIV-XV	posterior to XIII	XIV/XV-XV/XVI
seminal vesicle	XI-IX	XI-X	XI-IX	XI-VIII	XI-IX, rarely VIII
sperm funnel L:D	5-8:1	5-6:1	5-6:1	7:1 *	5-8:1
sperm funnel collar	regular = funnel	lobed >funnel	slight. lobed >funnel	regular * = funnel	regular ≤ funnel
penial bulb	large, not compact	compact	10 accessory bulbs	5-6 access. bulbs	10-12 accessory bulbs
peptonephridia	paired, unbranched	paired, unbranched	paired, unbranched	? absent	paired, unbranched
ecology	decaying seaweed compost heaps, sewage beds and effluents	decaying seaweed along shore	rotting debris; near pulp mill effluent, under wood fibre mat	under rocks at high tide	organic debris on coarse substrate beaches; under rocks
	almost cosmopol- itan, inc. Washington (Puget Sound), U.S.A.	Germany; Denmark; Massachusetts, U.S.A.	Seattle, Washington; Prince Rupert, B.C.	Low Inlet, B.C.	Alaska; Vancouver Island, B.C.

spermathecae
(each scale
line equals
100 μm)



"the diverticle
is wide in one
spermatheca,
in the other,
indistinctly
lobed,
forming
chambers
containing
balls of
spermatozoa."
(Eisen, 1904,
p.71)

* from Eisen, 1904, f.41a

B. New descriptions

Following is a description of a species new to science found in the survey material.

Enchytraeus bonus n. sp. Fig.16-20, Table 5

Etymology. Bonus, latin: good, indicating a distinct species.

Type material. Holotype: One whole mounted specimen; stained with borax carmine and mounted permanently in Canada balsam.

Type locality. Prince Rupert, British Columbia (near Port Edward pulp mill). 54°13.90' N at 130°17.20' W, at 3.6 m lower water line. September 1, 1976.

Material examined. Holotype only.

Description. Holotype. Small, littoral worm, length approximately 4.5 mm, with 27 segments. Setae straight with a slight ental hook (Fig. 16). Distribution:

preclitellar lateral: 1-3
 " ventral: 2-3,
 postclitellar lateral: 1-2, and
 " ventral: 2-3(0).

In XXIV many setae scattered in coelom, structure same as localized setae. Posterior margin of brain truncate.

Transition oesophagus to intestine gradual, intestinal diverticula absent. Three pair of primary septal glands (Fig. 17) present in IV, V and VI, all with ventral lobes

(secondary glands?), only posterior pair united dorsally, at VI/VII. Simple unbranched peptonephridia present, extending almost to IV/V. Outline regular, internal canal narrow. Chloragocytes colourless in fixed specimen, with refractile inclusions. Cells fairly large, densely packed along gut. Lymphocytes abundant anteriorly, nucleate, elliptical with elongate apices (Fig.16). Length of lymphocytes approximately equal length of posterior setae. Dorsal blood vessel arises posterior XIV (vessel is most enlarged in XIII but still separated from gut in XIV), blood faintly coloured in fixed specimen. Nephridia relatively large, anteseptale narrow, consisting of funnel only (Fig.18), posteptale with well developed interstitial tissue, efferent duct terminal. Nephridia present from VII/VIII, absent in XI to XII then present in all more posterior segments. Clitellum extends XII-XIII, gland cells large, approximately rectangular, in irregular rows. Testes small and compact, attached at X/XI. Seminal vesicles also small, filling only a very small part of XI. Sperm funnels short and pear shaped, length equal 1/7 body width (Fig.19), sperm collar not prominent, width equals width of funnel. Small, compact penial bulb present. One large egg present in XII. Vas deferens irregularly coiled in XII. Spermatheca simple, ampulla without diverticula. Ectal pore at IV/V, connected entally with gut at V/VI; ental and ectal ducts distinct. Ectal duct surrounded by small dense glands, no distinct rosette

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at pore. Ampulla flame-shaped with thick walls, spermatozoa irregularly arranged. Ental duct narrow, long (length duct equals length ampulla) with a distinct narrow canal (Fig. 20).

Habitat. Under rotting wood fibre mat, on very silty sediments; near a warm, organically enriched, pulp mill effluent; low salinities only; with Enchytraeus multiannulatus.

Distribution. Known only from type habitat.

Remarks. E. bonus n.sp. is closely related to the group of Enchytraeus species including E. buchholzi Vejdovsky, 1879, E. bulbosus Nielsen and Christensen, 1963, E. minutus Nielsen and Christensen, 1961, E. mariae Kasprzak, 1973, E. polonicus Dumnicka, 1977, E. dominicae Dumnicka, 1976, E. norvegicus Abrahamsen, 1969, and the dubious E. gillettensis Welch, 1914 (see Nurminen, 1973b). This group is characterized by small size, low setal number per bundle, dorsal vessel origin in or just behind clitellar segments, small seminal vesicle, and small, frequently pear-shaped, sperm funnel. Penial bulbs at the male pore are compact within this complex in contrast to the condition described for the group of large Enchytraeus species discussed previously. The species of the group can be distinguished (Table 5) on the basis of character complexes including

Enchytraeus bonus

Figure 16. a) Posterior seta

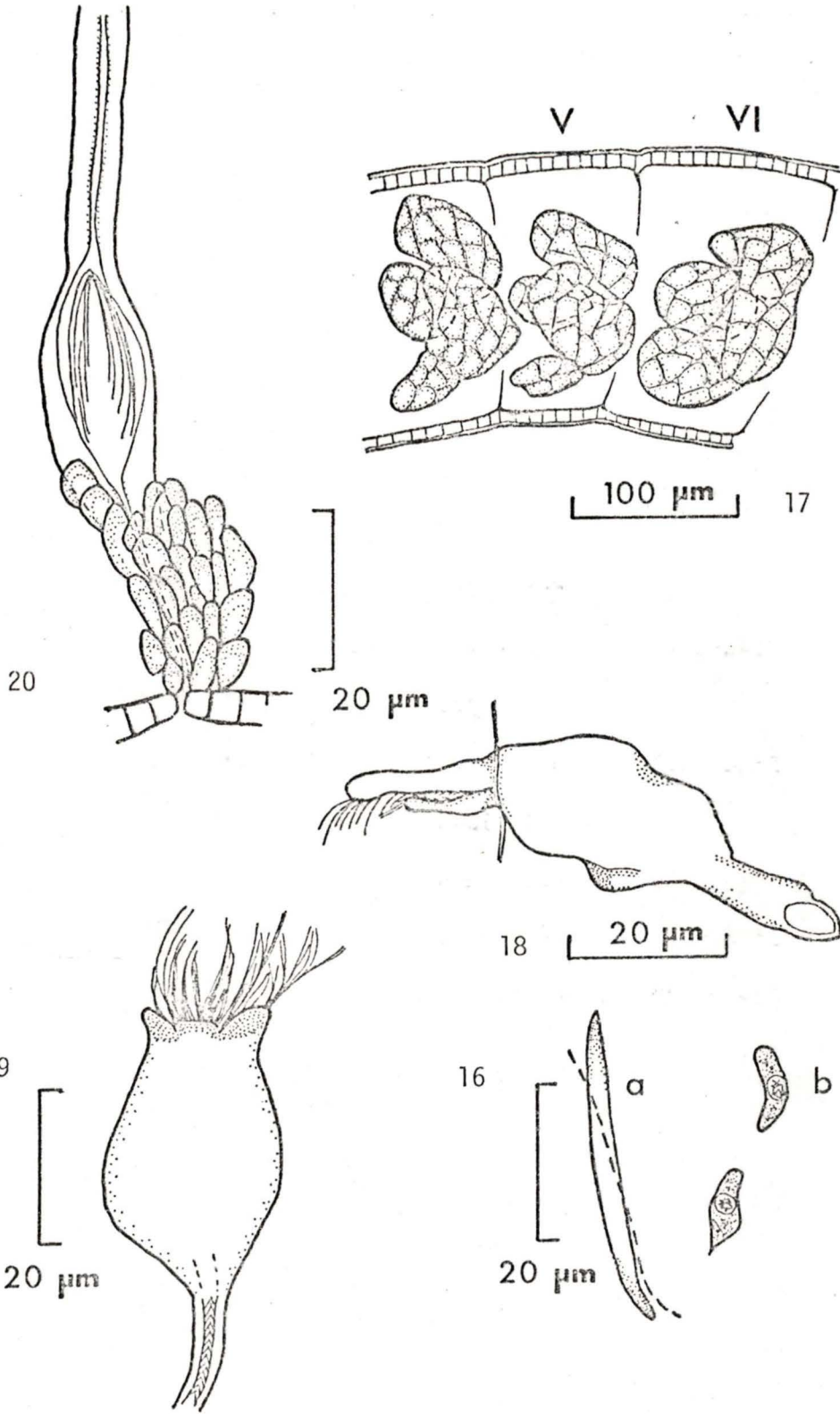
b) Lymphocytes.

Figure 17. Dorso-lateral view of IV-VI showing
septal glands.

Figure 18. Anterior nephridium.

Figure 19. Sperm funnel.

Figure 20. Spermatheca.



spermathecal structure, setal distribution, septal gland morphology, sperm funnel dimensions and other attributes.

The spermathecae of E. bonus are in general morphology most similar to those of E. polonicus (Table 5), however, in E. bonus gland cells cover the whole of the short ectal duct but in E. polonicus only the ectal half of the long duct is covered. E. bonus also has only one pair of spermathecae whereas E. polonicus has two. Setal distribution and septal gland morphology are different in E. bonus than in E. polonicus and the species are easily distinguished.

In setal distribution and sperm funnel morphology as well as spermathecal morphology E. bonus is also similar to E. norvegicus (Table 5) and E. minutus. Morphology of the septal glands and the ampullar structure of E. bonus serve to distinguish it from E. norvegicus and septal gland morphology and relative proportions of the spermathecae distinguish it from E. minutus.

Of the assemblage of Enchytraeus species shown in Table 5 only E. buchholzi, E. bulbosus (see Giere, 1976), E. minutus and E. bonus are recorded from intertidal habitats.

E. gilettensis, a poorly defined taxon, is most similar in known detail to E. minutus.

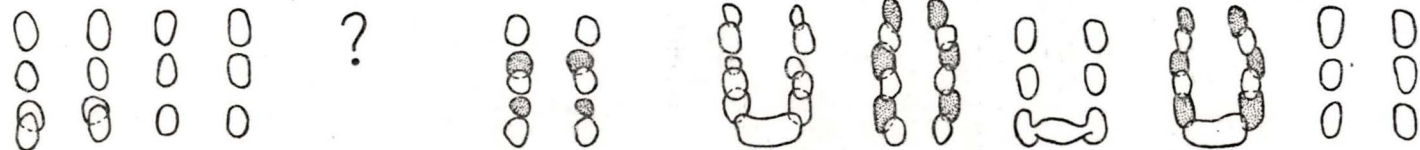
The lack of intraspecific variability (Table 5, eg., no. segments) in the group of species to which E. bonus is most closely related is probably, in large part, an

Table 5. Characteristics of some, small Enchytraeus species with morphological similarities to E. bonus n. sp..

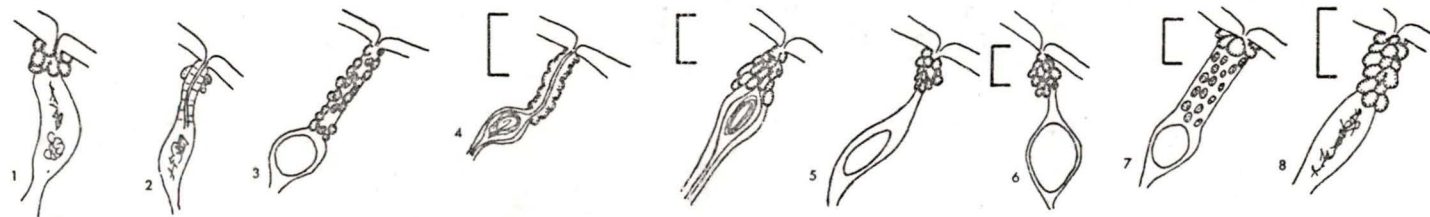
Spermathecae redrawn from 1. Nielsen and Christensen, 1959; 2. Nielsen and Christensen, 1963; 3. Welch, 1914; 4. Nielsen and Christensen, 1961; 5. Dumnicka, 1977; 6. Kasprzak, 1973; 7. Dumnicka, 1976; 8. Abrahamsen, 1969; or drawn from recent British Columbia material.

CHARACTER	SPECIES									
	<u>buchholzi</u>	<u>bulbosus</u>	<u>gillettensis</u>	<u>minusus</u>	<u>bonus</u>	<u>polonicus</u>	<u>mariae</u>	<u>dominicæ</u>	<u>norvegicus</u>	
	Vejdovsky	Nielsen & Christensen	Welch	Nielsen and Christensen	n. sp.	Dunnicka	Kasprzak	Dunnicka	Abrahamson	
length (mm)	5-10	5	2-5	3	4-5	6	8	5-6	2-4	
no. segments	24-40	30	25-27	26-34	27	27-30	33	24-31	21-30	
setal lateral distrib.	2-3:2-3	2:2	2(4 or 5)	2:2-3	1-3:1-2	2:2-3	3:3	2:2-3	1-2:2-3	
ventral	2-3:2-3	3:3	3(4 or 5)	2-3:3	2-3:2-3	3:3	3:3	3:3	2-3:2-3	
clitellum	XII-XIII	XII-1/2XIII	XII-XIII	XII-1/2XIII	XII-XIII	XII-XIII	1/2XI-XII	?	XII-1/2XIII	
origin of dorsal vessel	XII or XIII	XII or XIII	XIV	XIII	XIV	?	?	?	XIII	
seminal vesicle	XI, small	XI, small	(?prob. small)	XI, small	XI, small	XI, small	XI, small	XI, small	XI, small	
sperm funnel	L=preclit.seta	L=2 x preclit.seta	L=2.5 x preclit.seta	L=1.5 x preclit.seta	L=preclit.seta	L=1.5 x preclit.seta	L=2 x preclit.seta	L=2 x preclit.seta	L=1.5 x preclit.seta	
brain	L>W;truncate	L>W;truncate	L=2W;truncate	L>W;trun/convex	?; truncate	?;trunc/concave	L=2W;trunc/conc	?;trunc/convex	L=1.5W;trun/conv	
chloragogen	IV;dense V	IV/V;dense VI	?	V;dense VII	VI;dense VII	VI;dense VII	VII;dense VIII	dense VI	V;dense VI	
cutaneous glands	regular rows in clitellum	regular rows in clitellum	?	regular rows in clitellum	irregular rows in clitellum	reg throughout 6-10 rows	reg throughout 5-10 rows	regular throughout 5-7 rows	regular:5-7 rows irreg.in clitellum	
ecology	damp soils;decomposing plant material; sand and decaying seaweed	soil; intertidal (Giere, aff. <u>bulbosus</u>)	wet soil	grassland, forest litter, grassy beach, decaying wrack	brackish, high organic sediments	cave; clay covered with bat excrement	forest soil	cave; clay covered with humus saturated with water	forest soil	
	Widespread in Europe; S.America Canada,near Montreal	San Felice, Spain; S. Finland	Gillette Grove, Iowa	Europe; Greenland; England; Siberia; Canada, Montreal and Arctic	Prince Rupert, British Columbia	South Krakow-Czestochowa Upland,Poland	Great National Park; Poland	Bat Cave, Jerzmanovice, S. Krakow - Czestochowa Upland,Poland	As, Astershus, Norway	

primary and secondary septal glands



spermathecae (scale lines equal 20 µm, except E. mariae equals 40 µm)



artifact of the lack of information about widely distributed populations of the different taxa. Only three of the species, E. buchholzi, E. bulbosus, and E. minutus, are reported from other than their type localities. E. buchholzi, presently known to be the most widely distributed, is also the most variable with regards to the glandular arrangement around the ectal duct of the spermatheca (Nielsen and Christensen, 1959, p. 94 and Kasprzak, 1973, p. 281).

C. Status of other taxa previously recorded from British Columbia, Washington or Alaska.

Specimens of the following taxa were not found in samples collected for this survey.

Enchytraeus albidus Henle, 1837 Table 4,

Appendix 4

Enchytraeus albidus (partim) Henle, 1837,
p. 184-190, table VI f. 1-9.

E. albidus: Michaelsen, 1900, p. 89.

E. albidus: Benham, 1905, p. 295

E. albidus: Moore, 1905, pp. 394-395.

E. albidus: Michaelsen, 1908, pp. 17-79.

- E. albidus: Stephensen, 1911, pp.59-61, f.13,
pl.II f.16.
- E. albidus: Welch, 1917, pp.120-123.
- E. albidus: Stephenson, 1922a, p.1133.
- E. albidus: Stephenson, 1926, p.1316.
- E. albidus: Michaelsen, 1927, pp.13-14.
- E. albidus: Cernosvitov, 1929, p.148.
- E. albidus: Stephenson, 1932a, p.257
- E. albidus: Altman, 1936, p.28.
- E. albidus: Cernosvitov, 1937a, p.291.
- E. albidus: Cernosvitov, 1937b, p.205.
- E. albidus: von Bulow, 1955, p.259
- E. albidus: Bell, 1958, pp.11&12.
- E. albidus: Nielsen and Christensen, 1959,
pp.91-92, f.95-100.
- E. albidus: Bell, 1962, p.159.
- E. albidus: Christensen, 1962, p.6.
- E. albidus: Marcus, 1965, pp.66-67.
- E. albidus: Nurminen, 1965a, p.3.
- E. albidus: Nurminen, 1965b, p.14.
- E. albidus: Nurminen, 1965c, p.17.
- E. albidus: Lasserre, 1966, p.299.
- E. albidus: Nurminen, 1970a, p.205.

- E. albidus: Tynen, 1972, p.25.
- E. albidus: Cook and Brinkhurst, 1973, pp.16&20.
- E. albidus: McGrath, 1975, p.216.
- E. albidus: Lasserre and Erséus, 1976,
pp.452-453.
- E. albidus: Erséus, 1976a, p.4.
- Pachydrilus lacteus Claparède, 1861, p.85.
- Enchytraeus lacteus: Vejdovsky, 1884, p.41.
- Halodrilus littoralis Verrill, 1873, p.623.
- Enchytraeus littoralis: Czerniavsky, 1880, p.357.
- E. (Halodrilus) littoralis: Smith, 1895, p.289.
- Enchytraeus spiculus (partim) Möbius, 1873,
p.107.
- Neoenchytraeus vej dovskyi and N. stuxbergii
Eisen, 1879, pp.75-76.
- Enchytraeus vej dovskyi and E. stuxbergii:
Vejdovsky, 1884, p.41.
- Enchytraeus humicultor Vejdovsky, 1879, p.57.
- E. humicultor: Ude, 1892, p.84.
- E. humicultor var. similaris Ude, 1896, pp.26-27.
- Enchytraeus vermicularis Tauber, 1879, p.72: in
Michael sen, 1900, p.89.
- Enchytraeus sordidus Levinsen, 1884, p.235.
- Enchytraeus fucorum Levinsen, 1884, p.251.
- Archienchytraeus möbii Michael sen, 1885, p.237.
- Enchytraeus möbii: Michael sen, 1886, p.1.

Enchytraeus hortensis Goodrich, 1896, p.51.

Enchytraeus pellucidus Friend, 1899, p.264.

Enchytraeus simulans Benham, 1903, pp.219-221.

Enchytraeus sabulosus Southern, 1906,
pp.180-184, f.1-7.

Litorea krumbachi Čejka, 1913, pp.145-151.

Enchytraeus constrictus Backlund, 1947, p.8.

The synonymies for dates prior to 1900 are from Michaelsen (1900) in Das Tierreich, X, p.89. Enchytraeus pellucidus Friend, 1899 was proposed as a synonym by Cernosvitov (1937b). Post 1900 synonymies are primarily from Benham (1905) and Bell (1958). Nielsen (1955) and Nielsen and Christensen (1959) did not consider E. humicultor Vejdovsky, 1879 as a synonym for E. albidus. They gave it status species dubium in Enchytraeus but their discussion indicated that they in fact considered it a taxon generus incertus. Many others of the synonymies given by Michaelsen (1900) are possibly also doubtful due to the incomplete state of most older descriptions.

Type material. Typus amissus, MNHN.

Type locality. Kiel Bay, West Germany.

Description. See Appendix 4.

Habitat. Salt marshes, decaying seaweed, compost heaps, sewage beds, effluents (Lasserre, 1971a).

Distribution. Cosmopolitan.

Remarks. Nielsen and Christensen's amended description of E. albidus (Appendix 4) is the presently accepted. Altman (1936) collected E. albidus from debris in a salt marsh of the Naselle River, Washington and, in consideration of the known distribution for E. albidus, it is highly likely that it will also be found in British Columbia.

Enchytraeus multiannulatoides Altman, 1936

Enchytraeus multiannulatoides Altman, 1936,
pp. 33-37, pl. XIII, f.105-108a & 113.

Marionina multiannulatoides: Nielsen and
Christensen, 1959, p. 19.

Type material. UWMS.

Type locality. Not designated.

Material examined. UWMS; syntype specimens I-SI and S2, II-S1, S4 and S5, 7-32. Identified by Luther Altman.

Habitat. Compost heap consisting of alfalfa and clover mixed with horse urine and manure.

Distribution. Washington.

Remarks. E. multiannulatoides was transferred to Marionina by Nielsen and Christensen (1959) because it apparently lacked peptonephridia. Re-examination of whole mounted and sectioned type material has established without doubt that the genus of this taxon, is Enchytraeus. Typical of the genus, a pair of unbranched peptonephridia are present and the seminal vesicles are unlobed and compact.

E. multiannulatoides is only known from a single terrestrial habit and is not suspected to occur in marine environments. It is distinguished from other species of the genus by its spermathecal morphology and setal distribution.

Grania Southern, 1913

Grania Southern, 1913, pp.11-12

Grania:Kennedy, 1966, p.400

Grania:Lasserre, 1966, pp.313-314

Grania:Lasserre, 1967, pp.279-280

Grania:Erséus and Lasserre, 1976, pp.121-122.

Hemigrania:Lasserre, 1971, p.454.

Hemigrania:Erséus and Lasserre, 1976, p.128.

Diagnosis of the genus

The following diagnosis of Grania modified after that of Erséus and Lasserre (1976) is the most complete to date.

Type species: Grania maricola Southern, 1913.

Whitish, rarely pigmented, transparent marine enchytraeids, superficially resembling nematodes. Body often slender. Body wall usually transversely striated, with thick cuticle and small cutaneous glands scattered in transverse rows. Prostomium conical and rounded. A head pore probably present in all species at O/I, but not always easily detectable. Dorsal pores absent. Clitellum extending more or less completely over XII and XIII. Setae large and straight, without a nodulus. Proximal end of setae characteristically broad or curved. Setal bundles totally absent from the most anterior segments, and from segment XII in fully developed specimens. Ventral bundles beginning in a preclitellar or postclitellar region. Dorsal bundles beginning posterior to the first segment bearing ventral setae or totally absent. Only one seta per bundle. Non-localized "supplementary" setae often present in the coelom, or attached to the inner layer of

the body wall, of some segments. Brain anteriorly narrower and posteriorly incised. Gradual transition between oesophagus and intestine. Oesophagus and intestine without diverticula or appendages. Peptonephridia absent. Primary septal glands in IV, V and VI. Secondary glands present in varying numbers. Septal glands never united dorsally. Dorsal vessel originating behind clitellum. Nephridia simple, anteseptale consisting of funnel only. Lymphocytes oval and granulate. Anterior seminal vesicle absent. Posterior seminal vesicle extending through some segments. Sperm funnel large and cylindrical, often several times longer than wide. Collar approximately same width as funnel. Sperm duct long, narrow and convoluted, extending posteriad, sometimes reaching XVIII or XIX. Penial bulbs compact, with/without enveloping dorsal glandular mass (Erséus, 1977). Ova present in one or more segments behind the seminal vesicle. Spermathecae paired, and opening to the exterior dorso-laterally, or unpaired, and opening mid-dorsally. Ectal duct cylindrical and muscular, devoid of glands along its length, with or without small multinucleate glands at ectal orifice. Ampulla, occasionally with a sacciform diverticulum, communicating with the oesophagus. Spermatozoa often aggregated in balls or rings, scattered within the wall of the ampulla.

This diagnosis is modified to include Grania paucispina (Eisen, 1904), redescribed in this section, which has small, multinucleate glands at the ectal pore of the spermatheca.

Records of populations of Grania species from a wide geographic range were used by Erséus and Lasserre (1976) to interpret the taxonomic rank of closely related, allopatric forms. Morphological differences between allopatric populations were in many cases thought sufficient to justify recognition at subspecies level within one of two polytypic species, G. macrochaeta (Pierantoni, 1901) (Table 6) and G. postclitellochaeta (Knollner, 1935). The validity of these decisions is subject to question as a result of subsequent descriptions of populations of new and previously described taxa (Erséus, 1977a) sympatric with the species and as similar to the species as were some allopatric subspecies.

A. Amended description

The following description is modified on the basis of new British Columbia material.

Grania paucispina (Eisen, 1904) Fig.21-24, Table 6

Michaelsona paucispina Eisen, 1904, pp.73-74,
fig. 43.

?Grania paucispina: Erséus and Lasserre, 1976,
pp.127-128.

Type material. Typus amissus. CASF. Explanatory letter for type status is reproduced in Appendix 5.

Material examined. A single preserved specimen, stained in borax carmine, mounted whole in Canada balsam. Collected

March 2, 1978 by H.R. Baker; Victoria Inner Harbour, British Columbia, Canada; $48^{\circ}28.68'N$ at $123^{\circ}22.27'W$. 5 whole specimens collected 21 October, 1978 at 3m depth; Rennison Island, north tip, near Camano Sound.

Description. Small subtidal specimens, long and thin, approximately 8 mm long, with 39-48 segments. Setae proximally broad, slightly curved (Fig. 21). No setae in anterior segments, ventral setae present from IV, laterals from XIII in Victoria specimen, from XVII, XVIII or XIX in Rennison Island specimens. Anterior setae just greater than $1/2$ as long as more posterior, sharply tapered, posteriors long and thick. Gut simple, without diverticula. Pharynx small, heart-shaped. Three pair primary septal glands, two pair secondary glands in V, two large pair secondaries in VI, these together with primary interseptal gland at VI/VII fill VI laterally (Fig. 22). Brain deeply concave or incised posteriorly, posterior two-thirds thick and wide, anterior third narrow and about $1/2$ as thick as posterior. Blood colourless in preserved specimens. Dorsal vessel arises postclitellar in XV, in one specimen at anterior XIV. Nephridia small with very short ectal duct, anteseptale consists of funnel only. Clitellum distinct, including XII to XIII ventrally, but only $1/2$ XII to XIII dorsally. Cells large, more or less regularly distributed in transverse rows.

Seminal vesicle extends posteriorly to anterior of XIV, vas deferens extends also to XIV where it is very tightly coiled, large egg sac may extend to posterior of XV or anterior XIV and contains as many as four large, yolky eggs. Penial bulb of medium size, ratio of body width of XII to bulb diameter is approximately 2.8:1, without a large mass of glandular tissue on dorsal surface (see Erséus, 1977a). Sperm funnel in XI, length of funnel about 3 x width (Fig. 23), free end of funnel bulbous, collar regular equal funnel width. Spermathecae paired, with narrow muscular ectal duct (Fig. 24). With two or three multinucleate 'glands' closely associated in region of ectal pore. Ampulla large, pear-shaped; in this specimen a few, small aggregates of sperm were dispersed within the wall of the ampulla. Ampulla attached to gut near V/VI, probably, with a rather narrow connecting ental canal.

Habitat. California (Eisen, 1904): seashore. Victoria, British Columbia: subtidal, in brackish water.

Distribution. California and British Columbia.

Remarks. Since Eisen (1904) described Michaelsena paucispina from a single specimen collected near Santa Barbara, California no other material, until this study, has been recorded. Erséus and Lasserre (1976) suggested

Grania paucispina

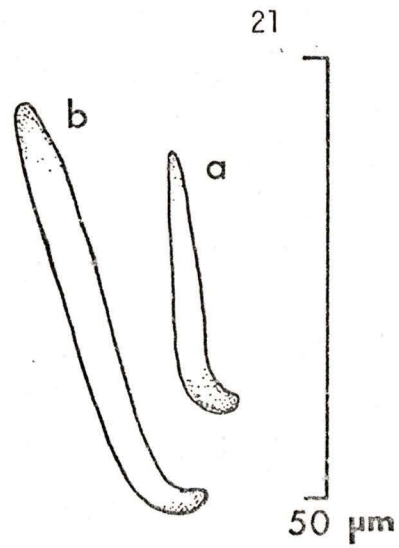
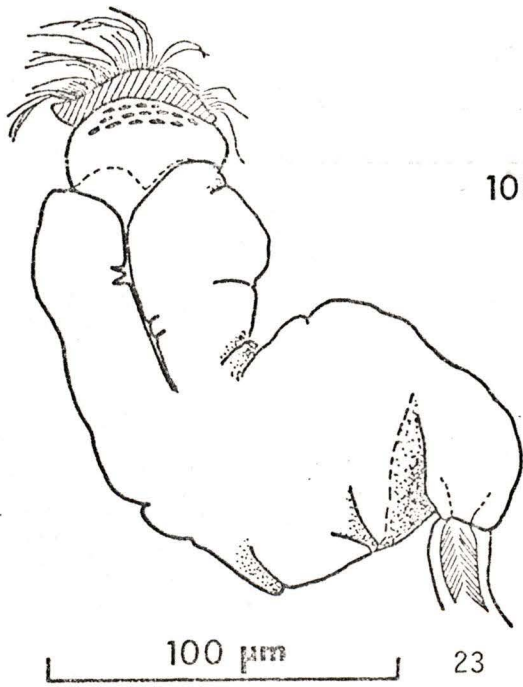
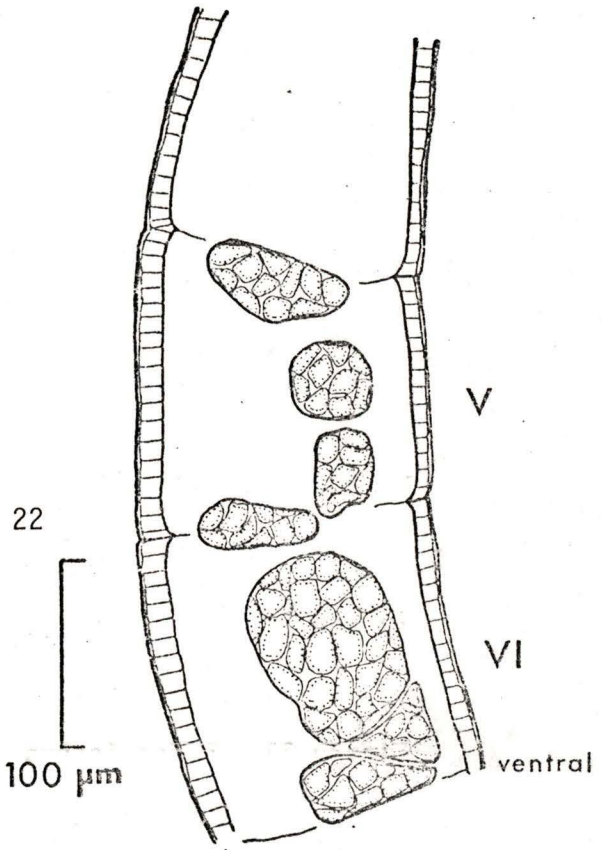
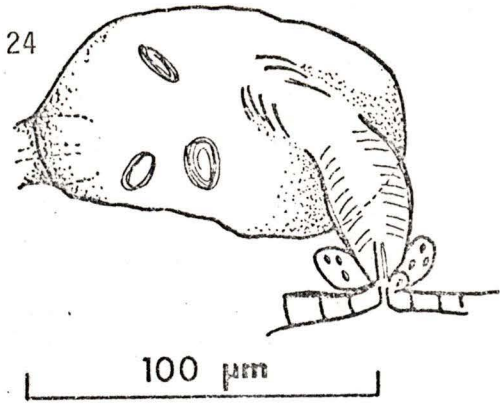
Figure 21. a) Anterior seta, X

b) Posterior seta, XXIX.

Figure 22. Dorso-lateral view of IV-VI
showing septal glands.

Figure 23. Sperm funnel.

Figure 24. Spermatheca.



the obvious generic relocation of Michaelsona paucispina to Grania paucispina but reserved final judgement until some new material could be located, the type material no longer being available.

In all known details the new material conforms to the description of Eisen (1904). There is a small variation between the Victoria specimen and the Rennison specimens in the segment of origin of the lateral setae. Observations of live specimens would yield more information about the 'glands' at the ectal pores of the spermathecae.

There are no other confirmed occurrences in the genus Grania of gland cells at the ectal orifice of the spermatheca. Michaelson (1888) reported such glands in Grania monochaeta; however, when Erséus and Lasserre (1977) redescribed G. monochaeta from specimens collected at South Georgia in 1902 and identified by Dr. W. Michaelson, himself, as "Michaelsona monochaeta (Mich)", they could find no glands.

G. paucispina is distinguished from others of the genus by setal distribution and morphology of the spermathecae (Table 6), which are definitive characteristics according to Erséus and Lasserre (1976). It clearly belongs near a species complex recognized by Erséus and

Lasserre(1976) which includes G. macrochaeta and G. maricola (Table 6), with both dorsal and ventral setae present in postclitellar segments. G. monochaeta (Michaelson, 1888), G. roscoffensis Lasserre, 1967 and G. variochaeta Erséus and Lasserre, 1976, also represented in Table 6, do not possess typical pear-shaped spermathecae and are recognized as distinct species. Because of the spermathecal peculiarity of G. paucispina it is also retained at the specific taxonomic level rather than considered an allopatric subspecies of G. macrochaeta.

B. New Taxa

Following is a description of a new taxonomic entity belonging within Grania.

Grania n. sp. Figures 25-27, Table 6

Material examined. 29 whole specimens, stained with borax-carmines. Collected by the author in Burrard Inlet, Vancouver, British Columbia at 1.9 m and .2 m above chart datum; November 22, 1976 (see Appendix 1).

Description. Long, thin, transparent worms with obviously striated cuticle. Head pore just anterior to O/I. Prostomium conical. Fixed length approximately 8mm, segment number varies

from 37 to 57. Setae proximally broad with a distinct hook, without a well marked heel (Fig. 25). Anterior setae about two-thirds as long as more posterior setae, much less robust. Setae absent from segments I through III. In all but two of thirty specimens, ventral setae commence in IV, (in the two, from V) lateral setae are present from XVII to XIX, XIX is the most common beginning. Posterior to XVII or XIX one setal bundle may be missing, without a pattern. Gut simple without diverticula, pharynx frequently everted in fixed specimens. Three pair of primary septal glands at IV/V to VI/VII, one pair secondary glands in IV, one pair in V and two pair in VI, glands do not extend posterior to VI/VII (Fig. 26). Brain deeply incised along posterior margin, posterior part thick. Nephridia small, anteseptale includes funnel only, postseptale oval, ectal duct distinct, short, wide, terminal or just sub-terminal. Blood colourless in fixed specimens. Dorsal vessel origin varies from XIV/XV to anterior of XVI. Clitellum extends XII to 1/2XIII or XIII, gland cells in approximately regular transverse rows. Sperm funnel very long and thin, length is 13 to 15 x width and 3 or 4 x body width of XII, extends posteriorly from XI to XV or XVI. Collar small and inconspicuous, width about equal funnel width. Seminal vesicle usually extends to XVI or XVII and vas deferens extends as far as posterior of XVIII. Penial

bulb compact, lacking an encapsuling, large glandular mass, ratio of body width XII to bulb diameter about 3.2:1. Vas deferens very narrow at point of entry into bulb. Spermathecae paired. Short, muscular ectal duct devoid of glands, joins ampulla subterminally near ectal end. Ampulla pear-shaped joined to oesophagus. Sperm present as numerous distinct rings or balls in the wall of ampulla, also a small amount scattered in lumen of ampulla near junction of ampulla and ectal duct (Fig. 27).

Habitat. Low intertidal; in shell-mud-sand substrates.

Distribution. Type locality only (see Appendix 1, Burrard Inlet).

Remarks. The population of Grania sampled at Burrard Inlet has not been assigned a final taxonomic location in account of ongoing, relevant research being done by Mr. C. Erséus, in Sweden.

It can be distinguished as a new taxonomic entity in Grania on the basis of the character complex shown in Table 6. Of the characteristics in Table 6, spermathecal and sperm funnel proportions of the new population are of particular taxonomic interest. The large spermathecal ampulla characteristic for the new population is similar in proportion to those of G. maricola Southern, 1913 and

G. ovitheca Erséus, 1977a (Table 6). The sperm funnels of the new population are very long as are those of G. ovitheca, "...exceptionally large, when compared to those of other Grania" (Erséus, 1977a), p. 296). G. maricola also has relatively long sperm funnels (Table 6).

Two main characters provide a basis for classification within Grania: setal distribution and spermathecal shape (Table 6a). Four, possibly five, basic spermathecal shapes or types can be distinguished within the genus Grania. The four are: 1) large ampulla;

2) small pear-shaped ampulla;

3) bipartite ampulla;

4) sacciform, diverticulate ampulla;

and the possible fifth, as represented by G. paucispina, is a medium-size ampulla (egg-shaped) but with glands at the ectal orifice of the muscular ectal duct. The species matrix of these spermatheca types and of different setal distributions is shown in Table 6a. It can be seen that the spermathecal 'type' of the new taxonomic entity found in Burrard Inlet is most similar to that of G. maricola and G. ovitheca.

The setal distribution of the Burrard population is most like some subspecies of the G. macrochaeta complex or G. roscoffensis. However, the characteristically smaller anterior setae, relative to the posterior setae, found in the B.C.

population is not recorded for subspecies of the G. macrochaeta complex.

Additional material from a broad geographic range (including some new material from California) that is presently being examined by Mr. Erséus is very likely to yield additional information re: the taxonomic status of the Burrard population of Grania.

C. Other taxa

No other Grania species or subspecies are known to have been recorded from the North Pacific.

Grania n. sp.

Figure 25. a) Anterior seta

b) Posterior seta.

Figure 26. Lateral view of IV-V, whole
mount, showing septal glands.

Figure 27. Spermatheca.

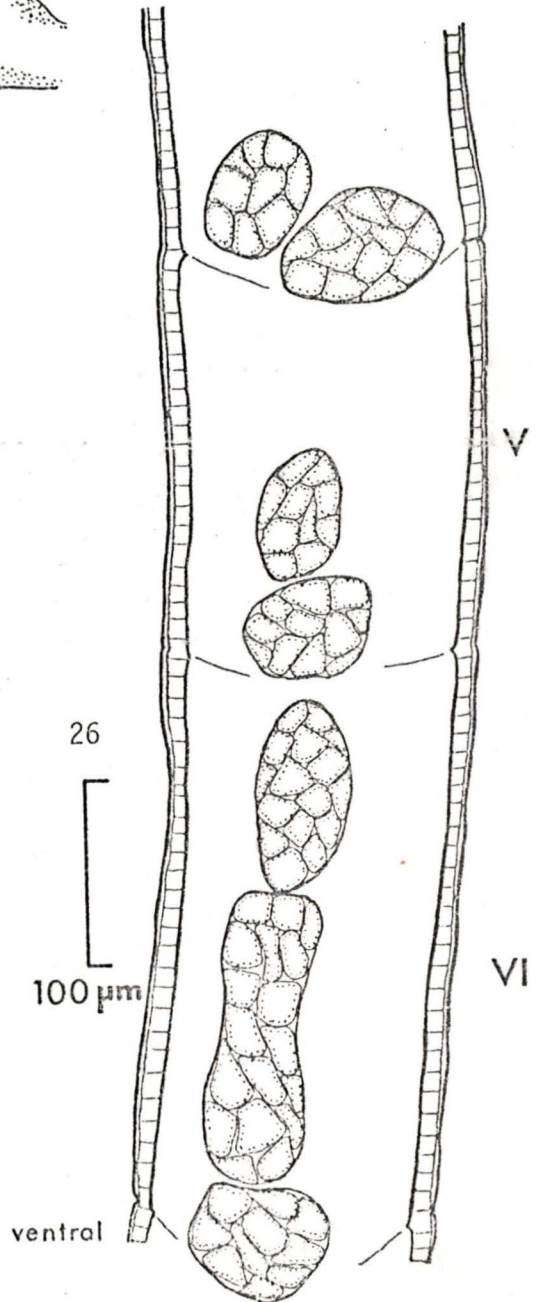
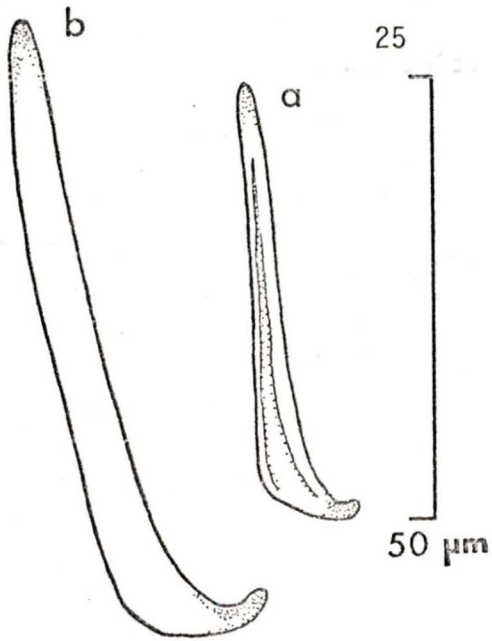
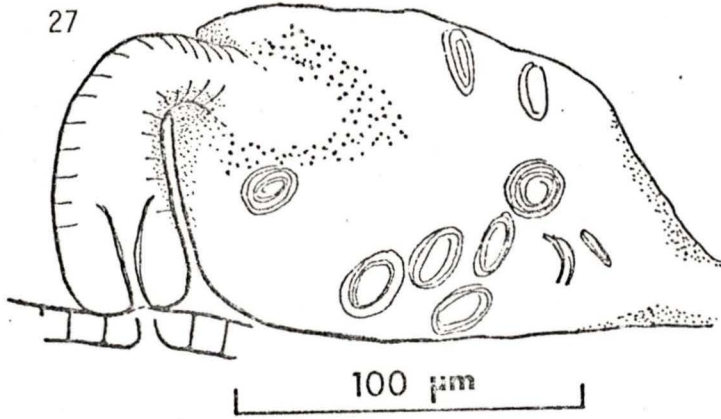


Table 6. Characteristics of some *Grania* species.

Spermathecae and setae drawn from British Columbia material or redrawn from 1. Erséus and Lasserre, 1976; 2. Jamieson, 1977; 3. Erséus, 1977; or 4. Erséus and Lasserre, 1977.

SPECIES

CHARACTER	macrochaeta (Pierantoni)				n. sp.	maricola Southern	ovithecæ Erséus	paucispina (Eisen)	monochaeta (Michaelsen)	roscoffensis Lasserre	variochaeta Erséus and Lasserre
	macrochaeta (Pierantoni)	pusilla Erséus	bermudensis Erséus & Lasserre	trichaeta Jamieson							
length (mm)	9-15	5-9	10	8-11	8	14-19	5-7	8	7-8	5-8	5-7
no. segments	45-60	37-49	57-59	44-56	37-57	54-62	47-55	39-48	49	41-54	39-55
* setal dorsal distrib. ventral	21-26 4-5	20-23 5-7	18-19 4	21-29(3);25-34(4) 5	18-19 4	23-25 6	absent 13-14	13-14,17-19 4	7-8 4-6	18-22 4	40-50 14-22
origin dorsal vessel	about XX	XVII to XVIII	posterior to XVIII	XVII to XIX	XIV/XV to XVI	XV to XXI	XIX to XXV	XIV to XV	XIX to XXII	XIV	XVII to XVIII
seminal vesicle	to XVII	XV-XVI,+	XVI-XVII	to XIV	XVI-XVII	to XIX	XVII-XXI	to XIV	XIV-XVII	to XV	XIV-XV
sperm funnel L:D	'several'	3-5:1	'several'	3:1	13-15:1	8-9:1	8-13:1	3:1	3-4:1	2:1	'several'
ecology	subtidal, 4-13 m, coarse sand, Bay of Naples, Italy	subtidal, 35-500 m, fine or coarse sand, Norway and Sweden, west coasts	subtidal, 8-12 m, coarse coral sand, Castle Island, Bermuda	subtidal, sand flats & shallow lagoons of coral reefs, Heron & Wistari Reefs, Great Barrier Reef, Eastern Australia	lower intertidal, to +1.8 m, sand- silt, Vancouver, B.C.	subtidal, 8-80 m, coarse sedi- ments, Ireland and Norway, west coast.	subtidal, 15-30 m, shell sand with gravel, Koster area, Sweden and Norway.	subtidal, 2 m, lower salinities, Santa Barbara, Ca.; Victoria and Rennison Is., B.C.	intertidal zone, South Georgia, S.W. Atlantic	intertidal zone, coarse sand, Harbour of Roscoff, France and Sweden, west coast	subtidal, 20- 140 m, hetero- genous sand, Norway and Sweden, west coasts
setal shape ventral end											
spermathecae (each scale line equals 50 µm)											

* setae found in segments including and posterior to number noted

Spermathecal Type

	large ampulla	small pear-shaped ampulla	bipartite ampulla	sacciform, diverticulate ampulla	with glands at ectal pore
Setal Distribution	<u>n. sp.</u> 4-5 17-19	<u>macrochaeta</u> (polytypic) 4-7 18-29	<u>roscoffensis</u> 4 18-22	<u>monochaeta</u> 4-6 7-8	<u>paucispina</u> 4 13-19
	<u>maricola</u> 6 23-25		<u>variochaeta</u> 14-22 40-50		
	<u>ovithec</u> 13-14	<u>postclitellochaeta</u> <u>longiducta</u> 13-14	<u>monospermathecus</u> 16-18	<u>postclitellochaeta</u> <u>postclitellochaeta</u> 13-17	

Table 6a. Two-way discrimination matrix of Grania species - spermathecal type x setal distribution.

Lumbricillus Oersted, 1844

Lumbricillus Oersted, 1844, p.68

Pachydrilus (partim) Claparède, 1861, p.75

Enchytraeus (partim) Ratzel, 1869, p.586.

"The name Lumbricillus was first used by Oersted in 1844 but was not given a permanent place in the nomenclature until 1900 [Michaelsen, Das Tierreich 10]. Previous to that time the old name Pachydrilus of Claparède [1861] was in common use, but Michaelsen, finding that the name Lumbricillus antedated Pachydrilus, replaced the latter by Lumbricillus which is now accepted by most workers in Oligochaeta."

Welch, 1914, p.141.

Diagnosis of the genus.

The following diagnosis by Nielsen and Christensen is the most complete as well as the most recent.

Type species. Lumbricillus lineatus (Müller, 1774).

"Setae sigmoid in most species but almost straight in some, without nodulus; the number of setae per bundle shows wide interspecific variation. Head pore at O/I. Dorsal pores absent. Brain usually incised posteriorly. Peptonephridia and oesophageal appendages absent. Gradual transition between oesophagus and intestine. Three pairs of primary septal glands; secondary glands absent. Dorsal vessel originating in or behind the clitellar region.

Blood usually coloured. Interstitial tissue of the nephridia well developed; anteseptale consisting of funnel only; efferent duct terminal, subterminal or postero-ventral. Testes large, lobed, enclosed in large seminal vesicles. Sperm duct long and narrow. Penial bulb present. Atrial glands absent. Copulatory glands often present. The spermathecae simple, attached to the oesophagus, usually with prominent glands at the ectal aperture and sometimes also along the ectal duct. Small to large species, the majority, littoral forms but some also occurring in limnic or terrestrial environments" (Nielsen and Christensen, 1959, p.96).

A. Amended Descriptions

The following descriptions of known taxa are modified when necessary on the basis of the British Columbia material.

Lumbricillus lineatus (O.F. Müller, 1774)

Fig.28-30, Plate 2, Table 7.

Lumbricus lineatus Müller, 1774, pp.29-30.

Lumbricillus lineatus: Welch, 1919, p.15-17.

Pachydriilus lineatus: Knöllner, 1935,
pp.435-436.

P. lineatus: von Bulow, 1955, pp.254-255, pl.41,
f.3-4.

Lumbricillus lineatus: von Bulow, 1957, pp.79-80.

Lumbricillus lineatus: Nielsen and Christensen,
1959, pp.100-102, f.109-112.

- ?Pachydrilus lineatus: Dahl, 1960, p.13.
- Lumbricillus lineatus: Nurminen, 1965c,
p.16-17.
- L. lineatus: Nurminen, 1965b, p.14.
- L. lineatus: Lasserre, 1966, p.299.
- L. lineatus: Nurminen, 1967, p.586.
- L. lineatus: Nurminen, 1970a, p.206.
- L. lineatus: Lasserre, 1971a, p.448.
- L. lineatus: Tynen, 1972, p.21-29.
- L. lineatus: Nurminen, 1973c, p.480
- L. lineatus: McGrath, 1975, p.216.
- L. lineatus: Erséus, 1976a, p.4.
- Pachydrilus verrucosus Ude, 1896, pp.3-6, f.6
- Lumbricillus verrucosus: Michaelsen, 1914,
pp.163-164, f.8.
- Pachydrilus claparedeanus Ditlevsen, 1904,
pp.431-433, f.28.
- Lumbricillus agilis Moore, 1905, pp.395-397.

Owing to shortcomings in descriptions, other records of Lumbricillus lineatus or one of its synonyms made prior to the revision of Nielsen and Christensen (1959) cannot be included with any certainty as records of what is now recognized to be L. lineatus. Lumbricillus agilis Moore was recognized as a synonym for L. lineatus by Welch (1917) and Lasserre (1971a) restated this synonymy subsequent to

the redescription of L. lineatus by Nielsen and Christensen (1959).

Type material. Typus amissus.

Type locality. Denmark, Baltic Sea, shoreline.

Material examined. More than 100 specimens from Port Alice Ocean Falls, and Prince Rupert, (Appendix 1), living and fixed.

Description. Medium sized, littoral specimens, approximately 10 to 15 mm; 40 to 49 segments, average about 45. Live specimens range from light red to deep red. Setae sigmoid, without nodulus (Plate 2 a); bundles fan-shaped, most ventral setae of ventral bundles and most dorsal of dorsal bundles are shortest. Distribution:

	preclitellar lateral: 3-7,
	" ventral: 3-8,
	postclitellar lateral: 2-5, and
	" ventral: 2-6.

Brain incised posteriorly, lateral margins converge anteriorly, brain length approximately equal width (Fig. 28). Three pair septal glands present, first two (IV/V and V/VI) with small ventral lobes, third with large ventral lobes, all pairs united dorsally, third only narrowly. Yellow-gold, nucleate chloragocytes present from VI, chloragogen layer more dense in postclitellar region (Plate

2b). Lymphocytes not abundant, spindle or elongate elliptical to pear shaped. Dorsal blood vessel arises XIII/XIV to XIV/XV; blood in specimens from most habitats deeply coloured, although varied from deep red to rose-pink. Nephridia small, anteseptale small equals funnel only, postseptale somewhat pear shaped, efferent duct terminal to postero-ventral (Fig. 29). Clitellum extends XII to XIII, cells deep and dense, irregularly distributed. Seminal vesicle and testes large, with 8 or 9 regular lobes extending to IX. Sperm funnel cylindrical, narrowing slightly to vas deferens, length funnel approximately 2.5 - 5 x funnel width (Plate 2c), length approximately equal body width of XI. Sperm collar equal or just greater than funnel width, in very mature worms slightly convoluted (Plate 2d). Vas deferens long, narrow, thin walled, tightly coiled in XII. Penial bulb average size, protrudes slightly. Small ventral bodies occasionally present on ventral nerve cord in XIV and rarely XV. Spermathecae large and simple (Fig. 30 and Plate 2b). Ental and ectal ducts distinct, no distinct ampullar cavity in mature worms. Ampullar area of spermatheca divided by a slight constriction into an ectal and ental portion, length of ectal about twice length of ental part. Most of spermatozoa embedded in ampullar wall of ental portion. Ectal pore and short ectal duct surrounded by a rosette of entally divided glands.

Habitat. Salt marshes; upper littoral zone; driftline

Lumbricillus lineatus

Figure 28. Brain.

Figure 29. Anterior nephridium, VII/IX.

Figure 30. Spermatheca.

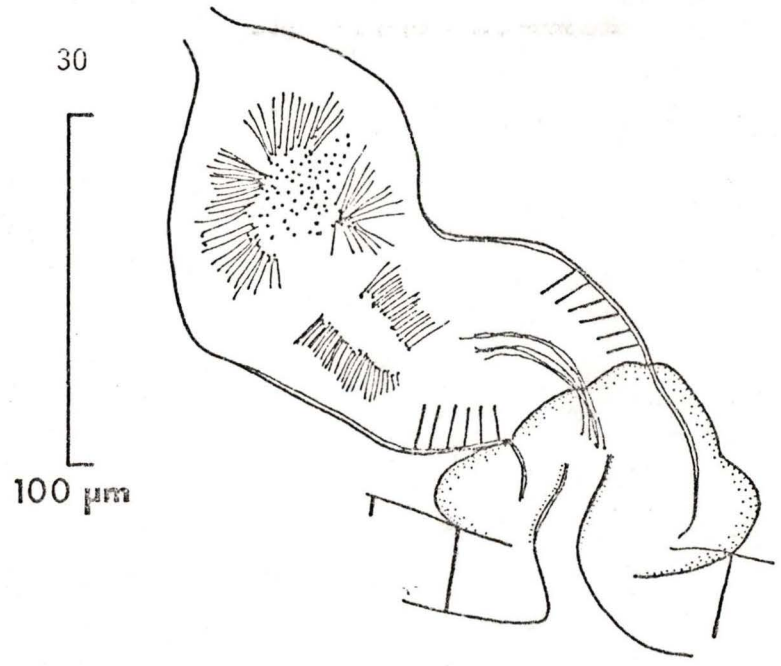
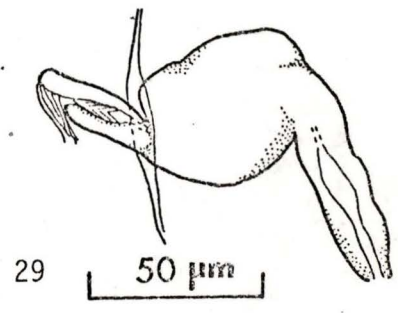
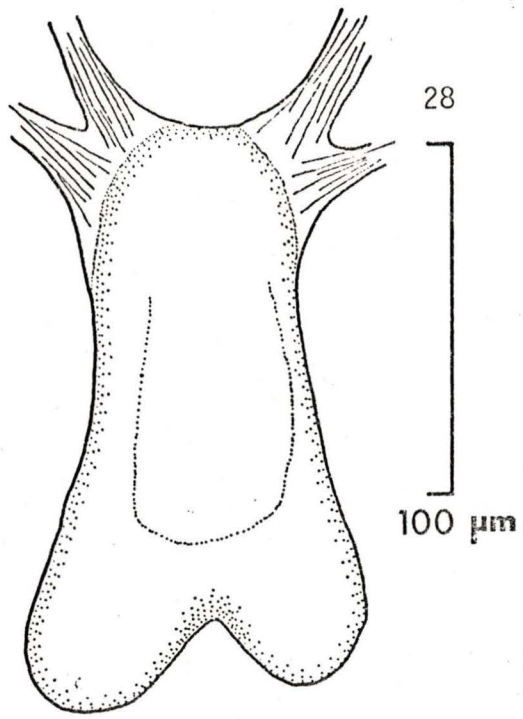


Plate 2. Lumbricillus lineatus (Müller), light microscope photographs of living specimens.

- a) anterior-ventral setal bundles;
- b) V-1/2VI, spermathecae \leftrightarrow and denser chloragocytes beginning in VI \rightarrow ;
- c) XI-XII, dorsal, sperm funnel;
- d) XI-XII, dorso-lateral, showing slightly convoluted sperm funnel collar \rightarrow .



seaweed deposits; sand, gravel, in mud under rocks; near an onshore sewer effluent.

New Records. Very black sediments (reduced), wood fibre and wood chips mixed with sand and silt; under rocks in estuarine areas near pulp mill (Prince Rupert and Port Alice) effluents; low to high intertidal.

Distribution. Europe: widely distributed. Hebrides. Tierra del Fuego. Greenland. U.S.S.R.(? widely distributed). North America: Atlantic: Maine (Casco Bay) to Massachusetts (Vineyard Sound); Woods Hole. Arctic: Barnard Harbour, N.W.T.

New Records. Northern Vancouver Island and northern mainland coast of British Columbia.

Remarks. Only since 1959 (Nielsen and Christensen, 1959) has Lumbricillus lineatus been clearly distinguished from L. rivalis Levinson, 1883 augm. Ditlevsen, 1904. The most consistent and repeated differences in descriptions of L. lineatus and L. rivalis according to synonymies proposed by Nielsen and Christensen (1959) are in:

size:

L. rivalis usually greater than 12 mm, 49+ segments,

L. lineatus usually 10 to 15 mm, 40 to 50 segments;

setal distribution:

L. rivalis with 5-12 (avg. 8 or 9) setae in an anterior ventral bundle,

L. lineatus with 3-8 (avg. 5 or 6) setae in an anterior ventral bundle;

sperm funnel L:D:

L. rivalis, 8 or 9:1 ranging 4 to 10:1,

L. lineatus, 4 or 5:1, ranging 2 to 5:1; and

sperm funnel collar:

L. rivalis frequently described with a very wide or convoluted collar,

L. lineatus, collar "regular" (Table 7).

In the various descriptions of the spermathecae there does not seem to be any consistently recorded difference between the two species. It is sometimes (Stephenson, 1911) remarked that the rosette around the ectal pore of L. rivalis spermatheca is deeply and distinctly lobed and that the ectal duct and spindle shaped ampulla are not easily distinguished.

Another reasonably consistent difference between the two species, as variously described, was in the recorded habitat (Table 7). L. lineatus was most frequently found on organically enriched brackish or marine shorelines, whereas L. rivalis was found not only there but also in wet terrestrial habitats including percolating sewage filter beds (Reynoldson, 1948).

Two species included in Table 7, L. imakus Nurminen (1970a) and L. rutilus Welch, 1914 are very like L. rivalis. Examination of type material of L. rutilus

Table 7. Characteristics of *Lumbricillus lineatus* (Müller) and *L. rivalis* Levinsen augm. Ditlevsen as synonymized, respectively, by Nielsen and Christensen; and characteristics of some similar *Lumbricillus* species.

Spermathecae either redrawn from 1. Nurminen, 1964;
2. Shurova, 1974; 3. Nielsen and Christensen, 1959;
4. Southern, 1909; 5. von Bulow, 1957; 6. Nurminen, 1970a;
or drawn from recent British Columbia material.

(Table 7. continued on following page.)

SPECIES

CHARACTER	<u>lineatus</u> (Møller, 1774) aff. Nielsen and Christensen				Moore, 1905 (<u>agilis</u>)	B.C. specimens	<u>fennicus</u>	<u>alaricus</u>	<u>rupertensis</u>
	Nielsen and Christensen 1959	Ude, 1896 (<u>verrucosus</u>)	Michaelsen, 1900 (<u>verrucosus</u>)	Ditlevsen, 1904 (<u>claparedeanus</u>)			Nurminen, 1964	Shurova, 1974	n. sp.
no. segments	38-42	45-50			30-48	40-49	30-32	31	33-41
setal shape	sigmoid	sigmoid			sigmoid	sigmoid	slight sigmoid	sigmoid	sigmoid
setal lateral distribution	4-6:4-7	3-5	3:1-3	4-6	5:3-4	2-7:2-5	3-5:3	3-5:3-4	3-5:2-5
ventral	6-8:5-8		4-5:1-3	5-9	5-8:4-6	3-8:2-6	4-7:4	4-5:3-5	4-6:3-6
ventral bodies		XIV-XV	present	present		XIII-XIV	? absent	? absent	XIII-XV
sperm funnel L:D	~5:1	4-5:1	4-5:1	3-4:1	6-8:1	2.5-5:1	1-1.5:1 (lobed)	1.4:1	1.5:1
sperm collar	regular; =funnel					regular; =funnel	regular	regular; =funnel	regular; =funnel
ecology	decomposed seaweed on shore; no acceptable inland records		intertidal; under seaweed		intertidal; high water mark, in eel grass	intertidal; brackish, organically enriched, -not natural- locales only, B.C.	intertidal; decaying wrack and algal litter	lower intertidal; rubble, pebble;	intertidal; silty sediments and wood waste products
spermatheca									
ectal canal	distinct			not distinct	not distinct	distinct	very short, distinct	not distinct	not distinct
ental canal	distinct	distinct		not distinct	not distinct	distinct	very short, distinct	not distinct	not distinct
ampullar cavity	not distinct			? distinct	not distinct	not distinct	not distinct	not distinct	not distinct

(each scale line equals 50 µm)

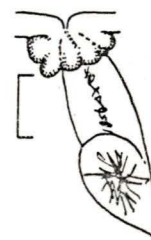
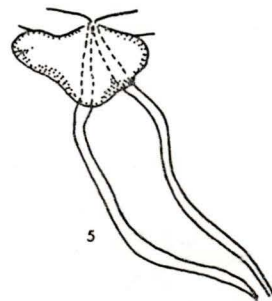
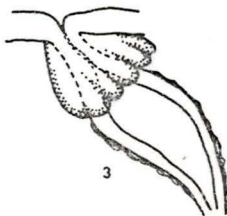


Table 7. (continued)

SPECIES

CHARACTER	<i>rivalis</i> Levinsen augm. Ditlevsen (synonymies after Nielsen and Christensen, 1959)					<i>imakus</i> Nurminen, 1970	<i>rutilus</i> Welch, 1914	
	Levinsen, 1883 augm. Ditlevsen, 1904	Nielsen and Christensen 1959	Southern, 1909 (subterraneus)	Southern, 1909 (evansi)	Stephenson, 1911 (subterraneus)	v. Bulow, 1957 (enteromorphae)		
no. segments		54-56			49-57	36-44	43-50	41-49
setal shape		sigmoid			sigmoid	sigmoid	sigmoid	sigmoid
setal lateral distribution	6-8	6-9:5-8	5:7	6-9	4-8:3-7	4-6:3-6	3-5:2-4	6-7:2-4
ventral	8-11	7-12:5-10			5-11:3-8	6-8:3-6	4-8:4-6	5-10:2-4
ventral bodies	XII-XV		XIII-XIV	XIII - XIV	XIII - XIV		? absent	XIII-XIV
sperm funnel L:D		~10:1		6-10:1	~9:1	~8:1	5-6:1	4-5:1
sperm collar		wide; convoluted		wide; convoluted	?	wide; convoluted	wide; convoluted	wide; convoluted
ecology		highly decayed seaweed, on shore; sewage beds, compost heaps, inland	well; town, water pipes; sewage works; contaminated stream	intertidal	seashore, above high-water mark	intertidal; associated with driftline seaweeds and <i>Enteromorpha</i>	intertidal; driftline seaweed and adjacent to a sewer effluent	sprinkling filter; Chicago sewage testing station
spermatheca								
ectal canal		not distinct	not distinct	not distinct	not distinct	not distinct	? very short, distinct	not distinct
ental canal		not distinct	not distinct	not distinct	not distinct	? not distinct	? not distinct	?
ampullar cavity		distinct		distinct	distinct	distinct	distinct	distinct



available from USNM would most likely necessitate the designation of this species as a synonym of L. rivalis which it is already known to resemble in size, setal distribution, sperm collar morphology and habitat (Table 7).

L. fennicus Nurminen, 1964, L. alaricus Shurova, 1974 and L. rupertensis n. sp. are more similar to L. lineatus (Table 7) but are distinctive with regards to their very short sperm funnels.

Note: some avesciculate specimens (Nielsen and Christensen, 1959, p.101, f.111-112) of L. lineatus were found in samples from very near the pulp mill effluent at Port Alice.

Lumbricillus tuba Stephenson, 1911 Fig.31-35,
Plate 3a-c, Table 8.

Lumbricillus tuba Stephenson, 1911, pp.42-46,
f.5, plate f.6-8.

Pachydrilus (Pachydrilus) tuba: Cernosvitov,
1937a, p.293.

P. (P.) tuba: Cernosvitov, 1946, unpublished
manu..

Lumbricillus tuba: Nielsen and Christensen,
1959, p.105, f.131.

L. tuba: Nurminen, 1965c, p.16.

L. tuba: Nurminen, 1967, p.586.

L. tuba: Nurminen, 1970a, p.206.

dense layer from VI or VII, cells not tall or highly coloured. Lymphocytes (Fig. 31) nucleate, granular, elliptical, length approximately $1/3$ or $2/3$ seta length, some attached by narrow extensions to the body wall. Dorsal vessel arises in XIV or XV (more often XIV), blood light red, yellowish in fixed specimens. Nephridia small, present in only few segments (Fig.33), postseptale elongate, ectal duct terminal, shorter than postseptale, with wide canal; anteseptale small, narrow. Clitellum extends over XII to $1/2$ XIII or to XIII, not complete ventrally, gland cells are deep, dense and irregularly distributed. Seminal vesicle in XI and X, a few regular lobes on each side of gut. Sperm funnel short and wide (occasionally bean shaped), length about 2 x width, collar regular approximately $1/2$ width of the funnel, extends lower down one side of funnel (Fig.34). Vas deferens long, narrow, tightly coiled in XII (Plate 3b). Penial bulb large, oblong, with an obvious muscular covering, occasionally partially everted in fixed specimens. Frequently with small ventral bodies in XIV and XV. Spermatheca simple, without diverticula (Fig.35 and Plate 3c) with distinct ental and ectal canals; ectal duct thick walled, aglandular, narrowing gradually from ampulla to ectal pore. Pore surrounded by a large compact rosette of glands, with, usually, one deep posterior incision. Ampulla large, oval or slightly angular, ectal canal invaginates slightly into the cavity of the ampulla. Ampullar walls

thin in equatorial region, much thicker in part adjacent to the oesophagus. Spermatozoa arranged in a ring perpendicular to the long axis of the spermatheca in equatorial "trough" created by invagination of ectal canal.

Habitat. Intertidal; salt marsh; along shoreline sewer effluent; sand, gravel, shingle; decaying drift algae.

New records. Estuarine; lower to upper mid-intertidal; in gravel, sand; with living Fucus sp. and/or emergent vegetation.

Distribution. Denmark: Kalo and Ebeltoft Vig; Oresund. Scotland. Finland. Greenland. N. Wales: Menai Strait area of Anglesey and Caernarvonshire.

New records. Northern Vancouver Island: Tsitika River estuary and Neroutsos Inlet shoreline. Mainland coast of British Columbia: Cousins Inlet near Port Alice and Porpoise Harbour near Prince Rupert.

Remarks. The segment number of the British Columbia specimens is more variable and on average higher than that indicated either by Stephenson (1911) or by Nielsen and Christensen (1959) for their respective specimens of L. tuba (Table 8). The presence and extent of ventral glands is variable in this taxon; none mentioned by Nielsen and Christensen (1959), small, in segments XIII to XVI recorded by Stephenson (1911), and in the B.C. specimens small, in

Lumbricillus tuba

Figure 31. a) Anterior lateral seta, IX

b) Lymphocytes.

Figure 32. Brain and body wall of O/I-II.

Figure 33. Posterior nephridium.

Figure 34. Sperm funnel.

Figure 35. Spermatheca.

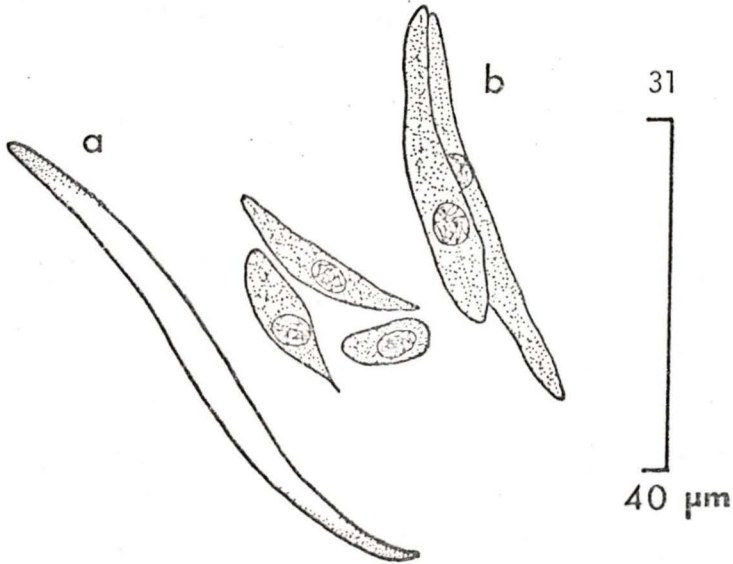
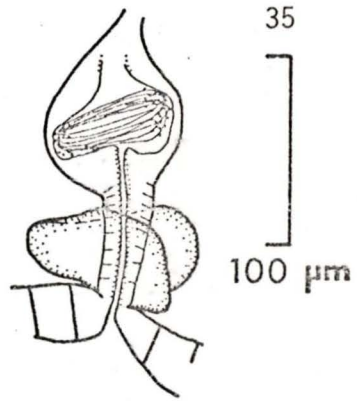
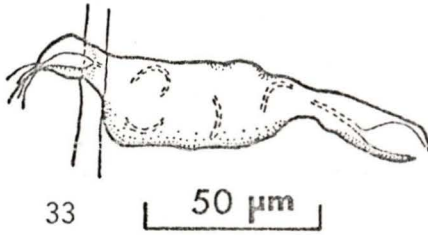
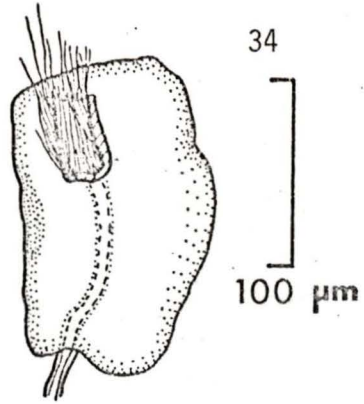
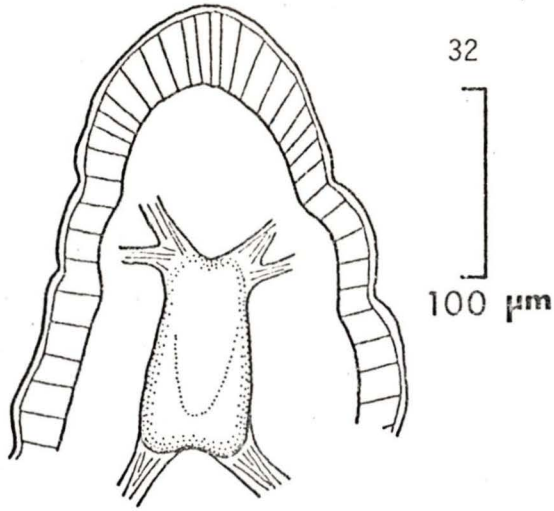
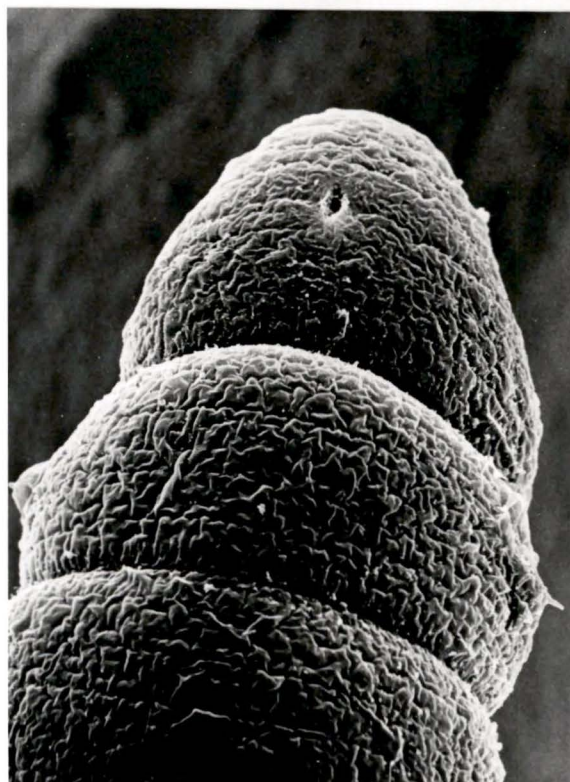
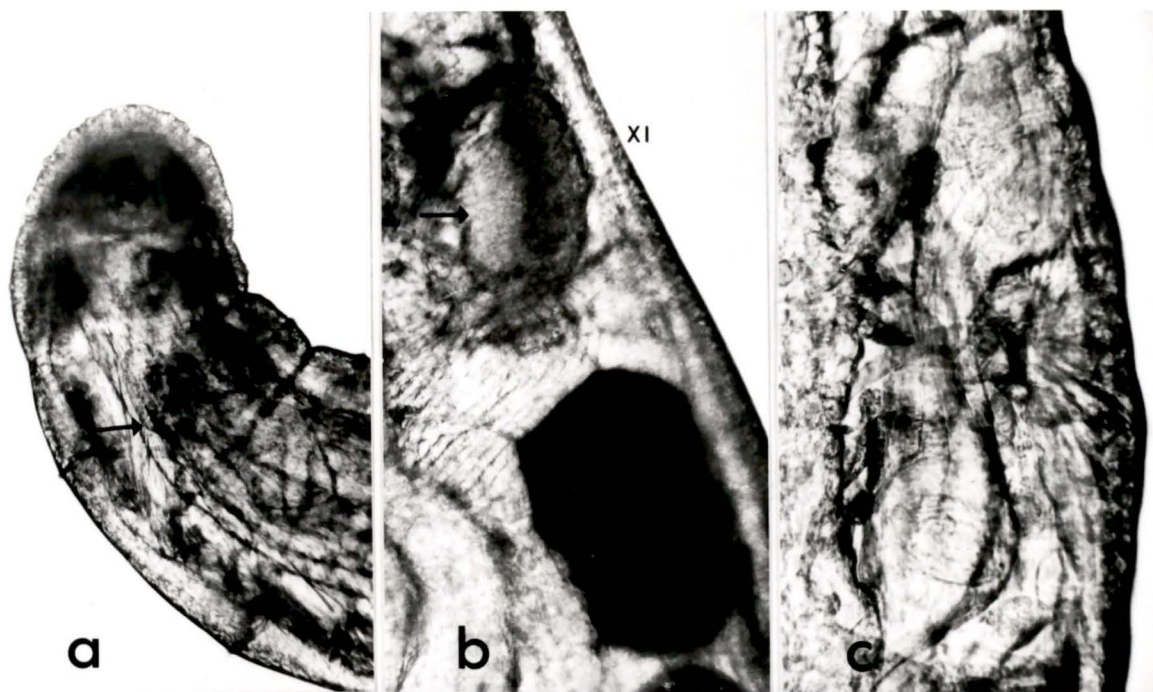


Plate 3. Lumbricillus tuba Stephenson, a-c, light microscope photographs of living specimens.

- a) 0/I-III, dorsal showing papillated prostomium and posterior margin of the brain →;
- b) 1/2XI-1/2XII, dorsal, showing sperm funnel, coil of vas deferens and an → egg in XII;
- c) V, dorsal, spermatheca.

Lumbricillus annulatus Eisen, d-e, S.E.M. photomicrographs.

- d) 0/I-ant.III, showing large head pore and texture of cuticle (x250);
- e) anterior setal bundle, note worn tips (x1530).



segments XIV and XV.

The very characteristic form of the spermathecae (Fig.35) in addition to all other similarities confirm that the B.C. specimens belong in the taxon L. tuba.

L. tuba differs most significantly from other Lumbricillus species described from this coast in that it has a long, distinct ectal duct not covered over its entire length by glandular cells. L.kamtschatkanus (Michaelson, 1929), without figures, is apparently very similar to L. tuba (Table 8); however, the spermathecal morphology of L. kamtschatkanus is not indicated to be of the same distinctive form as L. tuba. With regards to L.kamtschatkanus Michaelson (1929) wrote:

"Samentaschen: Ampulle

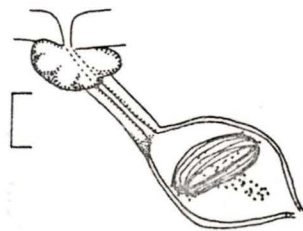
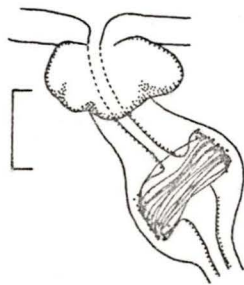
dick-zwiebelformig...Ausfuhrung scharf von der Ampulle abgesetzt, fast doppelt so lang, wenig mehr als halb so dick..." (p.317).

And the dimensions of the sperm funnel of L.kamtschatkanus are different than those for L. tuba. Shurova (1977), in collections from islands in the Kurilsk Sea, did not find any Lumbricillus species with a resemblance to either L. tuba or L.kamtschatkanus; all the species she recorded had dense glandular coats along the length of the spermathecal ental ducts. Nurminen (1973c), in the respect of the spermatheca, found L.kamtschatkanus rather near L. cf. helgolandicus (Michaelson, 1927) aff. Nielsen and

Table 8. Characteristics of some Lumbricillus species, with aglandular spermathecal ectal ducts, known from the North Pacific.

CHARACTER	SPECIES					
	tuba		cf. helgolandicus			kamschatkanus
	Stephenson, 1911	Nielsen and Christensen, 1959	B.C. specimens 1978	Nielsen and Christensen, 1959	B.C. specimens 1978	(Michaelsen) 1929
no. segments	35-39	33-41	36-53	42-48	30-34	40-45
setal shape	slightly sigmoid	slightly sigmoid	slightly sigmoid	sigmoid	sigmoid	sigmoid
setal distrib.	lateral 3-5:3-5 ventral 4-6:4-6	lateral 2-4:2-4 ventral 3-5:2-4	lateral 3-4:2-4 ventral 2-6:2-5	lateral 3-6:3-5 ventral 5-7:4-6	lateral 2-4:2-5 ventral 3-6:1-6	lateral 3-4:2-3 ventral 5-6:2-3
origin dorsal vessel	XIII-XV	XIV	XIV-XV	XIV	XII or XIII	XII
ventral bodies	XIII-XVI	?	small XIV-XV	?	none observed	small XIV
sperm funnel L:D	1.5-2.5:1	1.5:1	~2:1	2-3:1	2-3:1	2-3:1
sperm collar	?	regular; = 1/2 funnel	regular; = 1/2 funnel	regular; < funnel	regular; ≤ funnel	?
ecology	high water mark	intertidal	intertidal; estuarine	intertidal	intertidal; fine silty sediments; brackish	2-5 m dredge
	Scotland	Denmark; N. Wales; Scotland	British Columbia	Denmark; Germany; N. Wales	British Columbia	Kurilisk Sea, USSR (? in Cernos unpub. manu. Lake Kurilisk)

spermathecae
(each scale line
equals 50 μm)



"Ampulle dick-
zwiebelfrömig,
mit dem Darm
kommunizierend.
Ausführgang
scharf von der
Ampulle abgesetzt,
fast doppelt so
lang, wenig mehr
als halb so dick,
im Allgemeinen
nackt, nur vorn
am ektalen Ende
mit kleinen
mehrzelligen
Drüsen besetzt."

Michaelsen, 1929
p. 317

Christensen, 1959 (Table 8).

Lumbricillus pagenstecheri (Ratzel, 1869)

Fig. 36-40, Table 9.

Enchytraeus pagenstecheri Ratzel, 1869, p.587,
table 42 f.13, 20b&21.

Pachydrilus pagenstecheri: Vejdovsky, 1877,
p.298.

Lumbricillus pagenstecheri: Ude, 1901, p.9,
table I f.14.

L. pagenstecheri: Ude, 1901, p.17.

Pachydrilus pagenstecheri: Ditlevsen, 1904,
pp.433-434, f.29, pl.XVIII f.6.

Lumbricillus pagenstecheri: Southern, 1909,
p.153.

L. pagenstecheri: Stephenson, 1926, pp.1315-1316.

Pachydrilus pagenstecheri: Knöllner, 1935, p.436.

P. (Pachydrilus) pagenstecheri: Cernosvitov,
1937a, p.292.

Lumbricillus (P.) pagenstecheri: von Bulow,
1957, pp.77-78, table 25 f.1-7.

L. pagenstecheri: Nielsen and Christensen, 1959,
pp.104-105, f.117-120.

L. pagenstecheri: Christensen, 1962, p.7.

L. pagenstecheri: Nurminen, 1965a, pp.5-6.

L. pagenstecheri: Nurminen, 1967, p.586.

Lumbricillus pagenstecheri: Tynen, 1972,
pp. 23, 24&26.

L. pagenstecheri: Erséus, 1976a, pp. 5-6,
table 1.

Lumbricullus nervosus err. non Eisen sensu
Michaelson, 1900, p. 81.

Lumbricillus henkingi Ude, 1901, pp. 9-10, Table
II, f.15-18.

L. henkingi: Stephenson, 1926, p. 1315.

Lumbricillus ritteri Eisen (in part), 1904,
pp. 84-86, f. 53-54, pl. XIII, f. 5-9.

Pachydrilus (Pachydrilus) ritteri (in part):
Cernosvitov, 1937a, p. 202.

Lumbricillus ritteri (in part): Nielsen and
Christensen, 1959, p. 97.

L. ritteri (in part): Erséus, 1976a, pp. 5-6,
f. 12.

?Lumbricillus aegialites Stephenson, 1922a,
pp. 1126-1130, f.2-3.

L. aegialites: Stephenson, 1924, p. 211.

L. aegialites: Stephenson, 1926, pp. 1302-1303, 1314.

Pachydrilus (Pachydrilus) aegialites:
Cernosvitov, 1937a, p. 292.

Lumbricillus georgiensis Tynen, 1969a,
pp. 390-391, f. 1-3.

?Lumbricillus kalatdlitus Nurminen,
1970a, pp. 206-208, f.14-16,17b.

Lumbricillus necrophagus Stephenson was synonymized with L. aegialites Stephenson by Stephenson (1926). Nurminen (1965a) subsequently synonymized L. aegialites with L. pagenstecheri. Erséus (1976a) in considering L. pagenstecheri as synonymized by both Nielsen and Christensen(1959) and Nurminen (1965a) suggested that L. ritteri Eisen and L. kalatdlitus Nurminen were also possible synonyms, but reserved final judgement subject to examination of any available type material.

L. georgiensis is synonymized with L. pagenstecheri based on the examination of type material held at NMNS. Collections made on two different occasions at the possible type localities of L. georgiensis (Miracle Beach or Qualicum Beach, Appendix 1) yielded no specimens distinguishable as L. georgiensis.

The syntypes of L. georgiensis, NMNS 3405, a whole specimen preserved in alcohol and 1900-2865, cross sectioned specimens, are not distinguishable from L. pagenstecheri as described and synonymized by Nielsen and Christensen (1959) (Table 9). According to Tynen (1969a) the most unusual and apparently the distinguishing characteristic for L. georgiensis was the presence of 'sperm bags' in the spermathecae. No 'sperm bags' were observed in the spermathecae of syntype 3405 although an irregular clump of spermatozoa was present. Similarly, membrane boundaries around spermatozoa in the spermathecal ampullae of the sectioned syntype material were not found. Syntype 3405 was a good, mature specimen with five developing eggs and a well-developed clitellum so that immaturity is not an acceptable explanation for the absence of 'sperm bags'.

In size, setal distribution, sperm funnel morphology, extent of clitellum, blood colour, colour of chloragogen inclusions, origin of nephridial efferent duct and, most significantly, detailed spermathecal morphology L. georgiensis is indistinguishable from L. pagenstecheri (Table 9).

USNM syntype series 21107 contained three specimens of Lumbricillus annulatus Eisen and one specimen

that had a very strong morphological resemblance to L. pagenstecheri (Ratzel, 1869). This single specimen was not, however, completely mature and the spermathecae were difficult to observe in detail without damaging the specimen so that the possibility of it belonging in L. mirabilis Tynen, 1969 was considered.

Characteristics described by Eisen combined with the new observations, some of which are shown in Table 9, were the basis for concluding that L. ritteri Eisen (in part) belonged in L. pagenstecheri.

The single Eisen specimen observed for this study has long, subterminal nephridial efferent ducts and the posterior septal glands were massive with lobed margins, like L. pagenstecheri. The sperm funnel collar as figured by Eisen (1904) and as observed in the type material of L. ritteri is like L. pagenstecheri and the spermathecal morphology as illustrated by Eisen (1904, pl. XIII f. 5&6) is the same as that of L. pagenstecheri.

Type material. No types

Type locality. Not stated.

Material examined. Fixed specimens from Port Alice, Ocean Falls and Kitimat; in total about 75 mature specimens; see Appendix 1 for details of sample locations at which the species was collected. Also L. georgiensis syntypes from NMNS, 3405 whole specimen and 1900--2865 cross-sectioned specimens and L. ritteri syntypes, one whole specimen from USNM 21107.

Description. Medium size, robust species, 10 to 12 mm; segment number very variable, Port Alice population with 38, 45 to 48, Kitimat specimens 38, 42 and Ocean Falls population with 38 to 43, 50 to 55, 63. Cutaneous glands large, in 8 (usually) transverse rows per segment. Setae robust, straight or slightly sigmoid (Fig. 36), within a bundle more or less equal.

Distribution: preclitellar lateral: 2-5 (rarely 6),

" ventral: 3-6,

postclitellar lateral: 2-5(2-4 or 3-5), and

" ventral: 2-5.

Bundles fan-shaped. Brain small relative to body size

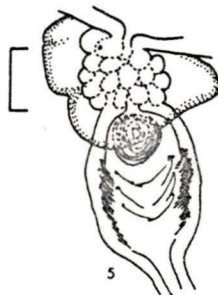
Table 9. Characteristics of some *Lumbricillus* species with morphological similarities to, and including, *L. pagenstecheri* (Ratzel).

Spermathecae redrawn from 1. Erséus, 1976a; 2. Tynen, 1969a; 3. Eisen, 1904; 4. Nurminen, 1970a; or 5. drawn from *Lumbricillus mirabilis* Tynen, 1969 syntype 3407 (NMNS).

SPECIES

CHARACTER	<i>psagenstecheri</i> (Ratzel)						<i>mirabilis</i> Tynen		
	Ude, 1901 (<i>henkingi</i>)	Stephenson, 1922 (<i>sejalites</i>)	Nielsen and Christensen 1958	Tynen, 1969 (<i>georgensis</i>)	Eisen, 1904 (<i>ritteri</i>)	B.C. specimens 1978	<i>kalatditus</i> Nurminen, 1970	Tynen, 1969	B.C. specimens 1978
no. segments	60	51-53	41-47	49-58	62	38-63	43-60	38-46	36-49
setal shape	sigmoid	straight or slight. sig.	straight or slight. sig.	slightly sigmoid	slightly sig.	straight or slight. sig.	almost straight	straight	straight or slight. sig.
setal lateral distrib. ventral	3-5 4-7	3:3 3-5:3	4-6:3-5 5-7:4-6	2-5:2-5 2-7:2-6	3-6:3-5 4-6:2-4	2-6:2-5 3-6:2-5	3-4:3-7 2-4:2-4	2-4:2-4 3-7:3-5	3-6:1-5 3-8:2-5
origin dorsal vessel	XIII	XIV	XII-XIV	XIV-XV	XIV/XV	XIII-XV	XIII/XIV- XIV/XV	XIII-XV	XII-XIV
ventral glands	XIII-XIV	XIV-XV	?	XV-XIX	XIV-XV	XIV-XV	?	XIV-XV	XIV-XV
sperm funnel L:D	~2:1	2-3:1	3-4:1	2-3:1	3-4:1	2-3:1	5:1	2:1	1.5-3.5:1
sperm collar	?	?	regular; = funnel	regular; = funnel	regular; = funnel	regular; = funnel	regular; = funnel	wide; convoluted	wide; convoluted
clitellum	normal (?XII-XIII)	1/2XI-XIII	1/2XI-XIII	XI-XIII	1/2XI-XIII	1/2XI - ant. XIV	1/2XI or XII- XIII	XI-1/2XIV	XII-1/2XIV
ecology	?	intertidal; seaweed at high tide mark	intertidal; decaying seaweed	upper inter- tidal; coarse deposits decaying algae	? (not stated)	intertidal; mixed sand with fresh or decaying algae	intertidal; seaweed deposits, grass along sewer effluent	upper inter- tidal; coarse deposits	upper inter- tidal; coarse beach deposits
	Baren Island, Arctic	Sptsbergen	widely distributed along European coasts	Vancouver Island, B.C.	Farragut Bay, Alaska	northern British Columbia,	west coast, Greenland, Canada	Vancouver Island, B.C; RUSSR	Vancouver Island; additional records

spermathecae
(each scale line
equals 50 μ m)



(Fig.37), lateral margins parallel, posterior margin concave or distinctly notched, length 1.5 to 1.75 x width. Septal glands three pair, all with ventral lobes, those of the third pair large with lobed margins, extending posteriorly into VII; two anterior pairs broadly united dorsally, third only narrowly connected. Chloragocytes small, golden to dark brown, a few cells in posterior IV and V, cells dense in VI. Lymphocytes small, elliptical or spindle shaped (Fig.36). Blood dark yellow in fixed specimens, light or dark red in living specimens (Port Alice); dorsal vessel arises most frequently at anterior XIV but ranges from posterior XIII to XV. Anteseptale simple, consisting only of funnel (Fig.38), postseptale large, lumpy, ectal duct long, stout, postero-ventral, just subterminal. Clitellum deep, dense, gland cells scattered; extends posterior XI to anterior XIV, less frequently XII to 1/2XIV or 1/2XI to XIII. Seminal vesicle with many small, regular lobes, extending through XI to IX. Sperm funnel length 2 to 3 x width (Fig.39), collar regular, just equal funnel width. Vas deferens narrow irregularly wound in XII. Penial bulb of average size, compact. Eight eggs found in one mature specimen, many specimens with more than four eggs at a time. Ventral bodies large, in XIV and XV, rarely also in XIII or XVI. Spermatheca (Fig.40) with distinct ental duct, ectal duct and ampulla, connected with gut at V/VI; ectal pore at IV/V. Length of ectal duct exceeds length ampulla,

duct completely covered by a prominent coat of gland cells with a distinct, compact rosette around ectal pore. Ampulla subsphaerical, with a conspicuous sperm mass. Ental duct short.

Habitat. Found in decaying seaweed along the coast (Nielsen and Christensen, 1959). Also records from inland localities.

New records. Found from mid to upper intertidal elevations in mixed sand (sand-silt-gravel) sediments; frequently associated with some alga, eg. Fucus sp., Bangia sp., or Enteromorpha sp., fresh or decaying.

Distribution. Widely distributed along European coasts, including Spitzbergen. North American records as L. ritteri, Eisen (1904) Farragut Bay, Alaska, and possibly as L. kalatdlitus, Nurminen (1970a) eastern Arctic.

New records. British Columbia: Ocean Falls, Port Alice and Kitimat (see Appendix 1).

Remarks. British Columbia specimens of L. pagenstecheri differ only in a few details from specimens described by Nielsen and Christensen (1959). In segment number L. pagenstecheri specimens from British Columbia localities were more variable than described by Nielsen and Christensen (1959) but such variability is known for some populations of the species. For fourteen specimens collected on the north

Lumbricillus pagenstecheri

Figure 36. a) Ventral setal bundle, VII

b) Lymphocytes.

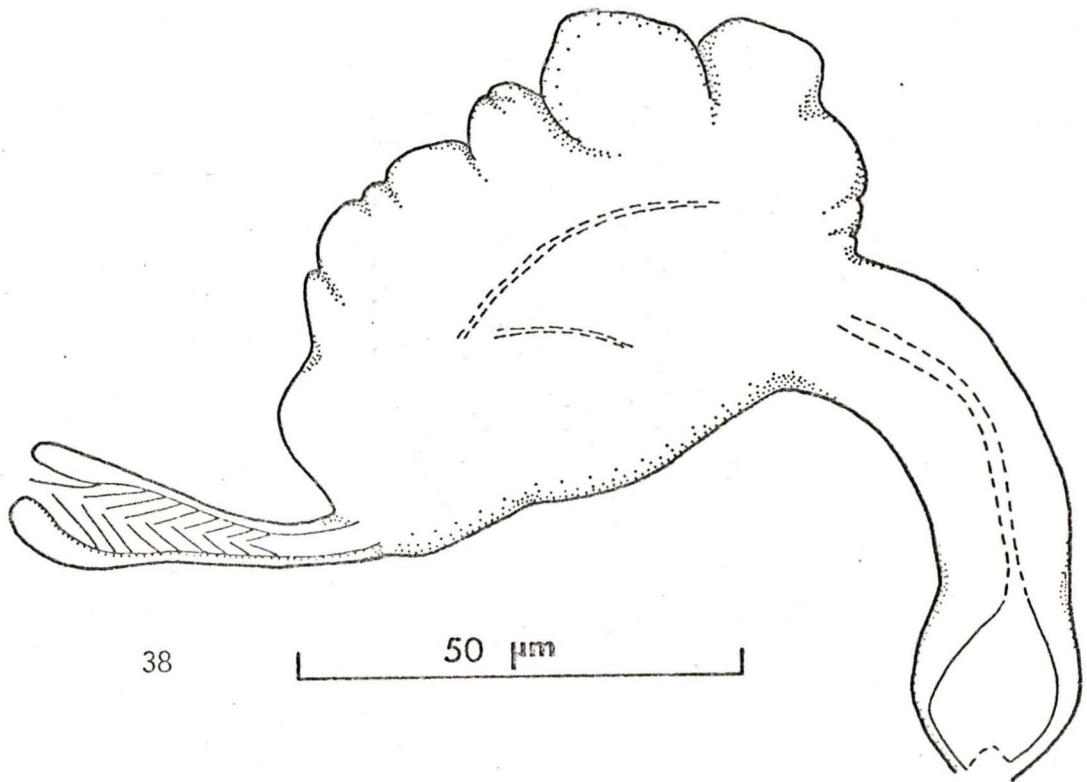
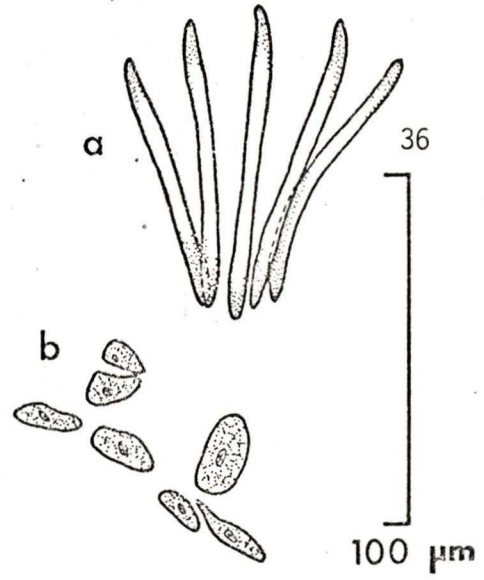
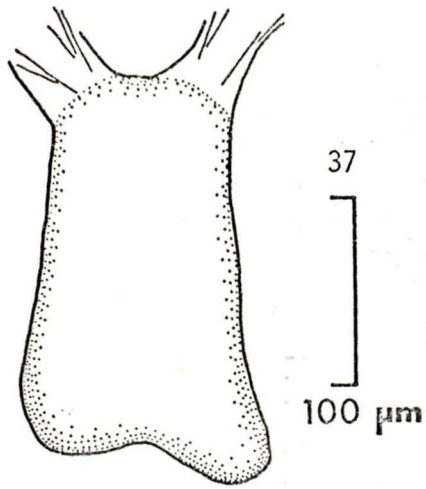
Figure 37. Brain.

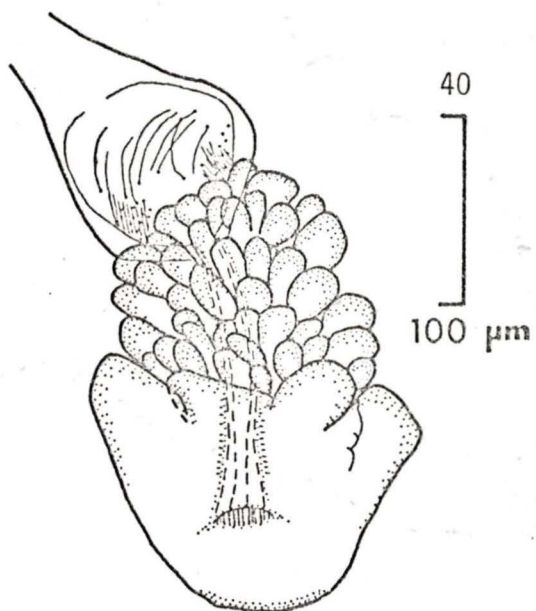
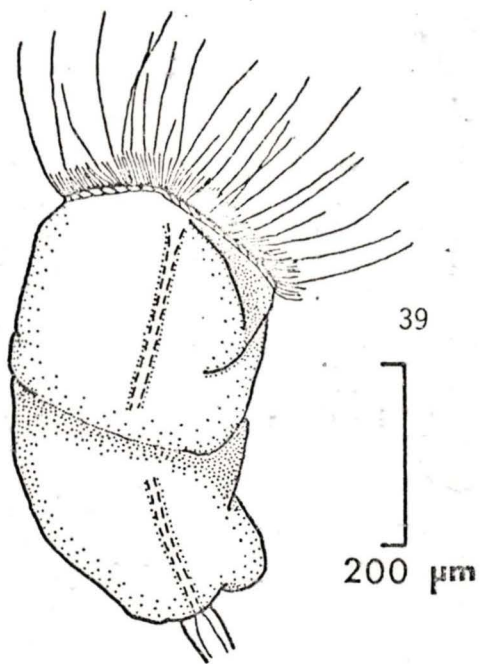
Figure 38. Posterior nephridium.

Figure 39. Sperm funnel.

Figure 40. Spermatheca.

123.





coast of Iceland, Erséus (1976a) found a variation in segment number from 39 to 62. Erséus (1976a) also found the setal distribution (numbers per bundle) to be quite variable. For the B.C. Specimens the ratio of the sperm funnel length: width was lower than recorded for European specimens; however, the estimation for the fixed B.C. specimens was conservative because the sperm funnel was in most instances slightly contorted, bent or twisted.

The morphology of spermathecae of the B.C. specimens is in detail the same as that of L. pagenstecheri specimens observed by Nielsen and Christensen (1959) and Erséus (1976a).

In Table 9 the high degree of morphological similarity between L. kalatdlitus, and L. pagenstecheri is shown. As discussed by Erséus (1976a) study in detail of any available material of L. kalatdlitus is necessary before changes in nomenclature can be affected.

Lumbricillus cf. helgolandicus (Michaelson, 1927)
augm. (Michaelson, 1934) aff. Nielsen and
Christensen, 1959 Fig. 41-45, Table 8.
Pachydrilus helgolandicus Michaelson, 1927,

postclitellar ventral: 1-6.

Brain narrow anteriorly, length just slightly greater than width, concave posteriorly (Fig.41). Three pair septal glands present, all with ventral lobes, no secondary glands; first and second pair united dorsally, third not or only very narrowly united (Fig.42). Chloragocytes present from V, dense from VI, large, golden-yellow, posteriorly cells are tall, to 1/3 seta length. Lymphocytes small elliptical to elongate, granular, nucleate, largest cells 1/3 to 1/2 seta length. Dorsal vessel arises intraclitellar, posterior XII or anterior XIII; blood deep yellow in preserved specimens. Nephridia large, anteseptale relatively small, funnel only, postseptale large and lumpy, with large, empty looking cells, ectal duct terminal (Fig.43). Clitellum extends XII to XIII, cells deep, dense, grainy, no regular distribution. Seminal vesicles with 5 to 7 regular lobes in XI and X. Sperm funnels cylindrical, length 1.5 x width, \leq body width (Fig.44). Vas deferens long, narrow, thin walled, coiled irregularly in XII. Penial bulb compact of average size. Spermatheca with long, narrow, thick walled ectal duct (Fig.45), ectal pore at IV/V surrounded by a small to medium-sized rosette of glands, not distinctly lobed entally. Ampulla large, thin walled, attached to oesophagus dorso-laterally. Spermatozoa arranged in an irregular ring shape perpendicular to the long axis of the ampulla.

Lumbricillus cf. helgolandicus

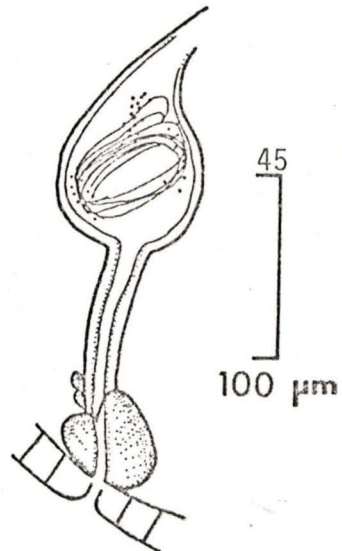
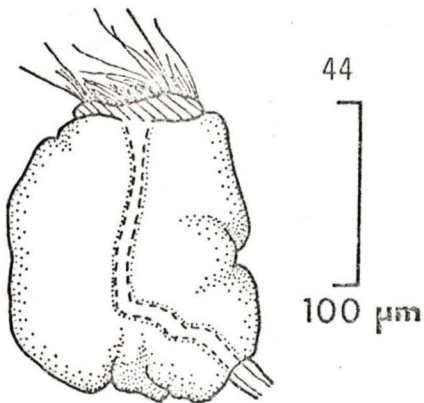
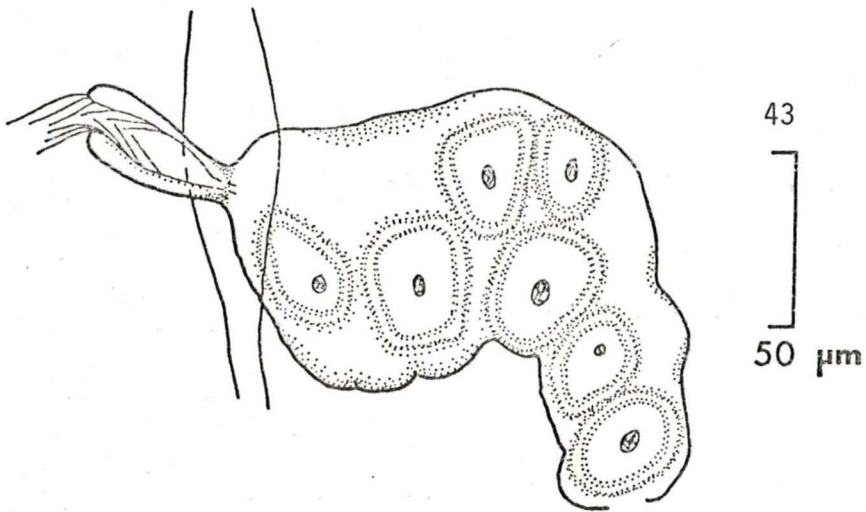
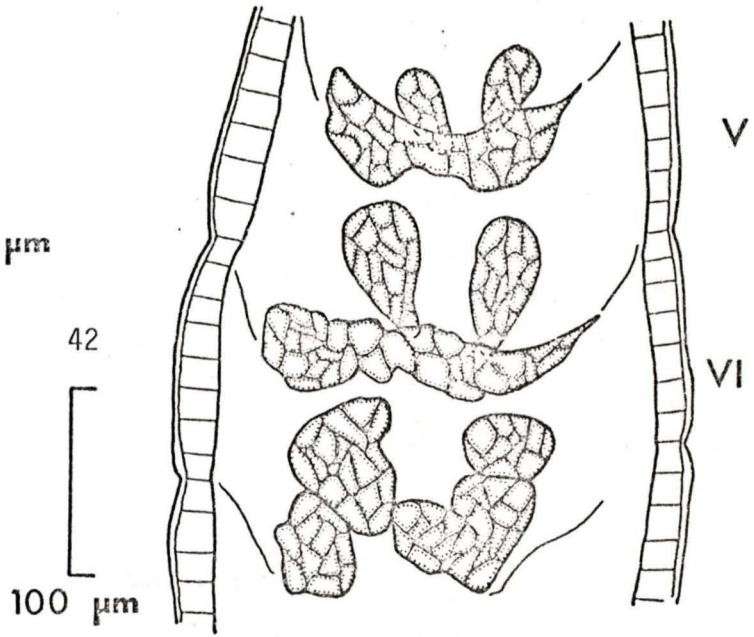
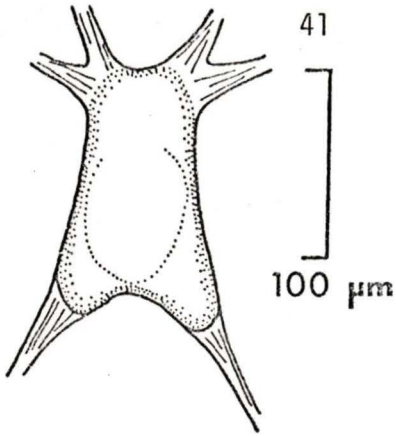
Figure 41. Brain.

Figure 42. Dorsal view of whole mount
IV-VII, showing septal glands.

Figure 43. Posterior nephridium.

Figure 44. Sperm funnel.

Figure 45. Spermatheca.



Habitat. Under stones, upper intertidal; near fresh water streams.

New records. In fine sediments; also in sediment comprised of wood fibre, wood chips, and silt; occasionally in locations dominated by the green alga Enteromorpha sp..

Distribution. Europe: Germany: Helgoland, Hannover, North Sea, Eckenforder Bucht Nord; Denmark: Avedore and Kattegat; Poland: Puck Bay, Baltic Sea (Moszynska, 1962); Great Britain: Ascog, Scotland and Anglesey and Caernarvonshire, North Wales.

New records. Near Prince Rupert, north mainland coast of British Columbia; and near Port Alice, northern Vancouver Island, B.C.; as material examined (also see Appendix 1).

Remarks. L. cf. helgolandicus aff. Nielsen and Christensen (1959) differs from the taxon as described by Michaelsen (1927 and 1934) in the relative dimensions of the sperm funnel. The British Columbia material examined agrees in all respects with L. cf. helgolandicus (Nielsen and Christensen, 1959) except for having a smaller segment number (Table 8).

Nurminen (1973c) points out the possibility of synonymy between L. kamtschatkanus (Michaelsen, 1929) and L. cf. helgolandicus. British Columbia specimens of L. cf. helgolandicus and the taxon as described by Nielsen and Christensen (1959) have sperm funnel dimensions as described for L. kamtschatkanus not as for L. helgolandicus.

Michaelson (1934) re: Pachydrilus helgolandicus wrote:
 "Samentrichter vielfach so lang wie dick, wie
 einem naher untersuchten Stuck ungefahr 12 mal so
 lang wie in der Mitte dick,..." (p.138).

But, the distribution of postclitellar setae is different
 for L. cf. helgolandicus and L. helgolandicus (Michaelson)
 (Table 8) than for L. kamtschatkanus.

L. kamtschatkanus (Michaelson, 1929) was described
 without illustrations so that the exact gestalt of the
 spermatheca is not determinable. In general it seems very
 like that of L. helgolandicus, with long, thin, naked ectal
 duct and an inflated onion shaped ampulla. It is possible
 that both the specimens that have been collected on the
 British Columbia coast and those described by Nielsen and
 Christensen (1959) and later authors should be transferred
 to L. kamtschatkanus in respect of the relative sperm funnel
 dimensions.

Von Bulow (1957) did not record a discrepancy
 between specimens collected at Eckernforder Bucht Nord and
 those of Michaelson (1927) in the relative length of
 the sperm funnels, although she did clarify the description
 of the ampulla of the spermatheca.

Lumbricillus annulatus Eisen, 1904 Fig. 46-52,
 Plate 3d-e, Table 10.

Lumbricillus annulatus Eisen, 1904, pp.81-84,
 f.50-52, pl. XVIII f.1.

Pachydriilus (Pachydriilus) annulatus: Cernosvitov,
1937a, p. 292.

Lumbricillus annulatus: Nielsen and Christensen,
1959, p. 96.

?L. annulatus: Shurova, 1974, pp. 128-129, f.1a,b,c.

Lumbricillus ritteri Eisen (in part), 1904.
pp. 84-86, f. 53-54, pl. XIII, f. 7-9.

Pachydriilus (Pachydriilus) ritteri: Cernosvitov,
1937a, p. 292.

Lumbricillus ritteri: Nielsen and Christensen,
1959, p. 97.

L. ritteri: Erséus, 1976a, pp. 5-6, f. 12.

Enchytraeus pugetensis Altman, 1931, pp. 154-163,
pl. XIV f.1-7, pl. XVI f.8-14.

Pachydriilus (?) pugetensis: Cernosvitov, 1937a,
p. 293.

Marionina pugetensis: Nielsen and Christensen,
1959, p. 109.

Lumbricillus vancouverensis Tynen, 1969a, p. 390,
f.4,11,13,15 & 17.

Prior to examination of Altman's specimens of
Enchytraeus pugetensis or of syntypes of Lumbricillus
annulatus Eisen, 1904, or L. ritteri Eisen, 1904, type
material of L. vancouverensis Tynen, 1969 (NMNS # 3409,
longitudinal sections) was examined. In particular
contradiction of Tynen's (1969a) description, ventral

glands were observed in the type in all of segments XVI, XVII and XVIII and the sperm duct was confined to XII. Tynen's description (Table 10) was further amended on the basis of new material collected from the type locality of L. vancouverensis. Segment numbers and setal distributions were modified; ventral bodies were found in all mature specimens and the clitella of these were deep and dense contrary to the thin structure reported by Tynen (1969a). The sperm duct was never observed to extend into XIV, only occasionally into the anterior part of XIII. The average ratio of dimensions of the sperm funnel of mature specimens was found to be somewhat less than that indicated by Tynen.

Examination of material identified by L.C. Altman as Enchytraeus pugetensis Altman retained at the University of Washington, Thomas Burke Memorial Museum, allowed a redescription of that species and allocation within Lumbricillus. Nielsen and Christensen (1959) on the basis of Altman's (1931) original description (Table 10) placed Enchytraeus pugetensis within their revised Marionina assemblage. The presence in E. pugetensis of a well developed, regularly lobed seminal vesicle precludes the possibility of inclusion in Marionina.

In characters additional to general spermathecal morphology it had been noted that E. pugetensis and Lumbricillus vancouverensis were very similar (Table 10), in particular, with regard to general size, habit and recorded life history observations (Altman, 1931 and personal observations). During reexamination of some of Altman's original material such high setal numbers as he described were not found; the sperm collars of the male funnels were observed to be wide and convoluted in mature worms; the relative dimensions of the sperm funnel were determined to be in the same range as indicated for L. vancouverensis, i.e., 2-3:1; and the spermathecae were found to be indistinguishable in detailed structure, from those of L. vancouverensis.

Examination of USNM 21107, syntypes of L. ritteri Eisen, 1904, specimens collected at Farragut Bay, Alaska, June 5, 1899 by Professor W.E. Ritter revealed three specimens clearly recognizable by their distinctive spermathecal morphology as L. annulatus, the same as Tynen's L. vancouverensis. One specimen was of a different species (see L. pagenstecheri (Ratzel)).

Finally, examination of syntypes of L. annulatus Eisen revealed that this taxon too had the same spermathecal structure as L. vancouverensis ("...sufficient to distinguish Lumbricillus vancouverensis from any other species of Lumbricillus so far described", Tynen, 1969a, p. 390).

For the syntypes of L. annulatus (Table 10) from Orca setae were found to be almost straight anteriorly to sigmoid posteriorly, and the sperm funnel collars of mature individuals were observed to be wider than the body of the funnel and folded or convoluted.

There are no significant morphological differences between the variously described specimen sets. By priority on account of seniority Lumbricillus annulatus is the correct name for the taxon and Enchytraeus pugetensis (Altman) and Lumbricillus vancouverensis are junior synonyms. L. ritteri is not available because it was not properly typified.

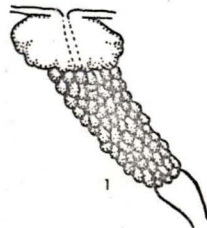
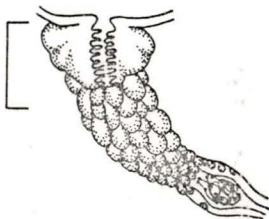
Shurova (1974) in an amendment of Lumbricillus annulatus Eisen did not describe the characteristic, pronounced, regular folding of the internal wall of the spermathecal ectal duct. Possibly the Russian material represents a distinct taxon. Yamaguchi (1937) described a species, Pachydrilus nipponicus, from Akkeshi Bay, Japan that in description is scarcely distinguishable either from the original description of L. annulatus or from the amended description of Shurova (1974). Shurova (1974) in one survey report gives records of both of these species and must have considered that comparatively they were distinguishable taxa. It is with some hesitation that her taxon recorded as L. annulatus is reported as a record of L. annulatus Eisen, 1904.

Table 10. Characteristics of *Lumbricillus annulatus* Eisen and two morphologically similar *Lumbricillus* species.

Spermathecae either drawn from recent British Columbia material or redrawn from 1. Yamaguchi, 1937; or 2. Eisen, 1904.

CHARACTER	SPECIES				
	<u>annulatus</u> Eisen, 1904			<u>nipponicus</u>	<u>merriami</u>
	Tynen, 1969 (<u>vancouverensis</u>)	Altman, 1931 (<u>pugetensis</u>)	1978 amended	(Yamaguchi, 1937)	(specific form) Eisen, 1904
no. segments	49-53	(46)52-74	45-69(74)	57-71	55-62
setal shape	slight sig. or sigmoid	slightly sigmoid	slightly sigmoid	straight to sigmoid	?
setal lateral distribution ventral	3-4:2-3 4-6:2-3	5-9:4-6 8-10:5-9	3-7(9):2-6 5-10:3-7(9)	3-5:2-4 5-8:4-6	3-5:2-3(4) 4-6:4-6?
clitellum	1/2XI-XIII	1/2XI-XIII	1/2XI-1/2XIV	1/2XI-1/2XIV	XI-1/2XIV
origin dorsal vessel	XIV-XV	XIV	XIII/XIV-XV/XV or XV	XIV-XV	
blood colour	red	yellowish	red	pale red	
ventral bodies	XVI-XVII *	XIV-XVI +	XIV-XX	XIV-XX	XIV-XVII
nephridia, postseptale	lumpy	lobed	lumpy	flattened	warty
sperm funnel L:D	3-4:1	large	2-3:1	3:1	3:1
sperm collar	wide; convoluted	wide; * convoluted	wide; * convoluted	"very wide"	small
ecology	under decaying seaweed; at high tide numerous	sand beaches, in decaying seaweed and other debris	sand, sand-gravel beach; fresh or decaying weed and debris	under stones; in seaweed; in gravel	under decaying seaweed
	Vancouver Island, B.C.	Puget Sound, Washington	Alaska; Vancouver Island; Puget Sound; Kurilisk Sea	Akkeshi Bay, Japan	Popof Island and Metlakatla, Alaska

spermathecae
(scale line
equals 50 μ m)



* Information changed or added through examination of type material for the respective synonymies.

Type material. USNM 21109-21110; two series of syntypes.

Type localities. Metlakatla, Alaska (21109); Orca, Prince William Sound, Alaska (21110).

Material examined. Lumbricillus annulatus Eisen, 1904. USNM type series 21110; 19 whole specimens.

Lumbricillus ritteri Eisen, 1904. USNM 21107, in part; 3 whole specimens.

Enchytraeus pugetensis Altman, 1931. UWMS specimens, type status not designated; whole mount 1-30-36, L.C.A., transverse serial sections, L.C.A. and a whole specimen from a series Sucre(?) Island, 1918.

Lumbricillus vancouverensis Tynen, 1969, NMNS syntype 3409; longitudinally sectioned specimen.

New material from several beaches around Vancouver Island, British Columbia (Appendix 1).

Description. Medium to large (12 to 24 mm), robust, heavily muscled worms. Anterior segments very red. Large head pore at 0/I(Pl.3d). Segment number range of Eisen's

syntypes, 56 to 65; of Altman (Enchytraeus pugetensis) specimens, 46 to 74; of Vancouver Island specimens, 45 to 59 and 62 to 69 (from an organically enriched beach near Port Alice). Setae robust anteriorly (Plate 3e and Fig. 46), slightly sigmoid, more sigmoid posteriorly, bundles slightly fan shaped, setae within a bundle more or less equal.

Distribution: preclitellar lateral : 3-7,
 " ventral: 5-10,
 postclitellar lateral: 2-6, and
 " ventral: 3-7(9)

Brain concave posteriorly, lateral margins approximately parallel, length about 1.75 x width (Fig. 47). Septal glands three pair, all with ventral lobes; at least two anterior pair connected dorsally, third usually connected narrowly, rarely not. Ventral lobes of third pair large, almost occlude VII. Chloragocytes golden to rusty brown, present from V, dense from VI, nucleate, very granular. Lymphocytes nucleate, granular, extended spindle or oval shaped, with filamentous ends (Eisen, 1904), lymphocytes 1/4 to 1/5 seta length (Fig.46). Blood deep red or dark yellow in fixed specimens. Dorsal vessel arises XIII/XIV to XIV/XV or in XV (Eisen: to XVI). Anteseptale simple, consisting only of funnel, postseptale large, lumpy (Fig.48a and b) (?Shurova, 1974 and Eisen, 1904: rugose); efferent duct postero-ventral, terminal or subterminal. In mature

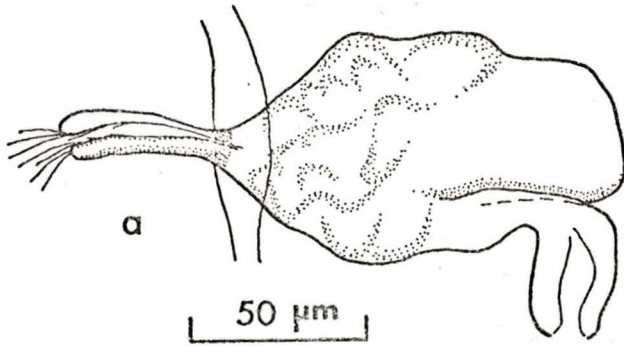
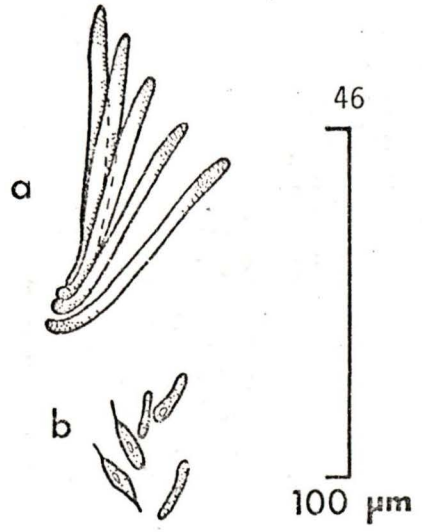
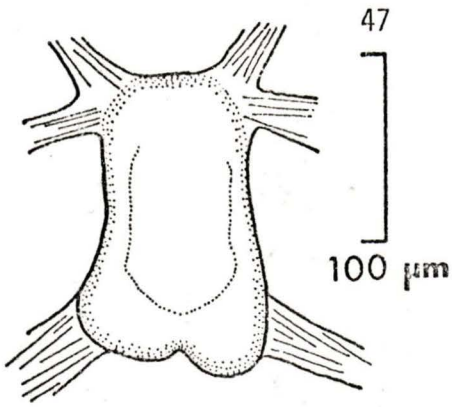
specimens with eggs, clitellum deep and dense, extends 1/2 XI to XII, rarely over anterior XIV. Seminal vesicles regularly lobed in XI and X, occasionally extending into IX. Sperm funnel regular, barrel shaped (Fig.49), length 2 to 3 x width; sperm collar pronounced, wide, often convoluted. Vas deferens not narrow or long, irregularly coiled in XII, rarely extending into XIII. Penial bulb large, oblong; length bulb about 1/3 width of segment XII, with a prominent muscular coat (Fig.50). Ventral bodies present in segments XIV to XX, XVI to XIX, or only XVII and XVIII; increasing in size posteriorly. Spermathecae simple, tubular, with distinct ental and ectal ducts (Fig.51 and Fig.52). Ectal duct length 3 to 4 x length ampulla, duct surrounded by small glandular cells which decrease in size entally, ectal end with distinct rosette, lobed entally. Inner wall of ectal canal regularly folded into either a spiral ridge or a series of concentric rings (not determined). Ampulla, small onion shaped, width just equal ectal duct, connected terminally to oesophagus at V/VI.

Habitat. Abundant on sand and sand-gravel beaches, at high tide levels, under and in fresh or decaying seaweed (?Shurova, 1974: density = $280 \times 10^3/m^2$). Also found on gently sloping gravel beach in high numbers at elevations from low to high tide levels.

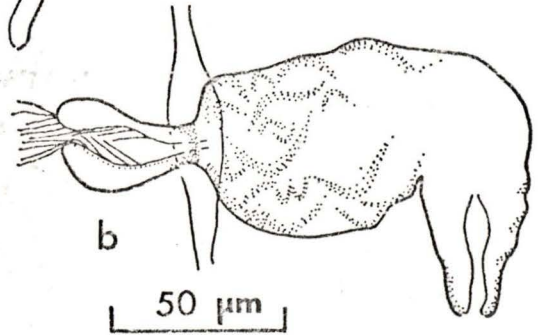
Distribution. Alaska, Metlakatla and Orca Islands and

Lumbricillus annulatus

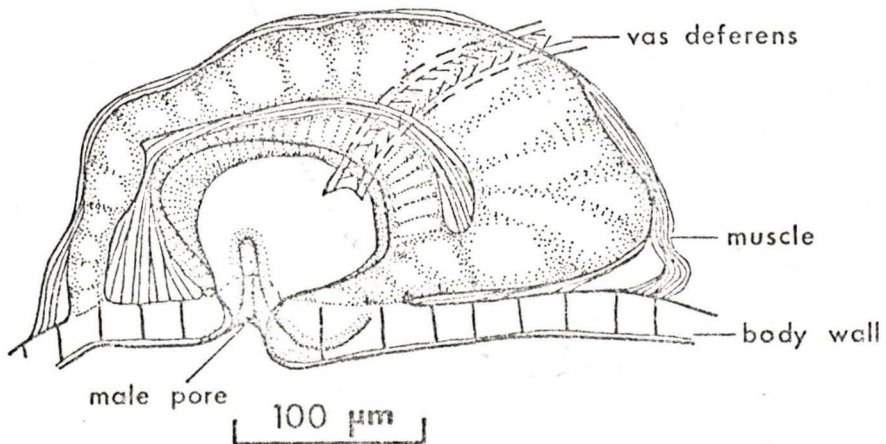
- Figure 46. a) Anterior ventral setal bundle,V;
b) lymphocytes.
- Figure 47. Brain.
- Figure 48. Posterior nephridia
a) with subterminal efferent duct;
b) with terminal, postero-ventral
efferent duct.
- Figure 49. Sperm funnel.
- Figure 50. Penial bulb.
- Figure 51. Spermatheca.
- Figure 52. Longitudinally sectioned spermatheca of
L. annulatus = L. vancouverensis Tynen, 1969,
syntype 3409.

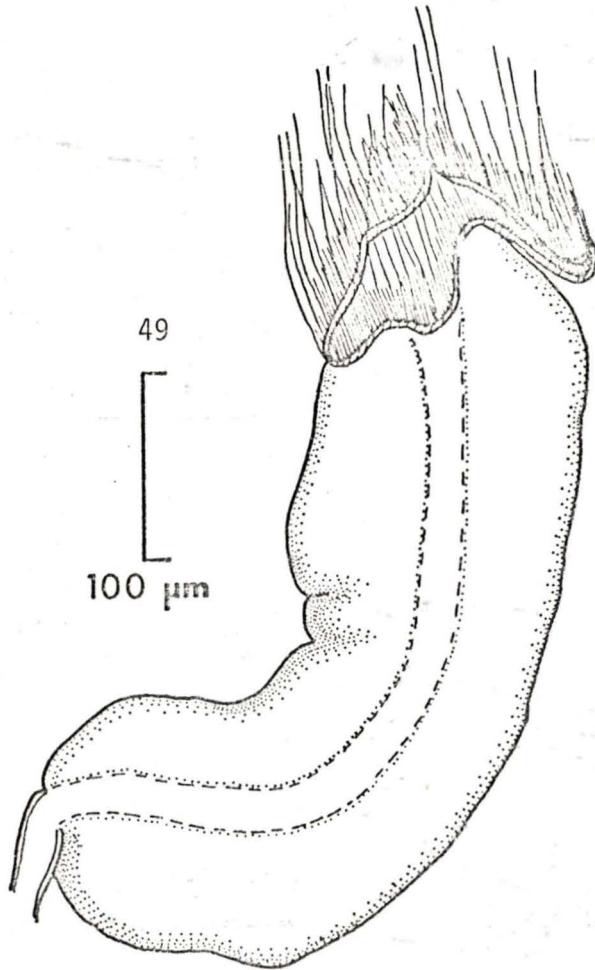
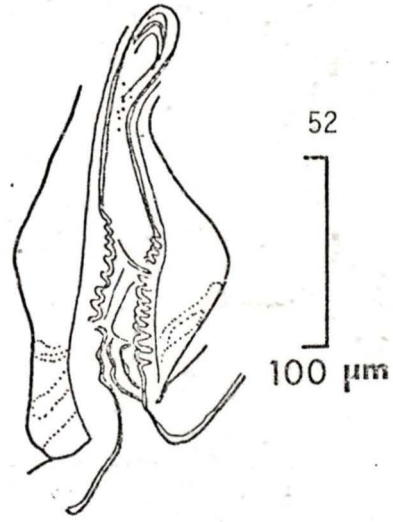
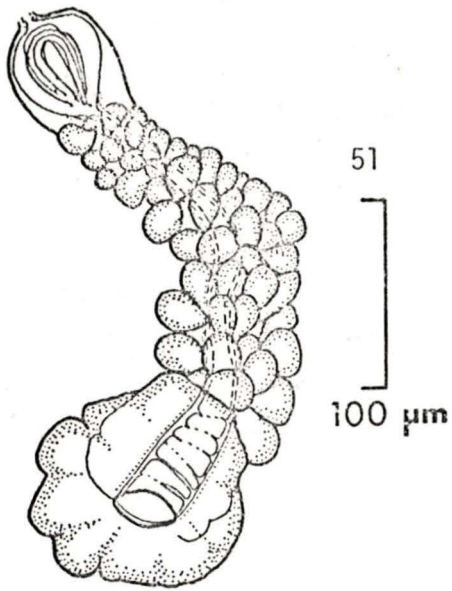


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50





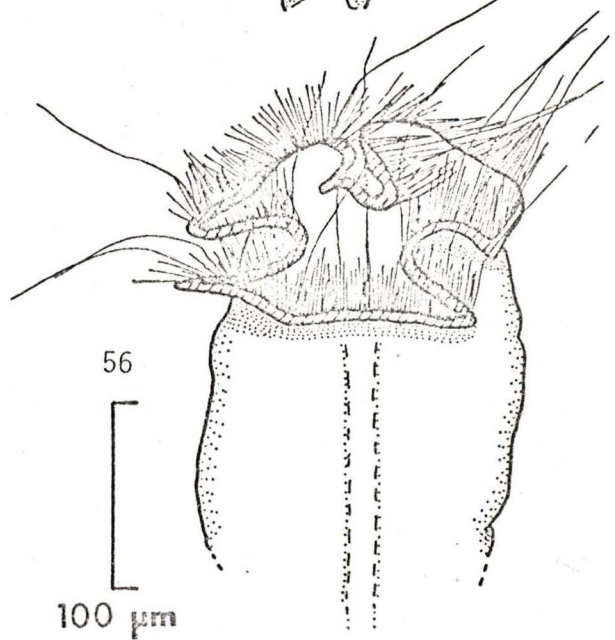
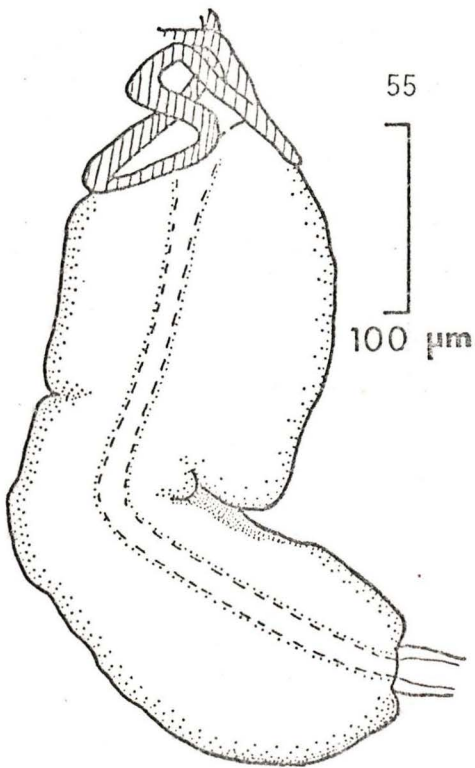
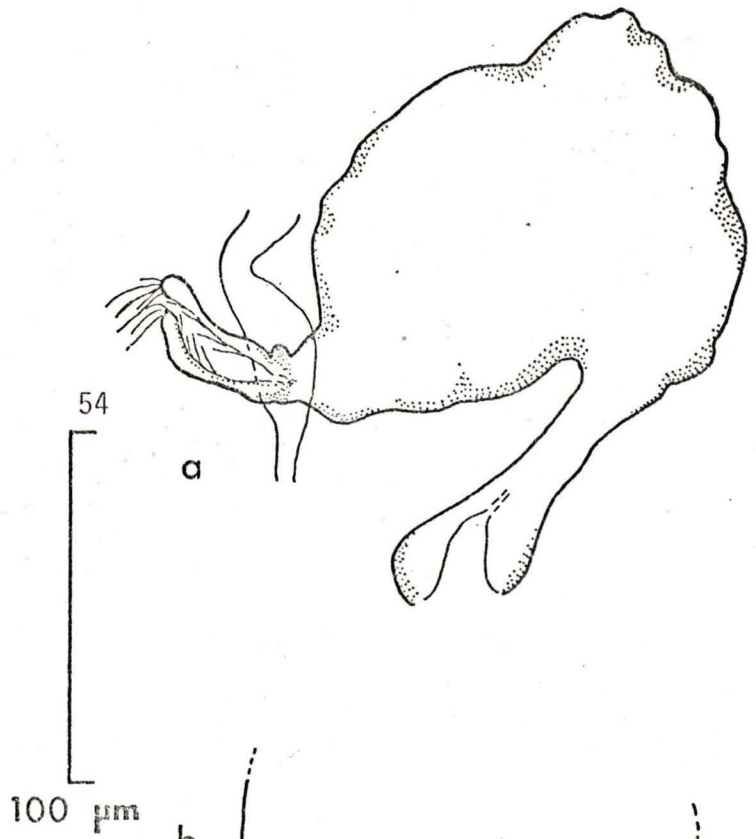
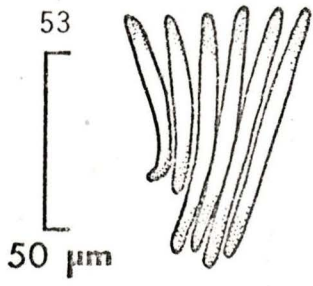
postclitellar lateral: 1-5, and

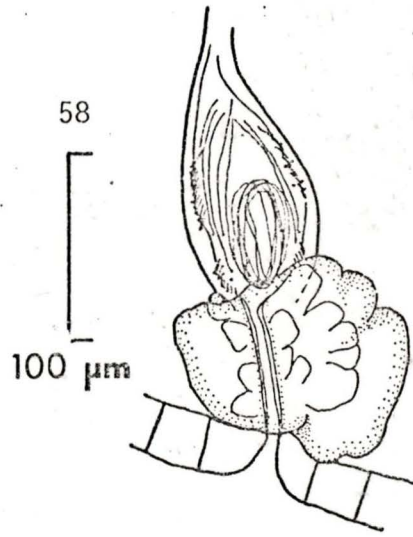
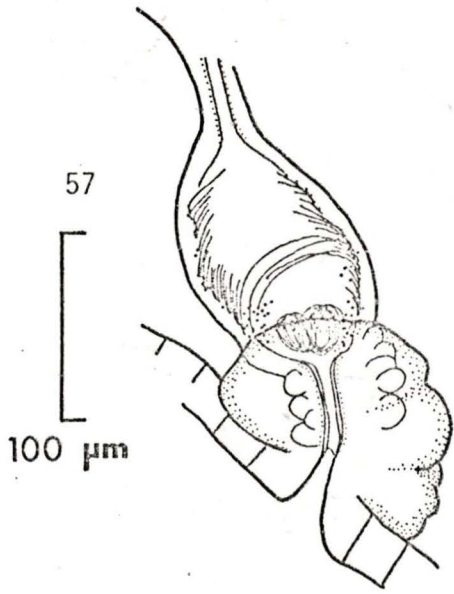
" ventral: 2-5.

Brain relative to body size, small, slightly concave or notched posteriorly, length usually just greater than 2 x width. Three pair septal glands present all with ventral lobes, first pair usually joined, however, is variation from all pairs joined narrowly to all separate. Chloragocytes fairly dense from VI, sparsely present from V or IV, granular, light green to brownish green in live specimens. Lymphocytes small, oval, nucleate. Dorsal vessel arises XII to XIV, blood red. Antespatale equals funnel only, postseptale large and grainy in postclitellar segments, efferent duct terminal or just subterminal (Fig.54a and b). Clitellum dense, incomplete ventrally, most often extends XII to 1/2 XIV, otherwise XII to XIII. Seminal vesicles extend through X and XI, occasionally into VIII, as many as 27 small, regular lobes. Sperm funnel cylindrical, length 1.5 to 3.5 x width (Fig.55), collar wide, highly convoluted (Fig.56). Vas deferens long, narrow, irregularly coiled in XII. Large ventral bodies consistently found in XIV and XV. Spermatheca simple (Fig.57 and 58), ampulla large, onion shaped. Short ectal duct surrounded along entire length by small, dense glands, with large compact rosette at ectal pore. Ectal canal distinct. Connected to gut at V/VI by distinct ental duct of somewhat variable length.

Lumbricillus mirabilis

- Figure 53. Anterior, ventral setal bundle.
- Figure 54. Posterior nephridia from consecutive segments
- a) with terminal, postero-ventral efferent duct;
 - b) with subterminal efferent duct.
- Figure 55. Sperm funnel.
- Figure 56. Detail of sperm funnel collar, dissected specimen.
- Figure 57. Spermatheca of syntype 3407, whole specimen.
- Figure 58. Spermatheca, dissected specimen, recent material.





Habitat. From 1.8 to 5.0 m above chart datum; in coarse sand, gravel shell deposits; frequently associated with driftline or other wash algae.

Distribution. East coast Vancouver Island; ? Iturup, Simushir, and Paramushir Islands of Kurilsk group, U.S.S.R. (Shurova, 1974).

New records. Additional beaches on Vancouver Island: east coast: Mt. Douglas and Elk Falls; west coast: Long Beach; also new material from Qualicum and Miracle Beaches. See Appendix 1 for details of sample location and habitat.

Remarks. On the basis of examination of NMNS 3407

Lumbricillus mirabilis Tynen some amendments and additions to the original taxon description (Tynen, 1969a) were made. The posterior setae of the type specimen had a slight double curvature, that is they were slightly sigmoid. Brain and nephridia have morphologies as described in the preceding amended species description. The clitellum was apparent over segments XII to 1/2 XIV not XI to 1/2 XIV. Five eggs were present, extending posteriorly to segment XVI; and lobes of the seminal vesicle were observed in all of segments X, IX and VIII not only X and IX.

In particular the spermathecal structure of NMNS 3407 was not well represented by Tynen's illustration (1969a, f.9). It was, in this preserved specimen, as shown in Figure 57, a camera lucida reproduction.

Examination of numerous mature specimens from recent collections allowed further additions (Table 9) and served to confirm amendments based on the type specimen. One change not indicated in Table 9 was allowance for a high degree of variability in dorsal fusion of the septal gland pairs.

Based on her specimens (see distribution information) Shurova (1974) also proposed some amendments to the original taxon description. The spermathecae as described and illustrated by Shurova (1974, f.36) are very similar to what was observed in both the type and the new British Columbia material; however, the distribution of spermatozoa in the ampullar cavity is more diffuse than found in B.C. specimens. There is some doubt about the identity of the Kurilsk material (Shurova, 1974) with the B.C. material (Tynen, 1969a and new records) because Shurova (1974) did not observe the wide convoluted sperm funnel collar that is characteristic for L. mirabilis.

In Table 9 is shown the extent of morphological similarity between L. mirabilis and L. pagenstecheri. The most obvious consistent morphological differences found in mature, fixed specimens of the two species were in the morphology of the sperm funnel collars, L. mirabilis with a wide and convoluted collar and L. pagenstecheri with a regular collar nearly as wide as the funnel; and in the relative dimensions of the spermathecae, L. pagenstecheri

having a longer ectal duct and a very well developed envelope of gland cells.

For live specimens, possibly the green coloured chloragogen of L. mirabilis would be distinctive, however, this colouration was observed to vary from bright green to a brown-green at which the distinction from "brownish" (Nielsen and Christensen, 1959, p.104) in L. pagenstecheri becomes very subjective. In fixed specimens the chloragogen inclusion colours for the species vary over a range of visually inseparable browns.

Lumbricillus qualicumensis Tynen, 1969

Fig. 59-64, Plate 4a-c, Table 11.

Lumbricillus qualicumensis Tynen, 1969a,

pp.391-392, f.6 & 8.

Type material. Not designated, not located.

Type locality. Qualicum Bay, east coast Vancouver Island, British Columbia.

Material examined. Fixed specimens from Qualicum Beach (appendix 1); Mt. Douglas Beach, and Port Alice. Living specimens from Port Alice.

Description. Small, thin, yellow specimens, 7 to 10 mm long, with 30 to 42 segments. Cutaneous glands in approximately 6 regular transverse rows per segment. Setae

sigmoid, without nodulus (Fig.59).

Distribution: preclitellar lateral: 2-6,
 " ventral: 2-6,
 postclitellar lateral: 1-5, and
 " ventral: 2-5.

Brain distinctly concave posteriorly, maximum length approximately 1.5 x width (Fig.60). Three pair septal glands present, all with ventral lobes, all united dorsally (Plate 4a). Lymphocytes nucleate, granular, spindle shaped, with attenuated tips, $1/2$ to $3/4$ seta length (Fig.61).

Chloragocytes large, colourless or pale gold, sparse from V, dense from VII, $1/2$ seta length, nucleus obvious. Blood faint yellow. Dorsal vessel arises most frequently at XIII/XIV, ranges $1/2$ XIII to $1/2$ XIV. Anteseptale consisting of funnel only, postseptale oval to egg-shaped, ectal duct postero-ventral, terminal or subterminal (Fig.62a and b).

Cells of clitellum deep, dense, scattered extend XII to XIII, ventrally also over posterior of XI. Seminal vesicle small, 3 to 6 lobes in XI and X. Sperm funnel length about 1.2 to 1.5 x width, collar constricted (Fig.63). Vas deferens long and narrow, regularly coiled in XII (Plate 4b). Penial bulb more or less sphaerical, height of bulb $1/4$ diameter of XII. Small ventral bodies usually present in XIV and XV. Spermatheca with distinct ental and ectal ducts. Ectal duct length 2 to 2.5 x ampulla length, covered densely with small glandular cells, with distinct, slightly

Lumbricillus qualicumensis

Figure 59. Anterior, lateral setal bundle, VI.

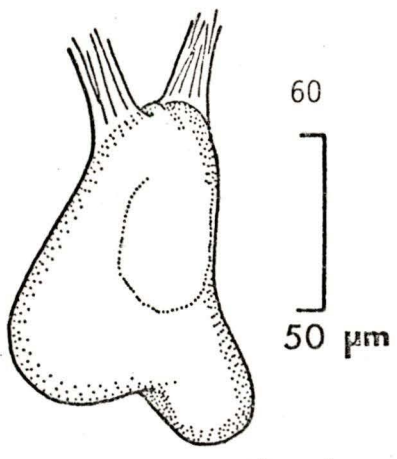
Figure 60. Brain.

Figure 61. Lymphocytes.

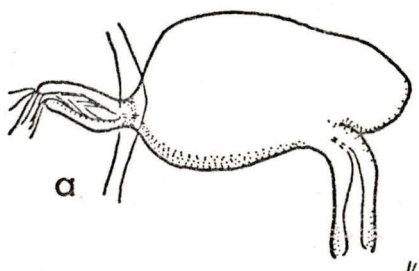
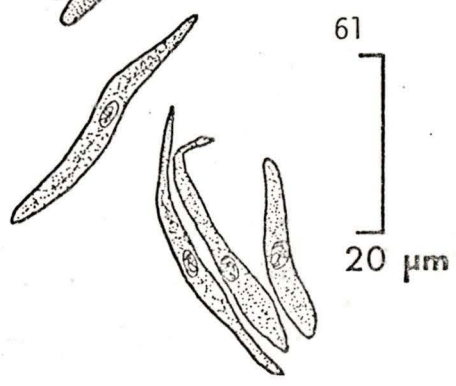
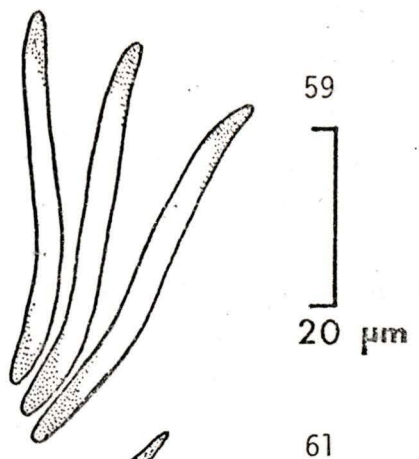
Figure 62. a) Anterior nephridium with
subterminal efferent duct;
b) posterior nephridium with
terminal, postero-ventral
efferent duct.

Figure 63. Sperm funnel.

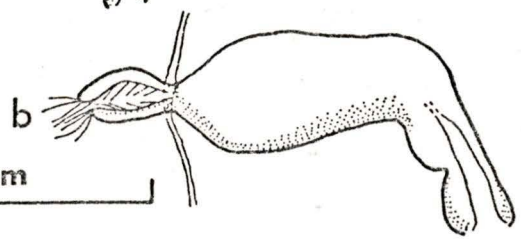
Figure 64. Spermatheca.



dorsal
lateral



62



100 µm

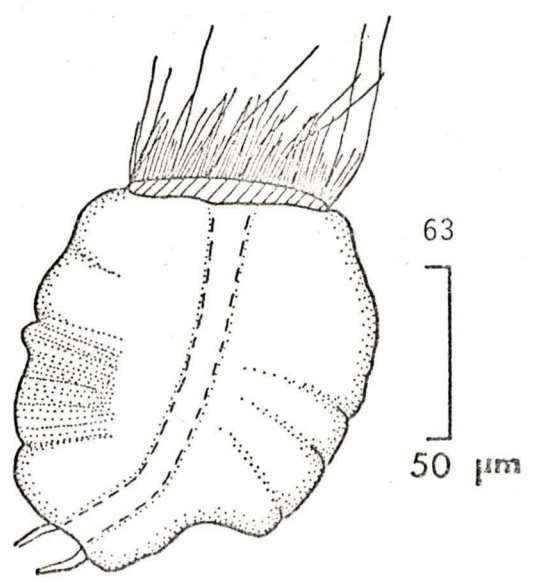
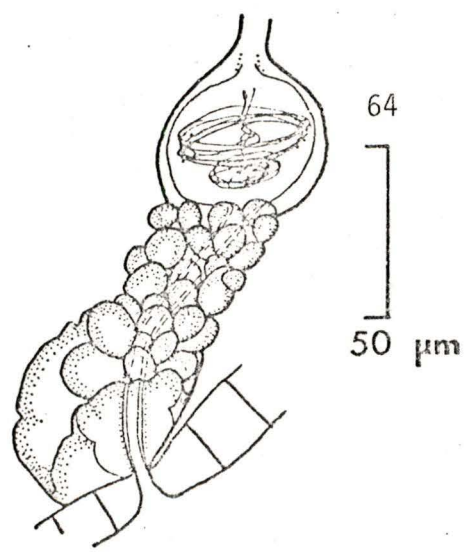
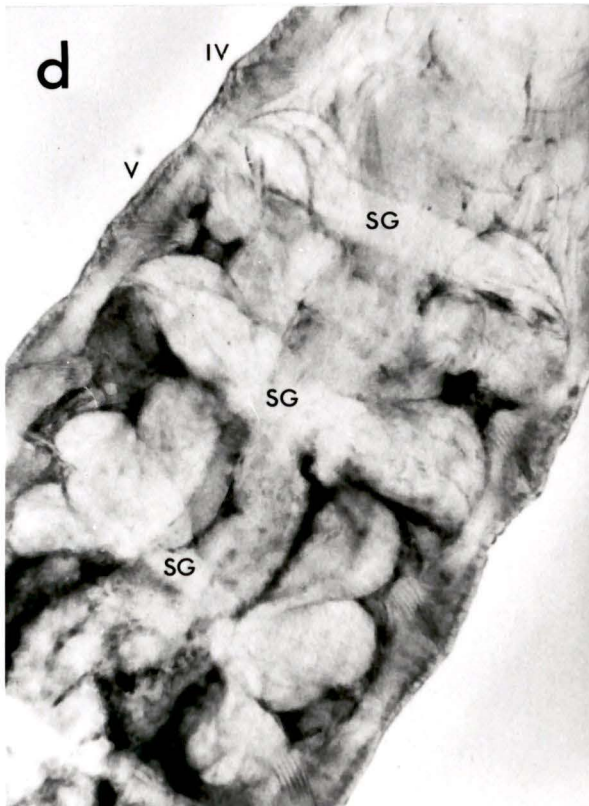
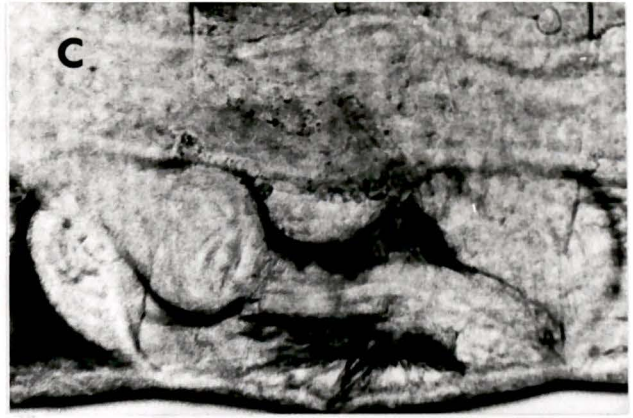
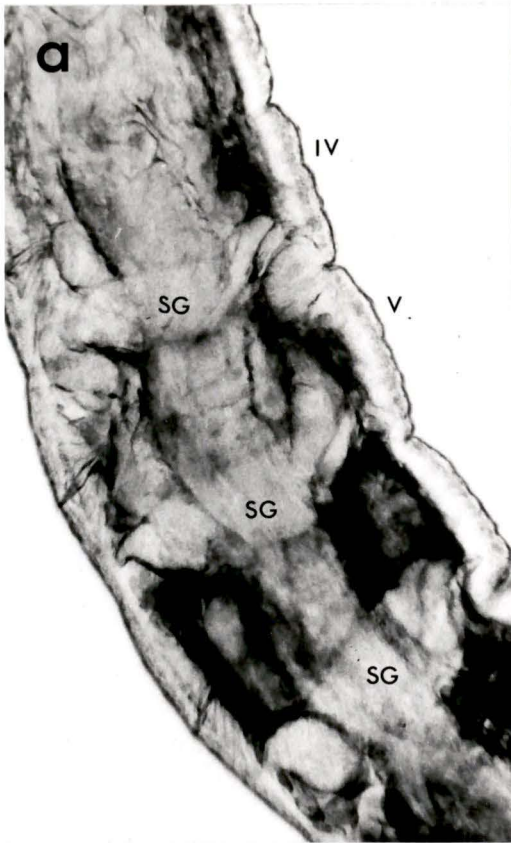


Plate 4. Lumbricillus qualicumensis Tynen, a-c, light
microscope photographs of living specimens.
a) III-VI, dorsal, showing septal glands(SG);
b) XII, coil of vas deferens;
c) IV-V, dorso-lateral, showing spermatheca.

Lumbricillus curtus n.sp., d-e, light
microscope photographs of living specimens.
d) IV-VII, dorsal, showing septal gland morphology(SG);
e) IV-VI, showing spermathecae.



lobed rosette at ectal end. Ampulla round, with a regular ring of spermatozoa, connected via terminal ental canal to oesophagus (Plate 4c and Fig.64).

Habitat. Mid to high intertidal; in sandy substrates, frequently associated with wash and/or attached algae.

New records. As above.

Distribution. Miracle and Qualicum Beaches, east coast of Vancouver Island, British Columbia.

New records. Additional records for Miracle and Qualicum Beaches; Mt. Douglas and Port Alice. See Appendix 1 for details of samples in which specimens were obtained.

Remarks. Of all known species of Lumbricillus, specimens reported here as L. qualicumensis most nearly resemble L. qualicumensis Tynen. The original description of the species, however, was somewhat scanty, giving no details of relative sizes of lymphocytes and chloragocytes; of brain size or dimensions; of nephridia; or of morphology of septal glands. Tynen (1969a) states too that the clitellum was "inconspicuous" and this arouses the suspicion that his specimens were not fully mature. No type was designated for this taxon (Tynen, 1969a and 1970a) nor could any type material be located with other type material of Tynen's (1969a) Vancouver Island species held at the Canadian National Museum of Natural Sciences.

In some details the specimens recorded here as L. qualicumensis did not agree with the original description. Some of the differences can be seen in Table 11; they include a more anterior dorsal blood vessel origin in the recent material; greater variability in segment number range and setal distribution; and the presence of small ventral bodies in XIV and XV of mature worms.

L. ignotus Shurova, 1977 is very similar to L. qualicumensis. Minor differences between these taxa (Table 11) exist in the segment number ranges and setal distributions. In the origin of the dorsal blood vessel L. ignotus is like L. qualicumensis according to Tynen (1969a) but in presence of ventral bodies in XIV and XV it is nearer the condition of L. qualicumensis recorded for the recent material. In neither description of the Vancouver Island taxon is the clitellum as extensive as that described for L. ignotus by Shurova (1977). For both these taxa the described (written and illustrated) morphologies of the spermathecae and sperm funnels are the same. These few remarks serve to indicate quite clearly that the specimens identified herein as L. qualicumensis are neither exactly the same as the taxon described by Tynen (1969a) nor as L. ignotus (Shurova, 1977) and that significant morphological differences probably do not exist between L. ignotus and L. qualicumensis. Because the specimens described herein were collected in the vicinity of the reported type locality of

L. qualicumensis, in spite of reservations on account of the limited detail of the original description and absence of type material, they were identified as L. qualicumensis and the taxon description was amended as required. If upon examination of L. ignotus Shurova, 1977 type material it is found that the taxa are synonymous, then L. qualicumensis as senior synonym would be the valid name of the taxon. It would be presumptive to propose this synonymy without examining type material because Shurova (1977) apparently considered L. qualicumensis prior to designation of L. ignotus.

L. qualicumensis is distinguished from L. belli Tynen, 1969a (Table 11) on the basis of relative dimensions of the sperm funnel and morphology of the sperm funnel collar. Similarly it is distinguishable from L. pagenstecheri (Table 9) which also is a noticeably longer and more robust worm, with straight or only slightly sigmoid setae.

L. semifuscus (Claparède, 1861) augm. (Stephenson, 1911), only known from European and northern U.S.S.R. coasts, a small Lumbricillus species similar in general spermathecal morphology to L. qualicumensis, has, characteristically, very small glands along the ectal duct of the spermatheca and extensive septal gland lobes in VI and VII.

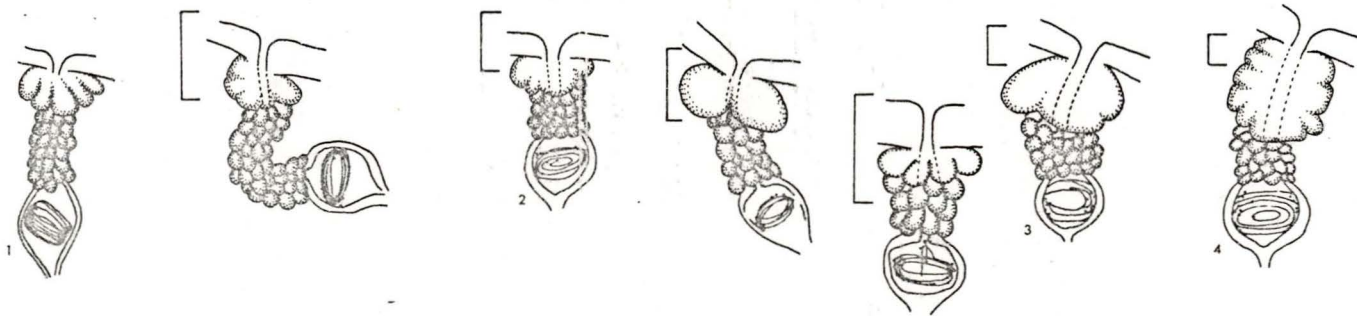
Table 11. Characteristics of some morphologically similar Lumbricillus species recorded from North Pacific coasts, including L. curtus n. sp., L. belli Tynen and L. qualicumensis Tynen from British Columbia.

Spermathecae redrawn from 1. Tynen, 1969a; 2. Shurova, 1977, fig. 2; 3. Shurova, 1977, fig. 4; 4. Shurova, 1977, fig. 1; or drawn from recent British Columbia material.

SPECIES

CHARACTER	<u>belli</u> Tynen	<u>qualicumensis</u> Tynen as amended	<u>ignotum</u> Shurova	sp. - with many nephridia	<u>curtus</u> n. sp.	<u>similis</u> Shurova	<u>corallinae</u> Shurova	
length (mm)	5-8	10	7-10	8-10	7	5	7-8	12-15
no. segments	26-38	30-36	30-42	40-50	39	34,37	38-45	29-35
setal shape	sigmoid	sigmoid	sigmoid	sigmoid	sigmoid	sigmoid	sigmoid	sigmoid
setal lateral distribution ventral	2-4:2-3 3-5:2-4	2-5:2-4 3-6:3-5	2-6:1-5 2-6:2-5	2-4:2-4 3-5:3-5	4-5:3-6 5-7:3-8	2-5:3-6 5-8:3-7	4-6:3-5 5-9:7-13	3-4:3-5 3-5:3-5
clitellum	XII-XIII	1/2XI-XIII or XII-XIII	1/2XI-XIII or XII-XIII	1/2XI-XIII	XII-XIII	XII-XIII	XII-XIII	XII-XIII
origin of dorsal vessel	?	XV	XIII or XIV	XV	XII or XIII	XII	XIII/XIV	XIII
blood colour	pale red	red or pink	yellow	?	?	red	?	rose
sperm funnel L:D	3-4:1	1.5:1	1.2-1.5:1	1.5:1	1.5:1	1.3:1	3:1 in XII	4:1
sperm funnel collar	regular; = funnel	regular; = 1/2 funnel	regular; = 1/2 funnel	regular; = 1/2 funnel	regular; = 1/2 funnel	regular; = funnel	regular; = funnel	regular; = funnel
vas deferens	regular coil, XII	regular coil, XII	regular coil, XII	regular coil, XII	coil, XII	short, not coiled, XII	regular coil, XII	regular coil, XII
ventral bodies	XV-XVI	?	XIV-XV	XIV-XV	XIV-XV, large XVI-XVIII, small	none	XIV-XVI	XIV-XV
brain	?	?	concave	concave	concave	? truncate	concave	concave
cutaneous glands	8 rows / segment (SNMS 3411)	?	6 rows / segment	?	not obvious	not obvious	?	?
ecology	high intertidal; coarse sand under seaweed	high intertidal; coarse sand under seaweed	mid to high intertidal; sand with algae	mid intertidal; rock-sand	upper intertidal; coarse sand; decay- ing algal debris	upper intertidal; rock, sand, silt	mid intertidal; in sand on reefs	mid intertidal; on rocks and reefs with <u>Corallina pilulifera</u>
	Vancouver Island, British Columbia	Vancouver Island, British Columbia	Vancouver Island, British Columbia	northwest Japan Sea (Gulf Last)	Qualicum Beach, Vancouver Island, British Columbia	Hastings Arm off Portland Channel and Neroutsoos Inlet, British Columbia	Gulf of Min; Simushir I., U.S.S.R.	northwest Japan Sea

spermathecae
(each scale line
equals 50 μ m)



third pair lacking, in another one dorsal lobe of third pair lacking, first and second pairs septal glands united dorsally, ventral lobes present for all pairs. Few chloragocytes present from V or IV, dense from VII, tall, granular, not intensely coloured. Lymphocytes small, oval to elongate, nucleate, abundant (Fig.65). Dorsal vessel arises intraclitellar, XII or XIII, blood very faintly coloured in fixed specimens. Anteseptale short, wide, funnel only, postseptale large, elongate, efferent duct wide, terminal (Fig.66). Clitellum extends 1/2XI to XIII, cells small not deep, arranged in particularly noticeable transverse rows ventrally. Seminal vesicles extend through XI, X and IX, 8 or 9 regular pear or club shaped lobes. Sperm funnel cylindrical, bent, length 1.75 to 1.5 x width, sperm collar width just less than funnel, not convoluted (Fig.67). Vas deferens long, narrow, thin walled, arises laterally from narrow end of sperm funnel coiled tightly in XII. Penial bulb small. Spermatheca simple, thick walled (Fig.68), ampulla is a widening of ectal canal. Connected to gut at V/VI by a very short ental canal. Spermatozoa embedded in ampullar walls. Ectal portion of ectal duct covered by small, dense glands, with a distinct, small rosette at ectal pore.

Habitat. In Enteromorpha sp. scraped from rocks and logs at high tide level.

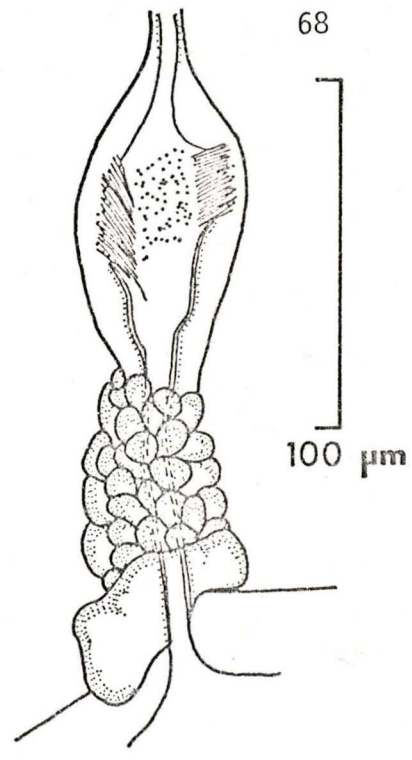
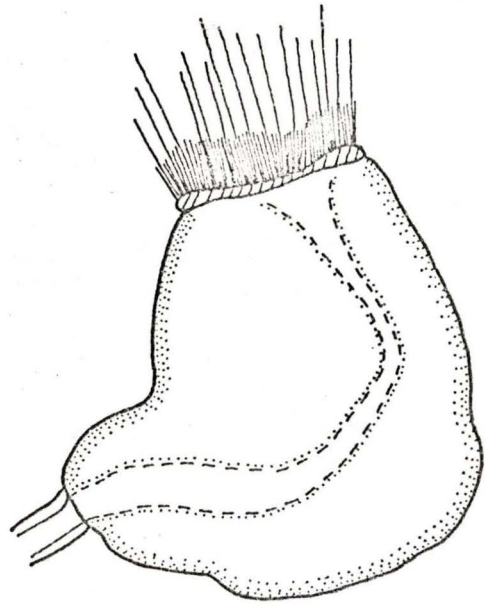
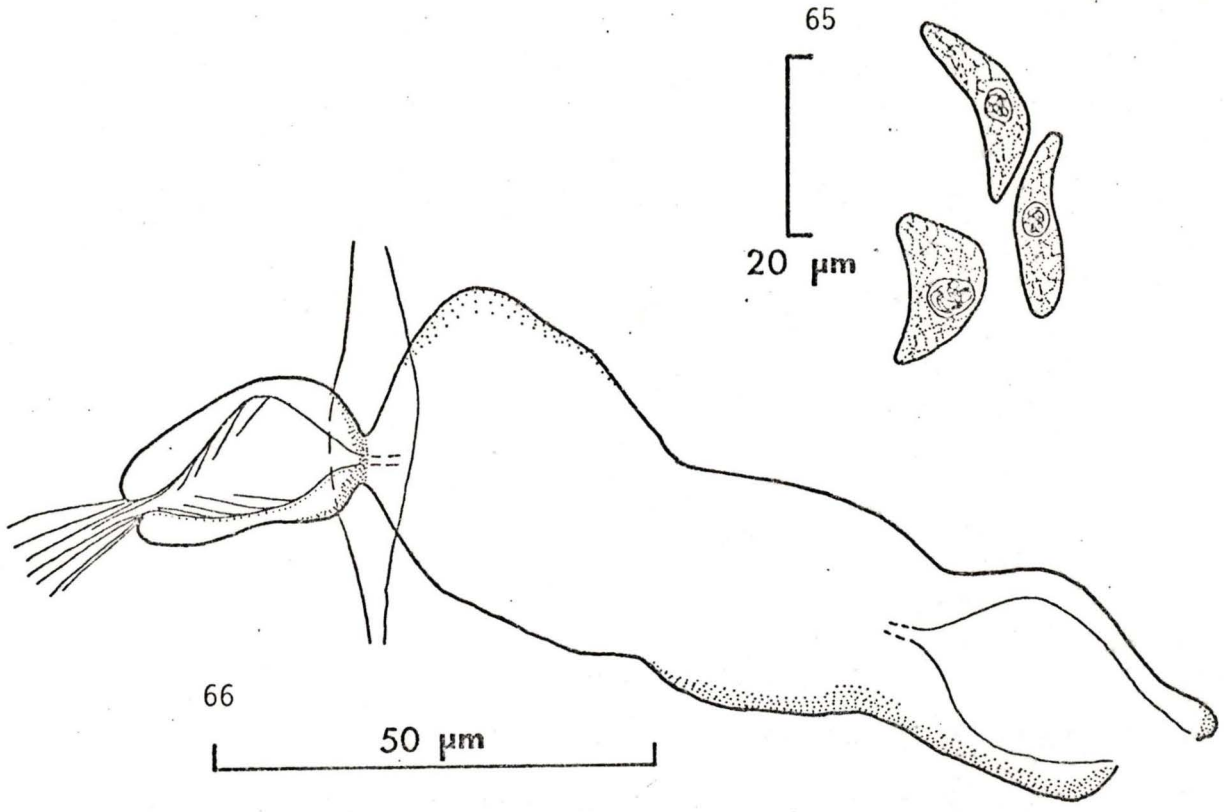
Lumbricillus tsimpseanis

Figure 65. Lymphocytes.

Figure 66. Posterior nephridium, XII/XIV.

Figure 67. Sperm funnel.

Figure 68. Spermatheca.



Distribution. As type locality only; near Prince Rupert, British Columbia (Appendix 1).

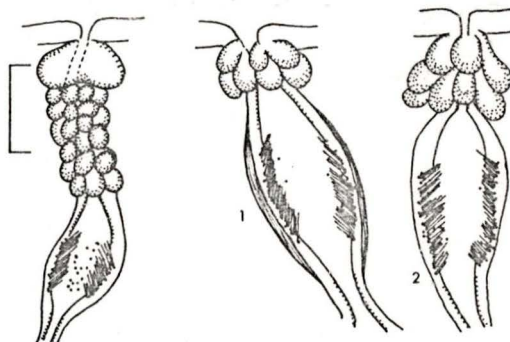
Remarks. Lumbricillus tsimpseanis has many similarities to two marine Lumbricillus species described in 1932 articles by J. Stephenson. L. pumilio (=pumillio, Nielsen and Christensen, 1959) (Table 12) was collected by Stephenson (1932b) on Ascophyllum sp. and Polysiphonia sp. in Wembury Bay, Plymouth, England. L. antarcticus (Table 12) was collected at Wilson Harbour, South Georgia in one or both of two hauls from 15 to 45 and 26 to 38 metres, taken in moss (Stephenson, 1932a). Taxonomically important characteristics of these three species are shown in Table 12. In sperm funnel and spermathecal morphology the species are very similar. For all three species the sperm funnels are short and wide, tapering toward the vas deferens; in L. pumilio and L. tsimpseanis the vas deferens exits from the side of the narrow end of the sperm funnel (Fig.67).

It is noted in descriptions of all the species that spermatozoa are embedded in the thick walls of the ampulla. The relative proportions of the spermatheca of L. tsimpseanis are different from both L. pumilio and L. antarcticus. L. tsimpseanis has the ectal duct of the spermatheca as long as or just slightly longer than the ampulla, the other two species have ducts approximately 2/5 as long as the ampulla (Table 12). All these species have glands surrounding the length of the ectal duct but only L.

Table 12. Characteristics of three small Lumbricillus species.
Spermathecae either redrawn from 1. Stephenson, 1932a;
2. Stephenson, 1932b; or drawn from recent British
Columbia material.

CHARACTER	SPECIES		
	<u>tsimpseanis</u> n. sp.	<u>punilio</u> Stephenson	<u>antarcticus</u> Stephenson
length	5	2-3	6-7
no. segments	29, 31, 33	23-25	35-38
setal shape	sigmoid	sigmoid	sigmoid
setal distribution lateral	1-3:1-5	4-6:4-6	3-5:2-5
setal distribution ventral	2-5:2-5	6-7:5-7	3-7:3-6
clitellum	1/2XI-XIII	XII-XIII	XII-XIII
origin dorsal vessel	XII/XIII	XII *	XIII
nephridia, ectal duct	short, distinct, terminal	short, distinct, not terminal	long ($\geq 1/2$ post-septale), terminal
sperm funnel L:D	1.5-1.8:1	1-2:1	1.2-1.3:1
origin vas deferens	lateral	lateral	terminal
ecology	high tide; in <u>Enteromorpha</u> sp. on logs and rocks	upper intertidal; <u>Polysiphonia</u> & <u>Ascophyllum</u>	subtidal (?) "moss dwellers"
	near Prince Rupert, B.C.	Wembury Bar, Plymouth, England	Wilson Harbour, South Georgia

spermathecae
(scale line equals 50 μ m)



* Information from Cernovitov unpublished manuscript

tsimpseanis has a small, distinct rosette of glandular cells at the ectal pore.

Unlike L. pumilio, the duct of the nephridia of L. tsimpseanis is distinct, and it is short and directed posteriad, not elongate as in L. antarcticus.

Only three partially mature specimens of L. tsimpseanis were obtained; all of these specimens had sperm in the ampulla of the spermatheca but eggs were not present in the body. Some characteristics of the species may not be well defined because they only reach their fullest state of development in completely mature worms.

Lumbricillus curtus n. sp. Fig.69-72, Plate
4d-e, Table 11.

Etymology. Curtus, Latin: shortened.

Type material. Holotype: whole mounted specimen; stained with borax carmine, permanently mounted in Canada balsam.

Type locality. Port Alice, Neroutsos Inlet, Vancouver Island, British Columbia, 50° 28.81'N at 127° 34.10'W; upper intertidal; June 19, 1978.

Material examined. One specimen as type; a second specimen, collected June 22, 1977 in Hastings Arm off Portland Channel, British Columbia, 55° 34.85'N at 129° 48.30'W.

Description. Very small intertidal specimens, approximately

5 mm long, with 37, 34 segments. Setae sigmoid, long, robust, bundles fan-shaped.

Distribution: preclitellar lateral: 2 - 5,
 " ventral: 5 - 8,
 postclitellar lateral: 3 - 6, and
 " ventral: 3 - 7.

Brain probably truncate posteriorly. Three pair septal glands present, all with ventral lobes, first or first and second pairs united broadly, third pair may or may not be narrowly united, ventral lobes of third pair extend posteriorly into VII (Plate 4d), margins lobed.

Chloragocytes nucleate, granular, dense, present from V, dense from VII, cells small, rounded, low. Lymphocytes small, ellipsoidal, nucleate, granular, abundant (Fig.69).

Dorsal vessel arises XII, blood red in living specimen (Port Alice). Anteseptale consists of funnel only, postseptale pear shaped, efferent duct varies from terminal to just subterminal, postero-ventral (Fig.70). Clitellum very thin, over segments XII to XIII, no noticeable gland cell pattern. Sperm funnel length 1.3 x width, collar regular, just less than funnel width (Fig.71). Vas deferens relatively short, with only 1 or 2 loose loops in XII, enters penial bulb laterally, near ectal edge of bulb. Penial bulb about same size as sperm funnel. Seminal vesicle, with 6 or 7 small, regular lobes, confined primarily to X with part of one lobe in XI. Spermatheca

simple, attached, apparently not connected, to gut at 1/2V (Fig.72 and Plate 4e). Ectal duct surrounded by fairly large, dense glands, rosette of 5 or 6 low, rounded cells at ectal pore. Ampulla round, thick-walled, ampullar cavity distinct, filled with a swirl of sperm which also extends into ectal canal.

Habitat. At type locality, upper intertidal in mixed sediments.

Distribution. As material examined.

Remarks. With regard to the number of mature specimens obtained this is a poorly described Lumbricillus species. Nevertheless, it is distinctive within Lumbricillus on account of the point of attachment of the spermatheca to the oesophagus; the extent and conformation of the septal glands; the small size of the sperm funnel and vas deferens; and setal distribution. A table of comparison of L. curtus n. sp. to other similar (in some characteristics) species serves to show that it is best designated as a new species (Table 11).

L. curtus is similar to L. semifuscus (Claparède, 1861) augm. (Stephenson, 1911) in possessing posteriorly enlarged ventral lobes on the third pair of septal glands but more significantly the relative dimensions and other details of the spermathecae serve to distinguish these two

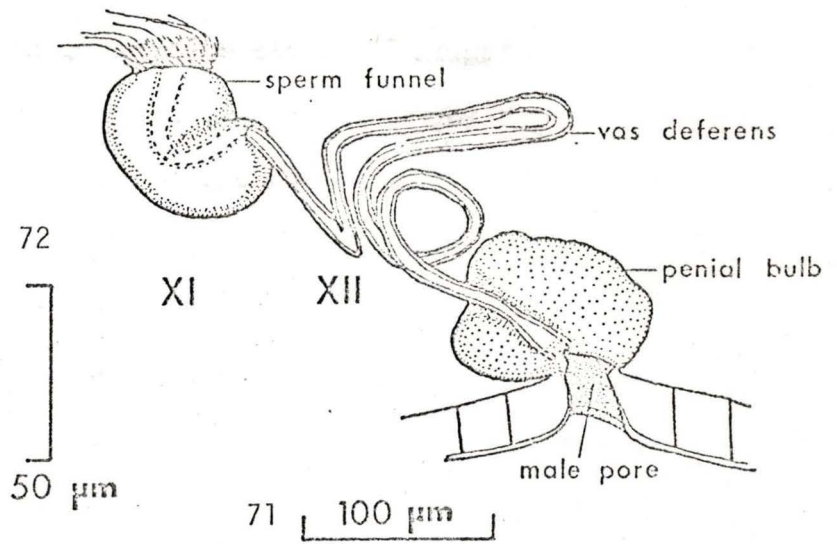
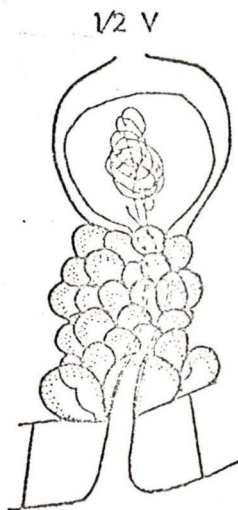
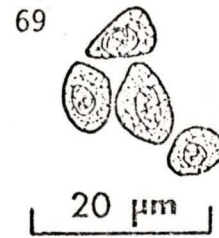
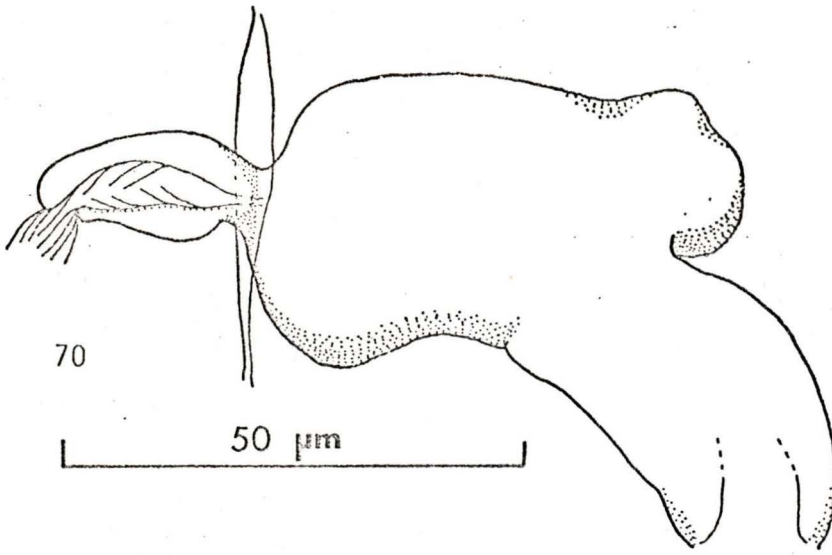
Lumbricillus curtus

Figure 69. Lymphocytes.

Figure 70. Anterior nephridium.

Figure 71. Male efferent apparatus.

Figure 72. Spermatheca; attached to
oesophagus at 1/2V.



species.

Because only two mature specimens of L. curtus were obtained and described the ranges of variation of different characteristics are unknown.

Lumbricillus rupertensis n. sp. Fig.73-77, Table 7.

Etymology. Named after location of collection of type specimens, in the vicinity of Prince Rupert, British Columbia.

Type material. Holotype: mounted whole in Canada balsam; stained with borax carmine; Paratypes: 9 whole specimens from same general geographic location as holotype; stained with borax carmine; 3 mounted permanently.

Type locality. Holotype: near Prince Rupert, British Columbia, 54° 13.58'N at 130° 18.02'W, intertidal, 22 to 24 August, 1974. Paratypes: general location as holotype; specifically, 54° 14.22'N at 130° 20.01'W - 3 specimens, 54° 13.58'N at 130° 18.02'W - 1 specimen in addition to holotype, 54° 13.58'N at 130° 16.21'W - 5 specimens, August 22 to 24, 1974. Sampling locations and other observations are reported on in Fisheries Research Board of Canada Manuscript Report Series #1345 (Levings, etal, 1975).

Material examined. Holotype and paratypes.

Description. Small intertidal species, 8 to 10 mm, with 33 to 41 segments, usually 39. Cutaneous glands in obvious rows anteriorly. Head pore just anterior to 0/I. Setae sigmoid, without nodulus (Fig.73).

Distribution: preclitellar lateral: 3-5,
 " ventral: 4-6,
 postclitellar lateral: 2-4, and
 " ventral: 3-6.

Brain deeply concave posteriorly, lateral margins converge anteriorly, length approximately 2 x width. Three pair septal glands present, all with ventral lobes, all united dorsally, third pair only narrowly. Chloragocytes from VI, faint gold, posterior to clitellum, cells large, dense, not deeply coloured. Lymphocytes small, elliptical, nucleate, reasonably numerous, length 1/4 to 1/3 seta length. Dorsal vessel arises posterior XIII to XIV. Blood yellow in fixed specimens. Anteseptale small, funnel only, postseptale large, rounded, efferent duct short, wide, postero-ventral (Fig.74). Clitellum extends XII to XIII, not covering most posterior of XIII, cells deep, granular, dense, distribution irregular, not as dense ventrally. Seminal vesicles regularly lobed in XI to posterior IX, about six lobes. Sperm funnels tapered to duct end (Fig.75), length about 1.5 x width, about 1/2 body width, collar just less than funnel width, regular. Vas deferens tightly coiled in XII, not very long or very narrow. Penial bulb small, sphaerical.

Two or three developing eggs present at one time. Small ventral bodies in XIV and occasionally in XV. Spermathecae (Fig. 76 and 77) in the most mature specimens with a single medio-lateral ampullar diverticulum, ampulla attached to gut at apex of diverticulum. Ental and ectal ducts not distinct, no distinct ampullar cavity. Spermatozoa embedded in the thick walls of the ampulla proper and of the diverticulum. Lobed, medium sized rosette of fused glands at ectal pore, no glands along ectal duct.

Habitat. Intertidal; finer silty sediments, with much wood debris.

Distribution. As material examined; near Prince Rupert, British Columbia, in the vicinity of the Port Edward kraft process pulp mill.

Remarks. L. rupertensis n. sp. is similar in number and shape of setae to several other Lumbricillus species including L. lineatus, L. fennicus Nurminen, 1964, L. alaricus Shurova, 1974, and L. imakus, Nurminen, 1970b (Table 7). In sperm funnel ratio it is most similar to L. fennicus and L. alaricus; however, of these two species, L. fennicus has characteristically a divided or lobed sperm funnel.

The characteristic morphology of the spermathecae of L. rupertensis, an indistinct ampullar cavity and only a

Lumbricillus rupertensis

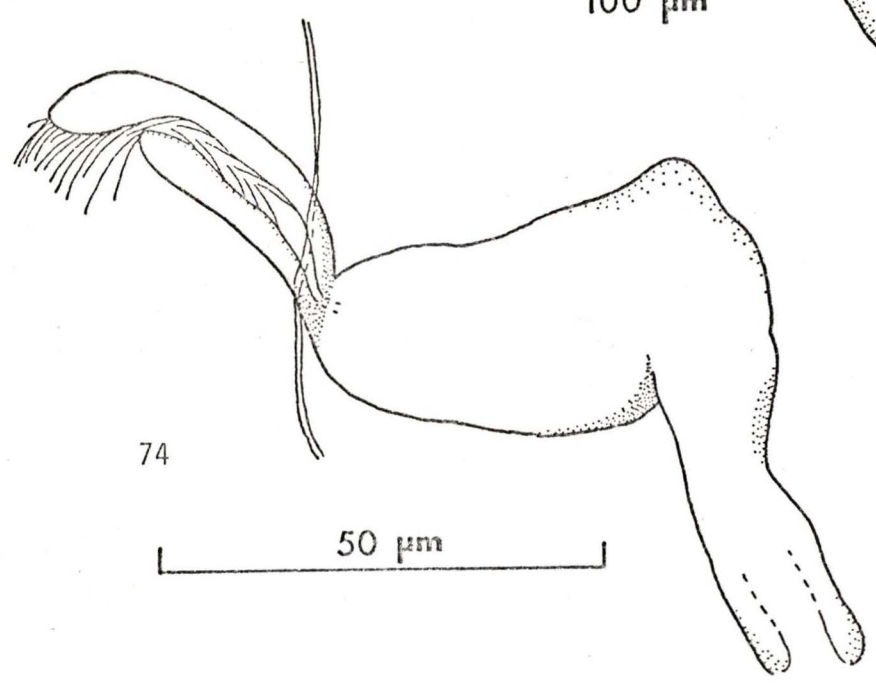
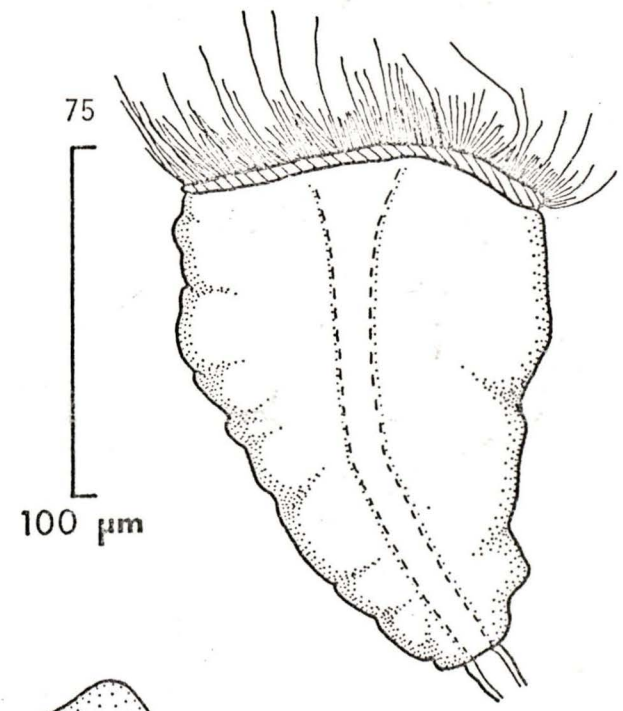
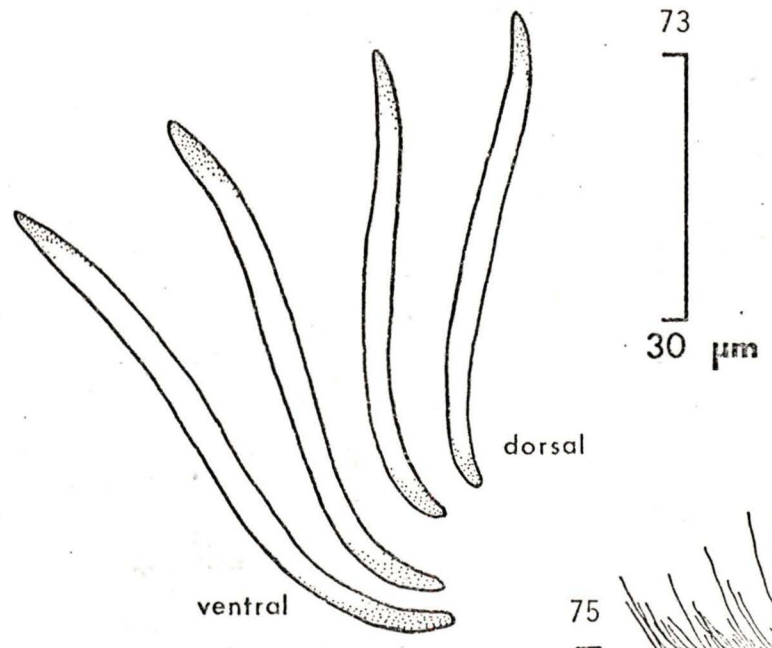
Figure 73. Anterior lateral setal
bundle, VIII.

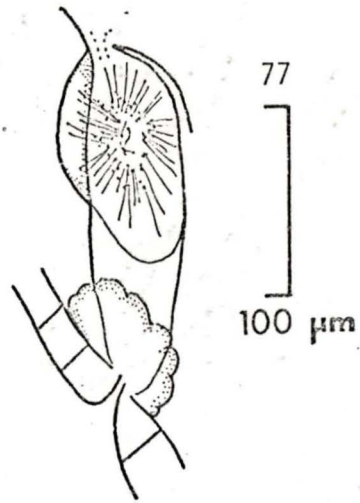
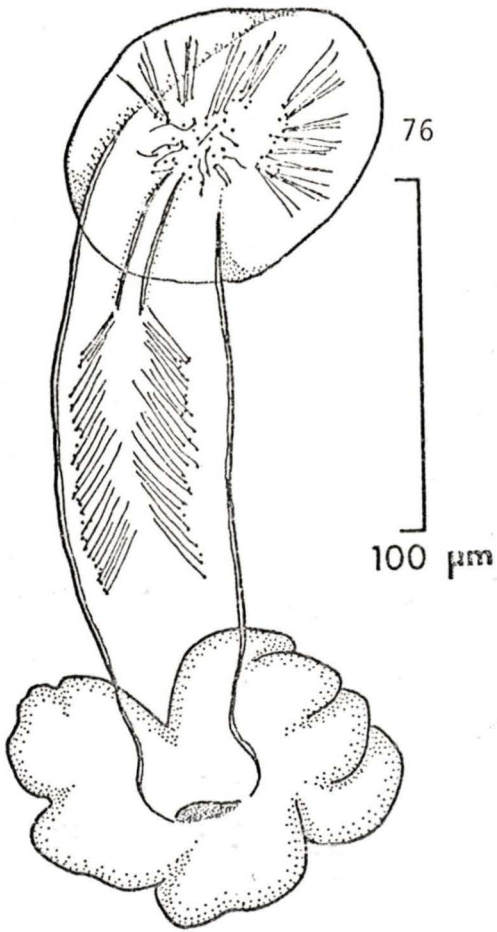
Figure 74. Anterior nephridium, VIII/IX.

Figure 75. Sperm funnel.

Figure 76. Spermatheca, lateral.

Figure 77. Spermatheca, dorsal.





crown of lobed glands around the ectal pore, is similar to all of L. lineatus, L. fennicus and L. alaricus (Table 7). However, the actual gestalt of the spermathecal ampulla of L. rupertensis, similar to L. sterreri Lasserre and Erséus, 1976, a globular diverticulum attached to the ampulla at or lateral to the junction with the oesophagus, is unique for L. rupertensis.

Lumbricillus sp. - characterized by presence of
nephridia in virtually all body segments

Fig.78-81, Table 11

Material examined. One mature specimen, with eggs; stored in 70% alcohol with 10% glycerin. Collected at Little Qualicum Beach, Vancouver Island, British Columbia: 49° 21.38'N by 124° 26.50'W; at high tide mark, 4.8 metres. June 10, 1976.

Description. Small, intertidal specimen, 39 segments. Setae distinctly sigmoid, bundles fan shaped, with most ventral and most dorsal setae being the shortest.

Distribution: preclitellar lateral: 4-5
 " ventral: 5-7
 postclitellar lateral: 3-6 and
 " ventral: 3-8

Brain emarginate posteriorly. Three pair septal glands present, all with ventral lobes, third pair does not appear to be united in this specimen. Chloragocytes tall, dense,

not highly coloured or granular, present from V. Lymphocytes nucleate, granular, $1/2$ or $1/3$ length of preclitellar lateral seta, tear to oval shaped (Fig.78). Dorsal vessel arises intraclitellar. Nephridia present from II/III to end of body with exception only of X/XI and XII/XIII. Anteseptale small consists of funnel only, postseptale egg shaped, very large, efferent duct arises subterminally, very long and wide relative to size of postseptale (Fig.79). Clitellum dense, over XII to XIII, gland cells not in regular arrangement, absent mid-ventrally between penial bulbs. Seminal vesicle with about 16 regular lobes, extending through XI to IX. Sperm funnel cylindrical, length $1.5 \times$ width, collar width approximately $1/2$ funnel width (Fig.80). Vas deferens narrow, coiled in XII. Penial bulb of average size. Large ventral bodies occur in XIV to XV, smaller bodies in XVI to XVIII. Spermathecae simple, without diverticula, ampulla oval shaped, thin walled (Fig.81), with a central ring of sperm. Dense glands along ectal duct, large rosette at ectal pore, distinctly lobed entally. Ampulla attached to oesophagus at V/VI (?connected).

Habitat. Upper intertidal; in coarse sand mixed with decaying algal debris; near a fresh water effluent; found with L. mirabilis, Enchytraeus kincaidi and Marionina trevori.

Lumbricillus sp. - with many nephridia

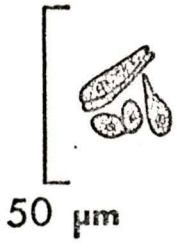
Figure 78. Lymphocytes.

Figure 79. Nephridia.

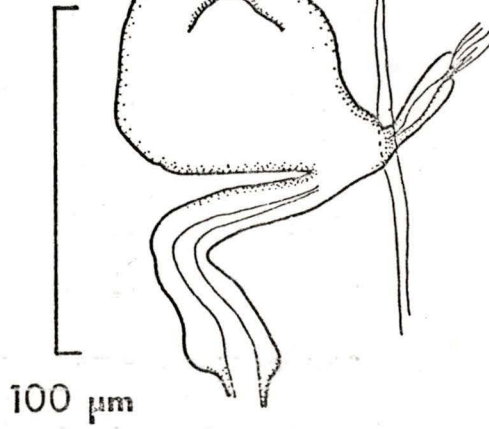
Figure 80. Sperm funnel.

Figure 81. Spermatheca.

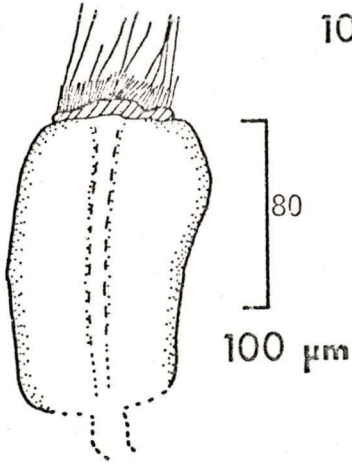
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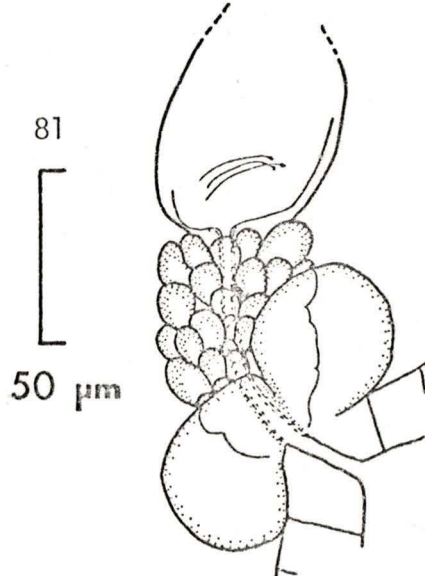
79



80



81



Distribution. Little Qualicum Beach only, as material examined.

Remarks. This Lumbricillus species requires further collection and probably amendments to its description before it could be proposed as a valid, distinct taxon. The most unusual characteristic of this specimen is the presence of large nephridia in most body segments. Table 11, including Lumbricillus sp., illustrates similarities of this specimen to other smaller Lumbricillus species, some also described from this coast.

Lumbricillus sp. is similar in general morphology of the spermatheca and sperm funnel to a group consisting of L. qualicumensis and L. ignotus (Table 11), which taxa may be synonymous. The setal distribution of Lumbricillus sp. (number of setae per bundle) is higher than for either L. ignotus or L. qualicumensis; the seminal vesicle of Lumbricillus sp. is larger than for either of the previous two species; and the distribution of nephridia found in the single specimen is distinctive. Observations of more specimens would confirm or deny that these are consistent morphological differences and that Lumbricillus sp. should be designated as a new species.

C. Status of other taxa previously recorded from Alaska to California

Specimens of the following taxa were not found in the samples collected for this survey.

Lumbricillus belli Tynen, 1969 Table 11.

Lumbricillus belli Tynen, 1969a, p.392, f.5&7.

Type material. NMNS 3411-3412.

Type locality. Qualicum Beach, Vancouver Island, British Columbia.

Material examined. Longitudinal serial sections, NMNS 3411.

Habitat. Upper intertidal, coarse sand, under seaweed.

Distribution. Type locality only.

Remarks. L. belli might be distinguishable from other species of the genus on the basis of the description given by Tynen (1969a). The existing illustrations of the species are not, however, sufficient and the original description is only adequate, not at all complete.

Examination of serial sections (longitudinal) of type 3411, not the holotype of the taxon but syntype (or paratype) material since two or more worms had been embedded together and sectioned simultaneously, yielded a little additional information. The clitellum, which extended over

segments XII to XIII, was not complete ventrally; the sperm duct was coiled regularly in XII; cutaneous glands were distributed in as many as 8 transverse rows per anterior segment; and the efferent ducts of the nephridia arose postero-ventrally. It was not possible to confirm the presence of ventral bodies on the ventral nerve cord in XV and XVI.

L. belli is distinguished from L. qualicumensis Tynen, taxa Tynen (1969a) found together, by the colour of chloragogen inclusions, size, setal distribution, length to diameter ratio of the sperm funnels, relative width of the sperm funnel collar, and seminal vesicle morphology (Table 11). Shurova (1977) has recently described three species from the far-eastern seas of the U.S.S.R. which are very similar to both of L. belli and L. qualicumensis, particularly with regards to the morphologies of the spermathecae. A comparison of these species in Table 11 illustrates the many interspecific similarities. Characteristic complexes of size, setal distribution and sperm funnel dimensions distinguish most of the species included in the Table.

Specimens fitting L. belli were not found in sediment samples collected in 1976 at Qualicum Beach in the general vicinity of the type locality. However, several specimens determined to be within the taxon Lumbricillus qualicumensis were obtained in those samples (Qualicum

Beach, see Appendix 1).

Lumbricillus franciscanus Eisen, 1904.

Lumbricillus franciscanus Eisen, 1904, pp.86-88,
f.55-57, pl.XIII f.1.

Pachydrilus (Pachydrilus) franciscanus:

Cernosvitov, 1937a, p.292.

Lumbricillus franciscanus: Nielsen and
Christensen, 1959, p.96.

Type material. CASF, typus amissus (Appendix 5).

Type locality. Santa Clara River, California.

Habitat. Moist soil of river bank.

Distribution. As type locality only.

Remarks. L. franciscanus Eisen, 1904 is not described in the specific form from an intertidal or marine habitat but other forms of the species were subsequently found in such habitats in Alaska (Eisen, 1904). There are some similarities between L. franciscanus and three species described by Ude (1896), L. americanus, L. insularis, and L. maritimus, from locations in South America. The morphology of the spermatheca of L. franciscanus distinguishes it from this group of three species.

Stephenson (1922a) thought that his species L. aegialites, subsequently synonymized with L. pagenstecheri

sensu Nielsen and Christensen (Nurminen, 1965a), was not unlike L. franciscanus. On the basis of existing descriptive material, it seems that the glandular arrangements around the spermathecal ectal ducts of the two species, L. franciscanus and L. pagenstecheri, are distinctively different. L. franciscanus is not known to have a distinct basal rosette of glands at the ectal pore.

Lumbricillus franciscanus var. borealis Eisen,
1904

Lumbricillus franciscanus var. borealis Eisen,
1904, pp.88-89, f.58.

Pachydrilus (Pachydrilus) franciscanus var.
borealis: Cernosvitov, 1937a, p.292.

Lumbricillus franciscanus var. borealis: Nielsen
and Christensen, 1959, p.96.

Type material. UWMS, note: this material was not located during a visit to the named institute.

Type locality. St. Paul Island, Pribilof group, Alaska.

Habitat. Not stated.

Distribution. As type locality.

Remarks. The description and erection of this taxon as a form of the species L. franciscanus was based on two mature specimens. The individuals of the species are long, thin

worms, of the form more robust animals; in the species the setae of a bundle are approximately equal in length, in this form the setae are of graduated lengths (Eisen, 1904). Eisen examined so few specimens of the form that it was not possible to determine any morphological variation occurring within this taxon and on the basis of the scanty morphological details in Eisen's (1904) description it is not determinable whether this is a taxon of the specific, subspecific, or infrasubspecific level in accordance with I.C.Z.N. (1961) regulations.

The location and habitat information that Eisen (1904, p.89) gave for L. franciscanus var. borealis is not exact and it was not possible to determine whether the specimens were found in terrestrial, intertidal or fresh water habitats. Since the greatest diversity of Lumbricillus species is found in intertidal habitats it is not unreasonable to suppose that these specimens were found there.

Lumbricillus franciscanus var. unalaskae Eisen,
1904

Lumbricillus franciscanus var. unalaskae Eisen,
1904, pp. 89-90, f.59.

Pachydrilus (Pachydrilus) franciscanus var.
unalaskae: Cernosvitov, 1937a, p.292.

Lumbricillus franciscanus var. unalaskae: Nielsen

and Christensen, 1959, p.96.

Type material. UWMS, note: as previous taxon.

Type locality. Unalaska, Unalaska Island, Aleutian group, Alaska.

Habitat. Not stated.

Distribution. As type locality.

Remarks. The shape of the setal bundles of the form L. franciscanus var. unalaskae is similar to that of the species. Relative body dimensions of this taxon are between those of the species and of the form L. franciscanus var. borealis. Other comments made with regard to L. franciscanus var. borealis also apply to this variety and it too should be considered a taxon of, at present, indeterminate position.

Lumbricillus merriami Eisen, 1904

Lumbricillus merriami Eisen, 1904, pp.79-81, f.47-48, pl.XII f.5.

Pachydrilus (Pachydrilus) merriami:

Cernosvitov, 1937a, p.292.

Lumbricillus merriami: Nielsen and Christensen, 1959, p.97.

Type material. USNM 5149, 21108.

Type locality. Metlakatla, 4th June, 1899, or Popof Island, June, 1899, Alaska.

Material examined. Both syntype series of Lumbricillus merriami Eisen, USNM 5149 from Popof Island and USNM 21108 from Metlakatla, were examined.

Habitat. Intertidal under decaying seaweeds.

Distribution. Type localities only.

Remarks. USNM 21108 consisted of two specimens which were very deep red, almost opaque in xylene, possibly due to fixation or staining processes. Morphological observation of the whole specimens was virtually impossible. However, the setae were seen to be straight with bent ental ends and the seminal vesicles were massive and unlobed, not lumbricilline.

Syntype 5149 consisted of two specimens, only one a mature Lumbricillus sp.. The one mature specimen was lacking O-V so that its specific status was indeterminable. Eisen (1904) stated that Professor Trevor Kincaid collected only a single specimen of L. merriami at Popof Island so that it was unexpected to find two specimens in syntype series 5149.

L. merriami as described by Eisen is similar in many morphological characters to both L. annulatus Eisen

and L. nipponicus Yamaguchi (Table 10). The relative dimensions of the spermatheca of L. merriami are different than those of the above mentioned species, with the ampulla being somewhat longer relative to the length of the ectal duct. The vas deferens of L. merriami is shorter than that of L. annulatus. The L:D of the sperm funnel is 3:1 for L. merriami, slightly longer than 2-3:1 for L. annulatus. As L. annulatus the anterior parts of the postseptale of the nephridia are covered by wartlike projections (Eisen, 1904) (note: even in the type material of L. annulatus the anterior part of the postseptale was at most noted to be granular). With respect to habitat this group of three species is very similar (Table 10).

The specific status of L. merriami is considered to be unstable and investigation of material from either type locality is desirable.

Lumbricillus merriami var. elongatus Eisen, 1904.

Lumbricillus merriami var. elongatus Eisen, 1904,
p. 81, f.49, pl.XII f.6.

Pachydrilus (Pachydrilus) merriami var.

elongatus: Cernosvitov, 1937a, p.292

Lumbricillus merriami var. elongatus: Neilsen
and Christensen, 1959, p. 97.

Type material. CASF, typus amissus. See explanatory
letter in Appendix 5.

Type locality. Metlakatla, Alaska, 4 June 1899.

Habitat. Intertidal, under seaweed (with specific form).

Distribution. Type locality only.

Remarks. The sperm funnels of L. m. var. elongatus
are of notably different relative dimensions than those
of the species (Eisen, 1904. 'globular' p. 81); setal
distribution is quite different from that of the species;
the testes have fewer lobes and the relative dimensions
of the spermathecae are different. If it had been
indicated by Eisen that the specimens of L. merriami
and L. m. var. elongatus examined were at the same level
of sexual organ development then it would be justified
to consider these taxa as two distinct species. Since
this information is not available at this time it is
not possible to resolve these two taxa and L. m. var.
elongatus must be considered as a taxon inquirendum.

Marionina Michaelsen, 1889

Pachydrilus (partim) Claparede, 1861, p.75

Marionia Michaelsen, 1889, p.28.

As discussed by Brinkhurst and Jamieson (1971, pp.662-663), Marionina not Enchytraeoides Roule, 1888 is the correct name for the assemblage of species typified by Pachydrilus georgianus Michaelsen, 1888. The genus Enchytraeoides was erected by Roule (1888) for an inadequately described species Pachydrilus enchytraeoides St. Loup, 1886. Without completing the description provided by St. Loup, Roule renamed the species Enchytraeoides marionii. The type species, Enchytraeoides marionii (St. Loup, 1886), of Enchytraeoides has remained a dubious species and Enchytraeoides is therefore not appropriate as an alternative to or synonym of Marionina.

The genus Marionina is identical with the enchytraeid genus Marionia (Michaelsen, 1889a) as the original name was proposed. The spelling of the enchytraeid genus name was altered because Marionia was already in use as a generic name of some tritonid snails (Ude, 1896, p.17).

Diagnosis of the genus

Taxonomic decisions regarding Marionina were made according to the following diagnosis by Nielsen and Christensen (1959), the most complete and homogenous diagnosis available.

Type species: Pachydrilus georgianus Michaelsen, 1888.

"Setae straight in most species but distinctly sigmoid in some; nodulus absent; the number of setae per bundle is variable but

usually low. Setal bundles may be missing on some segments. Head pore at O/I. Dorsal pores absent. Brain incised posteriorly or rounded. Peptonephridia absent. Oesophageal appendages are usually absent but present in three species and then in segments IV or VI. Intestinal diverticula absent. Three pairs of primary septal glands; secondary glands absent. Dorsal vessel originating in the clitellar region or - more rarely - farther back. Blood mostly colourless but coloured in a few species. Interstitial tissue of the nephridia well developed; anteseptale consisting of funnel and a few coils of the nephridial canal, rarely of funnel only; efferent duct usually arising in the posterior region of the postseptale but the origin may be variable in some species according to the segments considered. Testes are small and compact, a well developed seminal vesicle is usually absent. Sperm duct [vas deferens] usually long and narrow. Penial bulb present. Atrial glands absent. The spermatheca with or without diverticula and usually attached to the oesophagus, in a few species free. Glands are usually associated with the spermatheca along the ectal duct, at the ectal aperture or in either of these positions. Usually small species inhabiting marine, limnic or terrestrial habitats" (Nielsen and Christensen, 1959, pp.108-109).

A. Amended descriptions

The following descriptions of known taxa are modified, when necessary, on the basis of the British Columbia material.

Marionina subterranea (Knöllner, 1935)

Fig.82-86, Plate 5a-c.

Michaelsena subterranea Knöllner, 1935,
pp.455-460, f.26-28.

Michaelsena n. sp. von Bulow, 1957, p.95.

Marionina subterranea: Nielsen and Christensen,
1959, pp.110-112, f.132-134.

M. subterranea: Lasserre, 1966, p.315.

M. subterranea: Lasserre, 1971a, p.451-452.

M. subterranea: Lasserre, 1971b, pp.81, f.7.

M. subterranea: Tynen, 1972, p.23, table 1.

M. subterranea: Cook and Brinkhurst, 1975,
pp.143&145.

M. subterranea: Lasserre and Erséus, 1976, p.456.

Type material. Not designated.

Type locality. Kiel Bay, West Germany.

Material examined. 25 mature specimens, with developing eggs
in body. Elk Falls, British Columbia; collected 11 June,
1976. See Appendix 1 for detailed sample location data.

Description. Very small intertidal specimens, fixed length
about 1.5 or 2 mm, with 23-25 segments. Dorsal setae absent
from all segments, but bundles represented by cuticular
pads, pronounced posteriorly. Ventral setae straight, with
blunt points, 2 per bundle. With a deep staining (nuclear
stain) band of cutaneous glands on ventral surface between

setal bundles. Brain truncate or convex anteriorly and posteriorly, length less than 2 x maximum width, lateral margins converging anteriorly (Fig. 82). Transition oesophagus to intestine gradual, without diverticula. Septal glands (Fig.83) present at IV/V, V/VI and VI/VII, all pairs connected dorsally. Large, nucleate lymphocytes abundant. Chloragocytes present from V, cells very large relative to size of worm, possibly just longer than setae. Dorsal vessel arises in XIII, blood colourless in preserved specimens. Few nephridia present, anteriorly in VIII and XI and in one or two segments posteriorly. Anteseptale large, triangular, equals funnel and some of nephridia canal, efferent duct short, wide, terminal (Fig.84). Clitellum thin; large, square gland cells present over XII to XIII or XII to 1/2XIII, cells arranged in transverse rows. Seminal vesicle large, unlobed, extends as far forward as 1/2VIII. Sperm funnel outline (Fig.85) slightly irregular, very large and glandular, length approximately equal maximum width and about .7 x body width XI. Collar narrow, surrounded by cells with large deep-staining nuclei, about 1/3 or 1/2 width of funnel body. Vas deferens tightly coiled in XII, narrow, length probably 2 or 3 x funnel length. Penial bulb very small, just a glandular area through which vas deferens passes, a small external papilla present (?=extruded penial bulb). Two or three large eggs present at one time. Small ventral bodies present in XIII and XIV. Spermathecae small,

simple, attached at 1/2V. Ampulla sac-shaped, irregular outline, most mature specimens with peripheral clumps of sperm, otherwise with an irregular spray in centre of ampullar cavity (Fig.86). Ectal duct and canal distinct, duct surrounded by 6 or 7 large, ectally fused gland cells which extend as a rosette from ectal pore. Spermathecal ectal pores located just anterior to intersegmental furrow IV/V (Plate 5a).

Also noted: "sensory hairs" around anus and regular-shaped "sensory papillae" on antero-ventral part of prostomium (Plate 5, b and c).

Habitat. Littoral and sublittoral, sandy beaches at ground water; meiobenthic (Lasserre, 1971a).

Distribution. Europe: Atlantic, North Sea, Baltic Sea, Black Sea, Mediterranean Sea. North Africa: Tunisia, Algeria. United States: Massachusetts, North Carolina, California. Bermuda.

New Records. Elk Falls, Vancouver Island, British Columbia. See Appendix 1 for details of sample locations.

Remarks. The only differences between the British Columbia specimens and those described by Nielsen and Christensen (1959) are that the B.C. specimens are slightly smaller, only 2 or 3 mm when fixed; there may be as many as three developing eggs present in the bodies of the B.C. specimens

Marionina subterranea

Figure 82. Brain.

Figure 83. Dorsal view of whole mounted specimen, V-VI, showing septal glands.

Figure 84. Nephridium.

Figure 85. Sperm funnel.

Figure 86. Spermatheca.

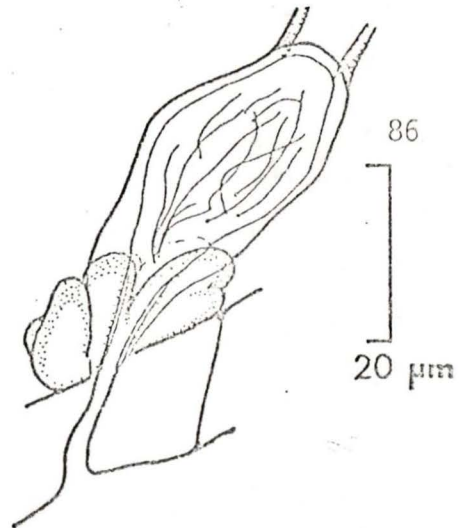
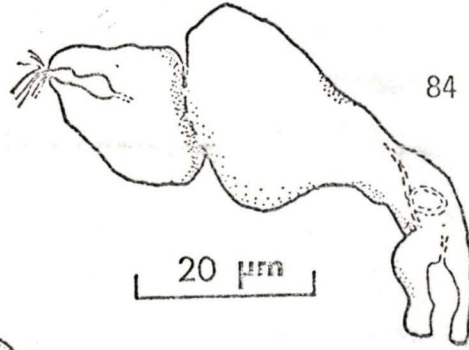
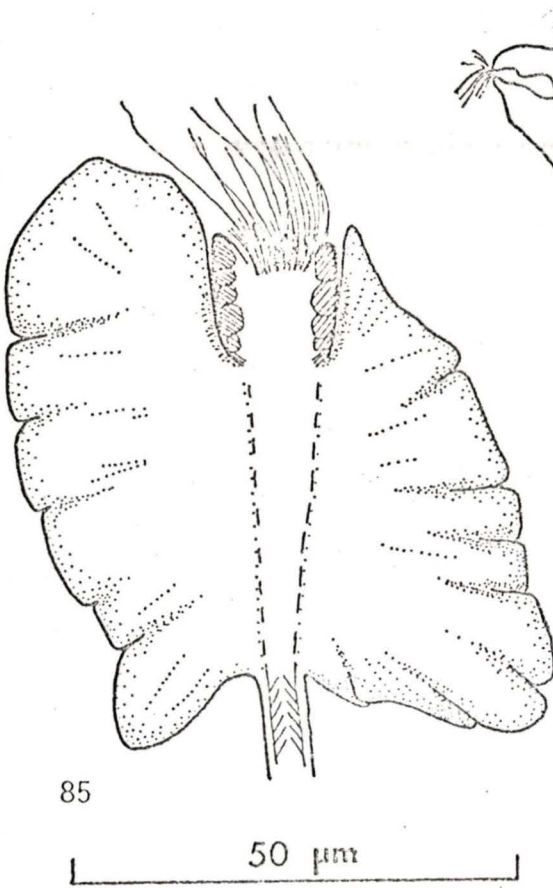
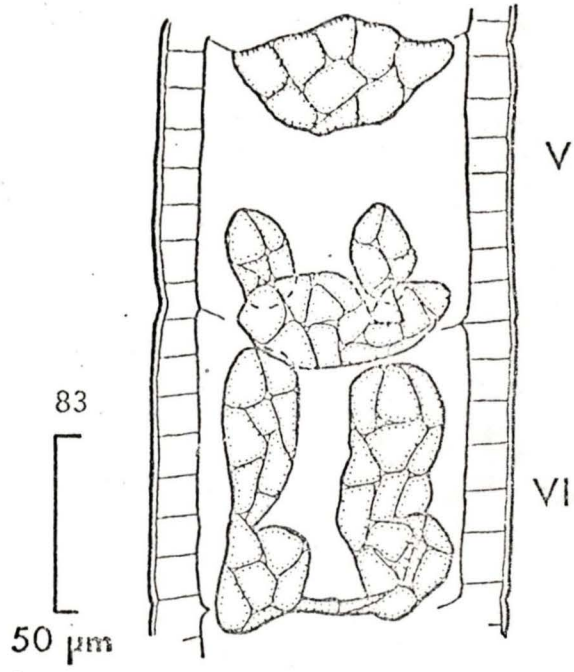
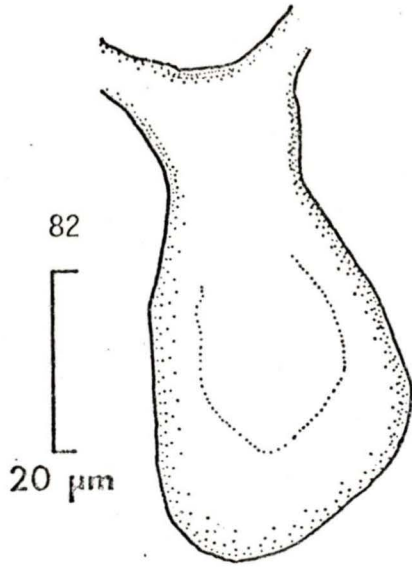


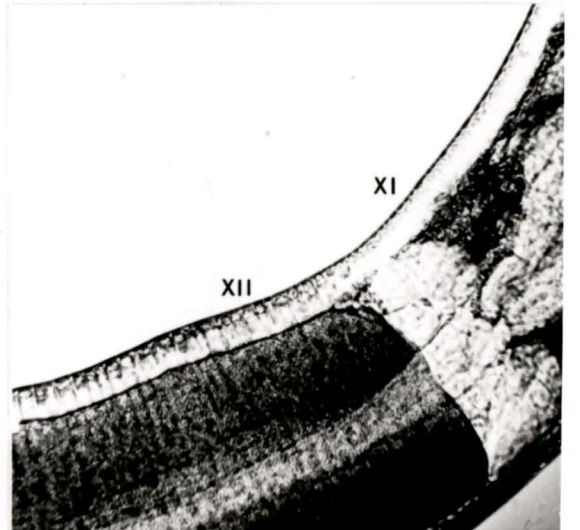
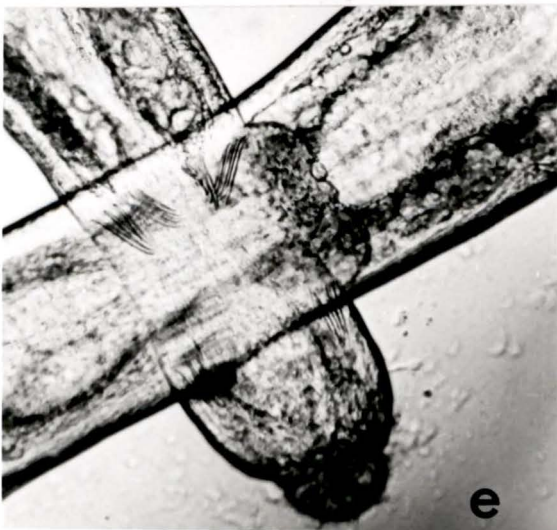
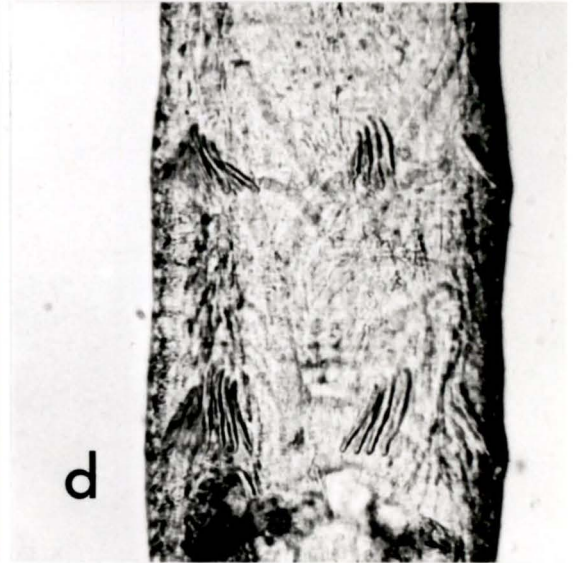
Plate 5. Marionina subterranea (Knöllner), a-c, S.E.M.
photomicrographs.

- a) Spermathecal pore \rightarrow , anterior to intersegmental groove IV/V (x2495);
- b) Sensory 'hairs' around anus, protruding primarily through foreign particles stuck on worm \longleftrightarrow (x4310);
- c) Sensory papillae on prostomium \longleftrightarrow (x1195).

Marionina appendiculata Nielsen and Christensen,

d-f, light microscope photographs of living specimens.

- d) Anterior setal bundles;
- e) Posterior setal bundles;
- f) X-XIII, showing body wall of clitellar region and large egg extending from anterior XII.



at one time; and very small ventral bodies, not noted by Nielsen and Christensen for their European specimens, were found in XIII and XIV of the B.C. specimens. None of these alone or all three combined, justify designation of the British Columbia material as a new taxon.

Marionina appendiculata Nielsen and Christensen,
1959 Fig.87-91, Plate 5d-f.

Marionina appendiculata Nielsen and Christensen,
1959, p.122, f.173-177.

M. appendiculata: Tynen, 1972, p.23, table 1.

Type material. MLFD.

Type locality. Ebeltoft Vig, Denmark.

Material examined. 2 specimens from Tsitika River (Appendix 1); 25+ specimens from Port Alice: June 13, 1976 (Appendix 1) and Drake Island rock, 50° 31.12'N at 127° 27.30'W, May 2, 1978; Old Park, 50° 23.08'N at 127° 27.30'W, May 3, 1978; Brown's Point, 50° 28.81'N at 127° 34.10'W, June 20, 1978; and Jeune Landing, 50° 26.52'N at 127° 29.90'W, June 20, 1978.

Description. Very small intertidal worms, fixed length about 3 mm, with 23 to 28 segments. Setae slightly sigmoid, without nodulus, bundles fan shaped, ventro-medial setae are shortest in bundle (Plate 5, d and e; Fig. 87a).

Distribution: preclitellar lateral: 3-4(6),
 " ventral: 3-5(6),
 postclitellar lateral: 2-4, and
 " ventral: 2-4(5).

Brain slightly convex posteriorly (Fig.88). Transition oesophagus to intestine gradual. No peptonephridia. Three pair septal glands present, IV/V to VI/VII, first pair joined dorsally, without ventral lobes, second also joined dorsally with small ventral lobes, third pair reduced, not joined dorsally. Lymphocytes large, grainy, nucleate, oval (Fig.87b). Chloragocytes present from V, grainy, not deeply coloured, densest posteriorly. Dorsal vessel arises XII/XIII or posterior XIII, blood not coloured in fixed specimens. Nephridia very large, anterior nephridium length about 1/2 of segment length, ectal duct wide arises postero-ventrally or terminally, anteseptale large, probably includes some of nephridial canal (Fig.89). Clitellum extends XII to 1/2XIII, cells not deep, rectangular, arranged in approximately regular rows (Plate 5f). Seminal vesicles absent. Testes small, attached at X/XI, very little sperm present. Sperm funnel very small, length approximately 1/4 width of segment XI, width 1/3 to 1/2 x length (Fig.90). Vas deferens in a tight spiral coil in XII. Penial bulb consisting in these specimens of one compact structure attached to the body wall immediately posterior to male pore; a noticeable, external, ventral

Marionina appendiculata

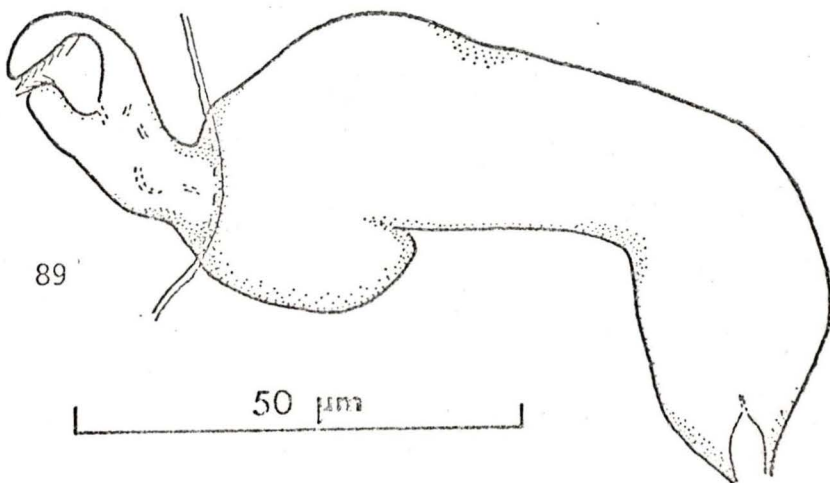
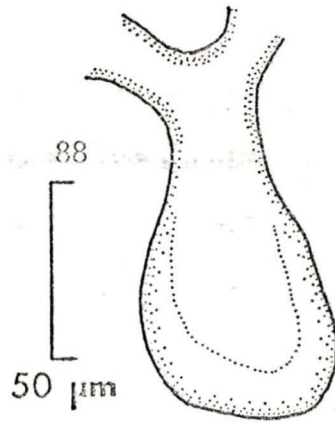
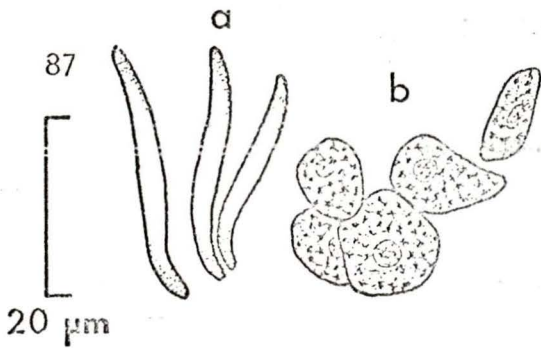
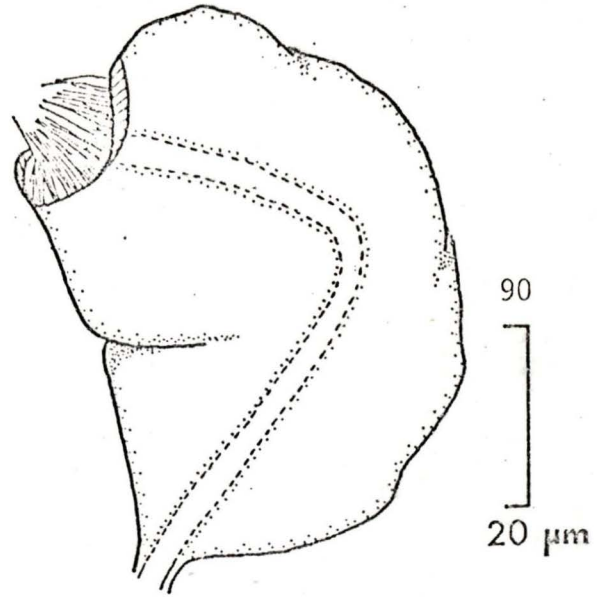
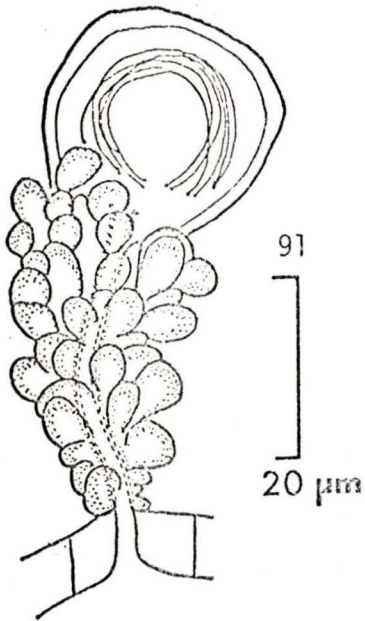
Figure 87. a) Anterior, ventral setal
bundle, VI;
b) lymphocytes.

Figure 88. Brain.

Figure 89. Nephridium.

Figure 90. Sperm funnel.

Figure 91. Spermatheca.



groove present between male pores. Spermathecae somewhat tubular (Fig.91), ectal pores at IV/V, attached to oesophagus at 1/2V. Ectal duct covered by irregular sized, small glands, canal distinct. Ampulla rounded or oval, with thick walls.

Habitat. Coarse sand and among grass roots near high water level.

Distribution. Denmark: Ebeltoft Vig, Kalo Vig. England: Anglesey.

New records. Vancouver Island, British Columbia (Tsitika River and Port Alice - as material examined).

Remarks. The British Columbia specimens differ from those originally described (Nielsen and Christensen, 1959) only in that the third pair of septal glands is usually very small and setal numbers are slightly higher. Additional to the original description, it has been noted that a noticeable groove is found externally on the body wall between the male orifices.

Marionina sjaelandica Nielsen and Christensen,
1961 Fig.92-96, Plate 6a-b, Table 13.

Marionina sjaelandica Nielsen and Christensen,
1961, pp.18-19, f.16-18.

M. sjaelandica: Tynen, 1972, p.23, table 1.

Type material. MLFD, holotype and paratypes.

Type habitat. Mikkeltborg, north of Copenhagen, Denmark.

Material examined. Specimens from Mt. Douglas, Tsitika River, Elk Falls, Long Beach, Port Alice and Ocean Falls. A few hundred specimens, most fixed but some, from Port Alice, alive. For details of collections, location, date and habitat, see Appendix 1 and Environmental monitoring section.

Description. Small intertidal worms, fixed length from about 5 to 7 mm, (22) 28 to 38 segments, most frequently 30 to 34. Setae straight with ental hook, consistently 2 per bundle, very rarely 1 or 3. Lateral setae in II very small and fragile, posterior setae more robust than preclitellar and most posterior (XXX-XXXVIII) approximately 1.5 x as long as most anterior (II-VIII). Brain incised posteriorly, length about 1.5 x width (Fig.92). Transition oesophagus to intestine gradual, gut without diverticula. Septal glands three pairs, IV/V, V/VI and VI/VII, first pair joined dorsally without ventral lobes, second joined dorsally with small ventral lobes, third not joined with elongate ventral lobes (Fig.93). Lymphocytes large, nucleate, grainy, quite abundant, just greater than 1/2 length of lateral setae in III. Chloragogen present from V, denser from VI, chloragocytes grainy, nucleate with refractile globules, large, diameter from 1/3 to 1/2 seta length. Dorsal vessel

arises XII/XIII or anterior XIII, blood colourless in live specimens. Nephridia (Fig.94) present from VII/VIII, anteseptale large, equals funnel plus some of nephridial canal, often greater than $1/3$ as long as postseptale including efferent duct. Efferent duct short, wide, terminal, postseptale lumpy. Clitellum extends XII to $1/2$ XIII, occasionally $1/2$ XII to $1/2$ XIII. Epidermis of clitellum not very deep, gland cells large and square, arranged in transverse rows. Seminal vesicle large, well developed, extends as far forward as IX. Testes attached at X/XI. Sperm funnel (Fig.95) outline somewhat irregular, maximum length up to 1.5 x maximum width, width approximately $1/2$ x width XI. Sperm collar everted, funnel-like. Vas deferens narrow, irregularly coiled in XII, not very long, possibly 2 x as long as funnel. Penial bulb small, compact. (Male pore is seen externally in Plate 6a.) A copulatory gland present in XIV, largest in most mature specimens, excretory tubules through ventral epidermis visible in cleared, whole mounted specimens. As many as 2 eggs present at one time. Spermathecae simple, without diverticula (Fig.96). Ectal duct with a crown of 7 or 8 separate glands around ectal orifice and with small glands along duct. Ampullae irregularly round, about 2 x as long as ectal duct, ental duct about equal in length to ectal, ental canal indistinct. In mature worms there are a number of sperm rings around periphery of ampulla, embedded

in ampullar wall. Spermathecae attached to oesophagus at V/VI. Also noted: that epidermal gland cells were in 7 or 8 distinct transverse rows per segment; that there were prominent "sensory papillae" on prostomium (Plate 6b).

Habitat. High intertidal on coarser gravel-sand beaches, with abundant decaying drift algae.

New Records. In finer sediment habitats of estuarine localities and on coarser sediment beaches.

Distribution. North of Copenhagen, Denmark and Anglesey and Caernarvonshire coastlines, England.

New records. Vancouver Island and mainland British Columbia coasts; wherever appropriate habitat existed. Mt. Douglas, Tsitika River, Elk Falls, Long Beach and Port Alice (Appendix 1).

Remarks. The British Columbia specimens of Marionina sjaelandica are the same as specimens described by Nielsen and Christensen (1961) in the diagnostic characteristics of spermathecal morphology, sperm funnel and other male organ morphologies including presence of a well developed seminal vesicle, and in setal distribution (Table 13).

Some differences, probably attributable both to geographic separation and to genetic, infraspecific variability, do exist between the British Columbia specimens and the originally described, European specimens (Table 13). The B.C. specimens of M. sjaelandica have more segments than

Marionina sjaelandica

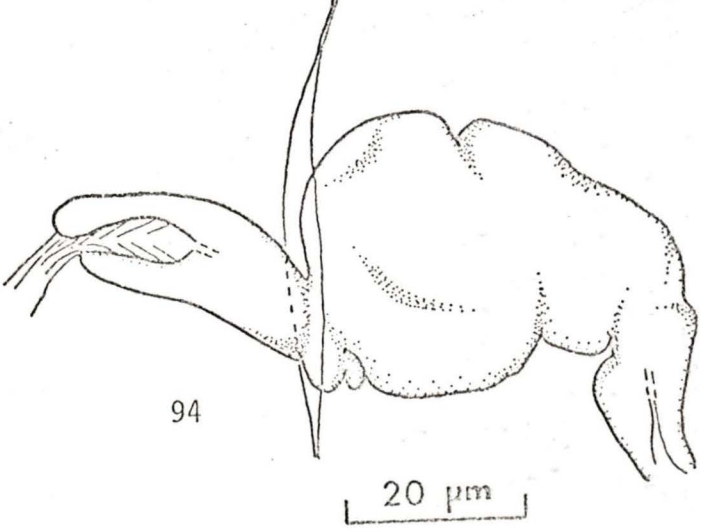
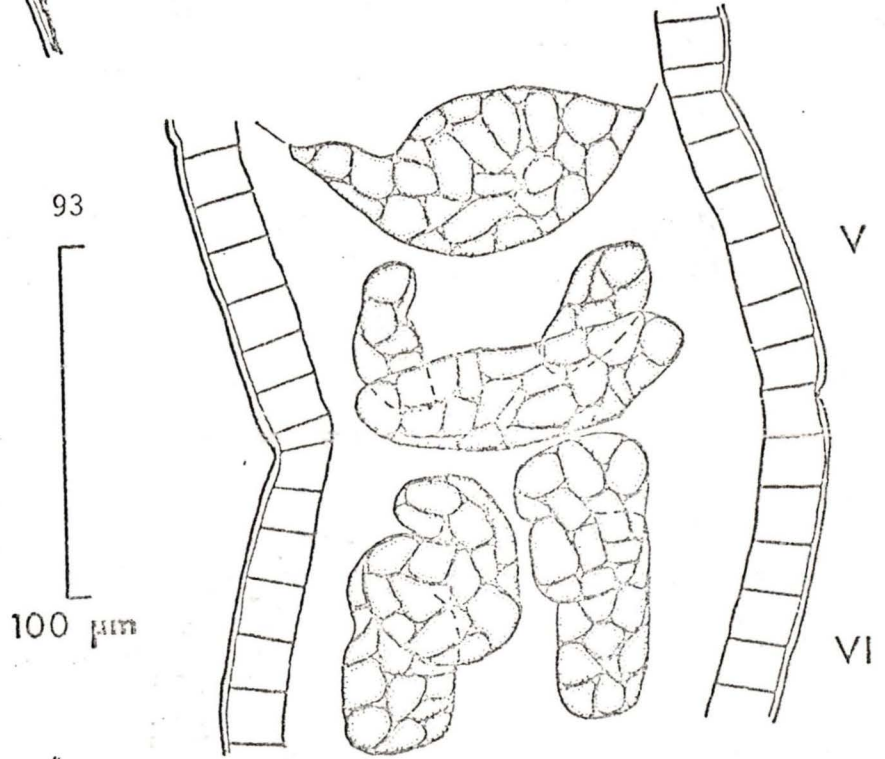
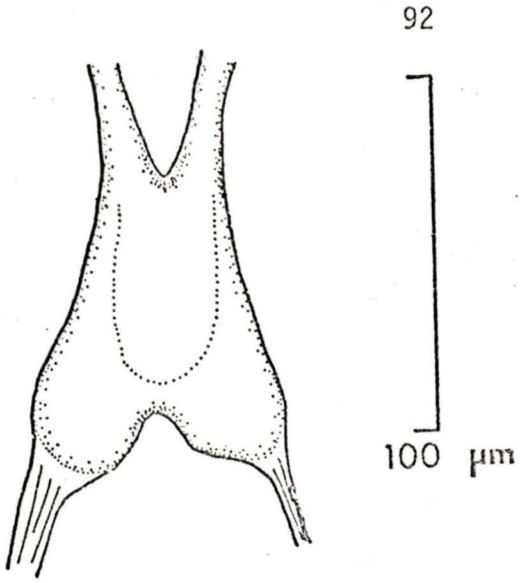
Figure 92. Brain.

Figure 93. Dorsal view of whole
mount, IV-VI, showing
septal glands.

Figure 94. Anterior nephridium.

Figure 95. Sperm funnel.

Figure 96. Spermatheca.



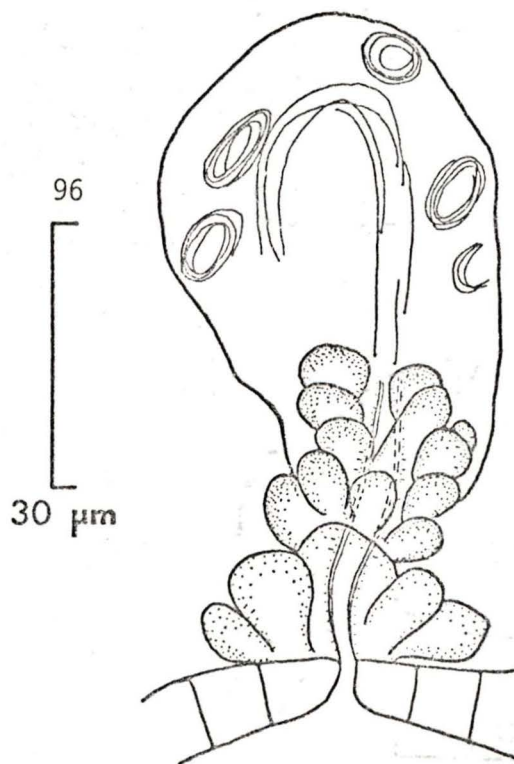
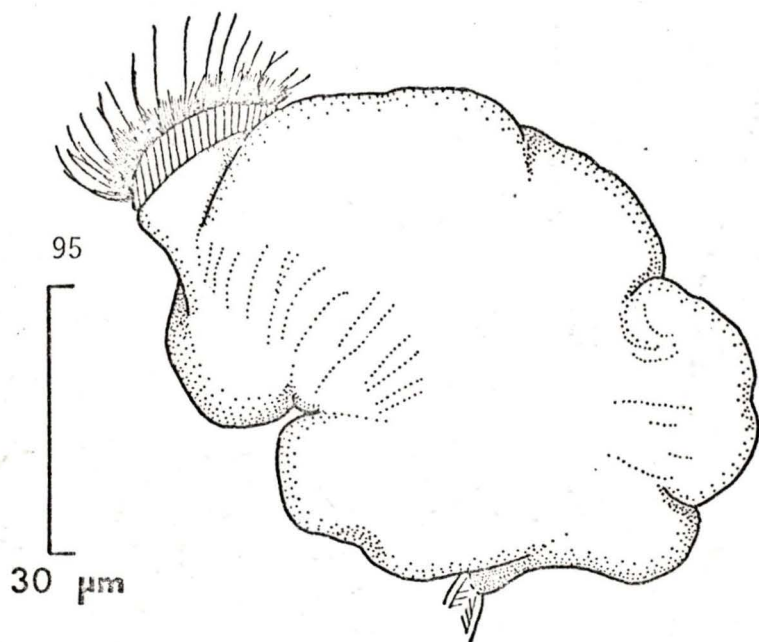


Plate 6. Marionina sjaelandica Nielsen and Christensen, a-b,
S.E.M. photomicrographs.

a) XII, ventral, showing male pores (x545);

b) lower magnification of prostomium showing
some 'sensory papillae' → (x900).

Marionina vancouverensis n.sp., c-d, light microscope
photographs of live specimens.

c) I-IV, lateral setal bundles;

d) setal bundles of posterior segments and anus.

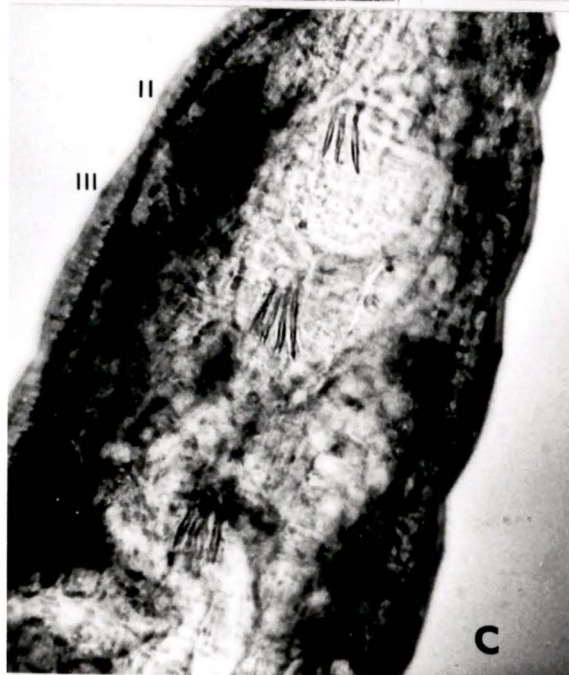
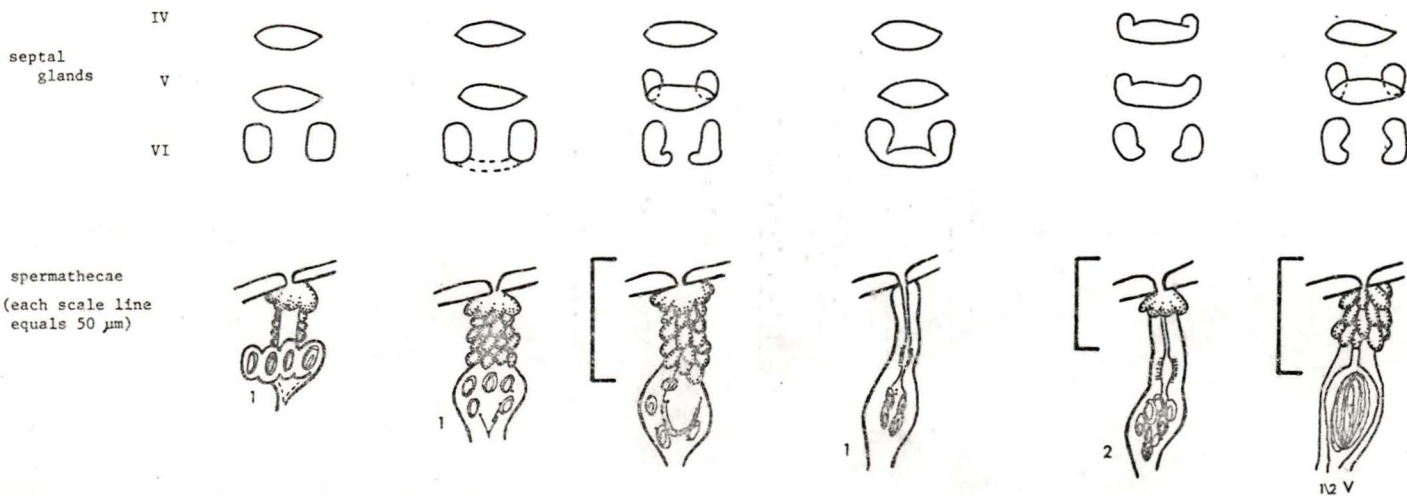


Table 13. Characteristics of some, small Marionina species with morphological similarities to *M. sjaelandica* Nielsen and Christensen and *M. charlottensis* n. sp., two species known from British Columbia.

Spermathecae redrawn from 1. Lasserre and Erséus, 1976, fig. 5; or 2. Lasserre and Erséus, 1976, fig. 4; or drawn from recent British Columbia material.

SPECIES

CHARACTER	<u>southerni</u>	<u>sjaelandica</u>		<u>simillima</u>	<u>swedmarki</u>	<u>charlottensis</u>
	(Cernosvitov)	Nielsen and Christensen		Nielsen and Christensen	Lasserre and Erséus	n. sp.
		aff. N & C	B.C.			
length (mm)	8-10	5	5-7	12	2-3	4-6
no. segments	28-36	24-27	28-38	34-36	19-28	25-32, 35
setal shape	straight with ental hook	straight with ental hook	straight with ental hook	straight with ental hook	straight with ental hook	straight with ental hook
setal distrib.	lateral absent II,2:2 ventral 2:2	2:2 2:2	2:2 2:2	2:1 2:2	2:2 2:2	absent II,2:2 2:2
oesophageal divert.	none	none	none	pair ventro-lateral in IV	none	none
seminal vesicles	present (to IX)	present	present (to IX)	absent	pres.(to IX or 1/2VIII)	present (to X)
ecology	upper intertidal	upper intertidal; sand, gravel	coarse beach seds & finer estuarine seds	woodland soils and pastures	intertidal	upper intertidal with algae
	widely distributed in Europe; Massachusetts, North Carolina	Denmark; England	British Columbia, Canada	Hols, Denmark	Ireland Island, Bermuda	northern British Columbia, Canada



the European specimens (Nielsen and Christensen, 1961), there is consistently a small ventral septal gland lobe in V of B.C. specimens and the dorsal margin of the brain of B.C. specimens is incised not truncate but this last varies with degree of contraction of either living or dead worms. Also, mature specimens of M. sjaelandica found in B.C. had a well developed glandular body on the ventral nerve cord of XIV, a condition sometimes reported for M. southerni (Southern, 1909) (see Nielsen and Christensen, 1959, p.113). In consideration of the essential identity of the reproductive organ morphologies of B.C. and European specimens they are considered to be of one species.

Table 13 illustrates the discriminatory characteristics of five small Marionina species, including M. sjaelandica. All of these except M. charlottensis n. sp. have spermatozoa distributed in discrete packets in the ampullar walls of the spermatheca. It can be seen here that the British Columbia and European specimens described as M. sjaelandica are considerably more similar to each other than to any of the other species diagrammed in Table 13.

B. New taxa

Following are descriptions of taxa new to science found in the survey material.

Marionina vancouverensis n. sp. Fig.97-101,

Plates 6c-d, 7a-c.

Etymology. Named for Vancouver Island, its general geographic type location.

Type material. Holotype 1 whole mount.

Paratype 7 whole specimens.

Type locality. Tsitika River Estuary, Vancouver Island, British Columbia; holotype: 50° 28.92'N at 126° 34.98'W. Paratypes: as holotype location. Collected 18 July, 1976.

Material examined. Whole, fixed and living specimens from Tsitika River Estuary, Port Alice (living specimens), and Ocean Falls. For details of collections see Appendix 1.

Description. Very small intertidal oligochaetes, fixed length about 2 or 3 mm, with 28 to 36 segments. Setae straight or possibly just slightly curved, with ental hook (Plate 6,c and d), present dorsally and ventrally from II.

Distribution: preclitellar lateral: 1-3,

" ventral: 2-5,

postclitellar lateral: (1)2-3(4), and

" ventral: 2-4

Setae approximately equal within a bundle. Brain (Fig.97) truncate or incised posteriorly, suboesophageal ganglion very large. Transition oesophagus to intestine gradual, without diverticula. Three pair septal glands present, IV/V joined dorsally sometimes with very small ventral lobes but not

distinct in all specimens, V/VI joined dorsally with small ventral lobes, large separate lobes present in VI (Fig. 98). Lymphocytes large, approximately equal $1/2$ seta length, abundant, nucleate, very granular, live specimens as a consequence are opaque white. Chloragocytes present from V, dense from VI, not highly coloured, nucleate, grainy. Dorsal vessel arises XII to XIV, blood colourless. Nephridia present from VI/VII, anteseptale large equal funnel plus some of nephridial canal, postseptale pear-shaped, efferent duct arises postero-ventrally, wide (Fig. 99). Clitellum extends XII to $1/2$ XIII, gland cells large, rectangular, arranged in transverse rows. Seminal vesicles absent, testes small, attached at X/XI, sperm morulae throughout coelom. Sperm funnel (Fig. 100) length about 2 x width. Irregular shaped with large, glandular looking outgrowths, collar width approximately $1/3$ to $1/2$ width of funnel, pronounced. Vas deferens, short, wide, length just greater than length of funnel (Plate 7a). Penial bulb relatively small, with an inner chamber at end of vas deferens. Often a small, external ridge visible ventro-lateral to male pore (Plate 7b). Spermathecae simple (Fig. 101), without diverticula, ectal ducts surrounded by small gland cells which diminish in size distally, canals distinct. Ampulla sac-shaped or more regularly rounded, relatively thick-walled, narrowly attached to oesophagus. Sperm present in ampulla as a central ring or more irregular

mass. Spermathecal pore in intersegmental groove IV/V (Plate 7c). As many as two developing eggs present at one time. Also noted that cutaneous glands were in 3 or 4 distinct transverse rows per segment (Plate 7c).

Habitat. Intertidal, estuarine, from lower to mid tide levels; uncommon at upper intertidal. In sand under stones and gravel.

Distribution. Vancouver Island and along mainland coast of British Columbia; Tsitika River, Port Alice and Ocean Falls, collection details are given in Appendix 1.

Remarks. M. vancouverensis n. sp. is very similar to M. spicula (Leuckart, 1847) with regards to the general morphology of the sperm funnel and vas deferens, although the vas deferens of M. vancouverensis is even shorter than that of M. spicula, about the same length as the sperm funnel not two or three times that length as for M. spicula. Other similarities between these two taxa are found in the setal numbers and distribution and in the conformation of septal glands.

The primary morphological difference that has been relied upon to distinguish M. vancouverensis from M. spicula is the absence in M. vancouverensis of the single large gland at the spermathecal ectal pore which is characteristic for M. spicula (see Nielsen and Christensen, 1959, f.146). Such a variation is not recorded from populations

Marionina vancouverensis

Figure 97. Brain.

Figure 98. Dorsal view of whole mount,
V-VII, showing septal glands.

Figure 99. Nephridium.

Figure 100. Sperm funnel.

Figure 101. Spermatheca.

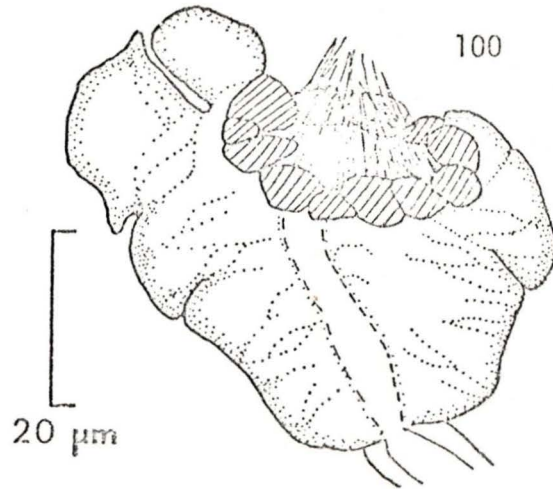
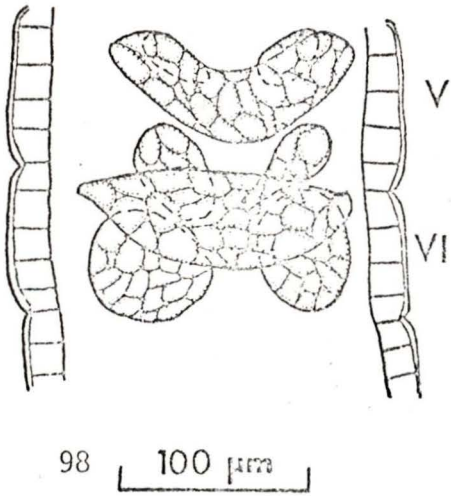
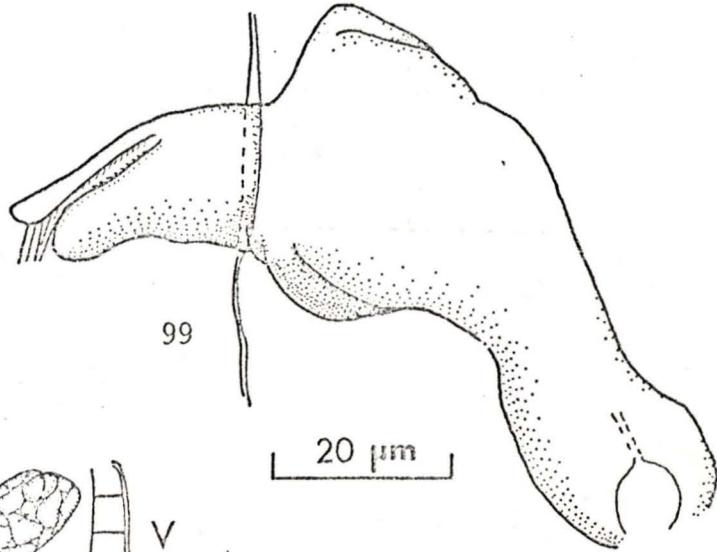
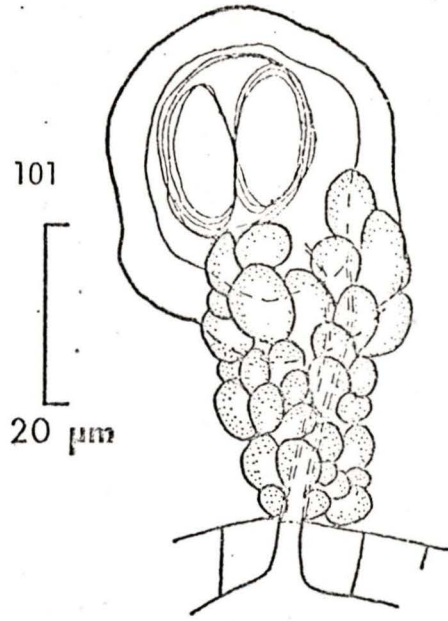
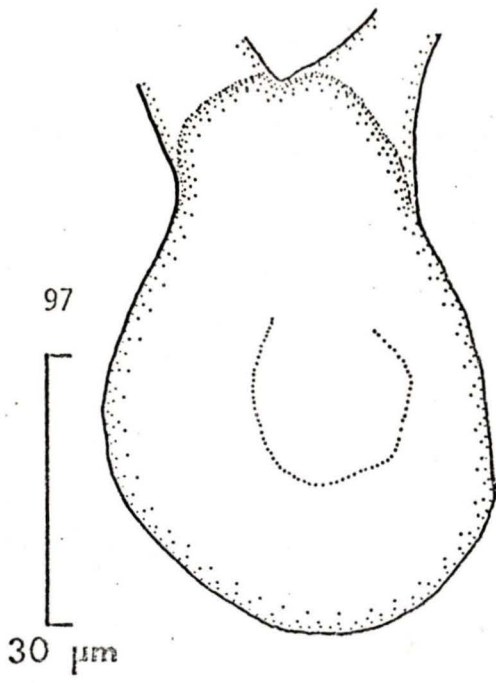
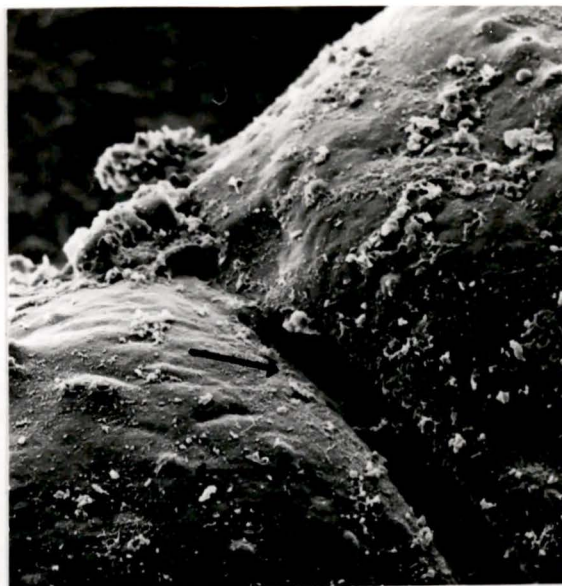
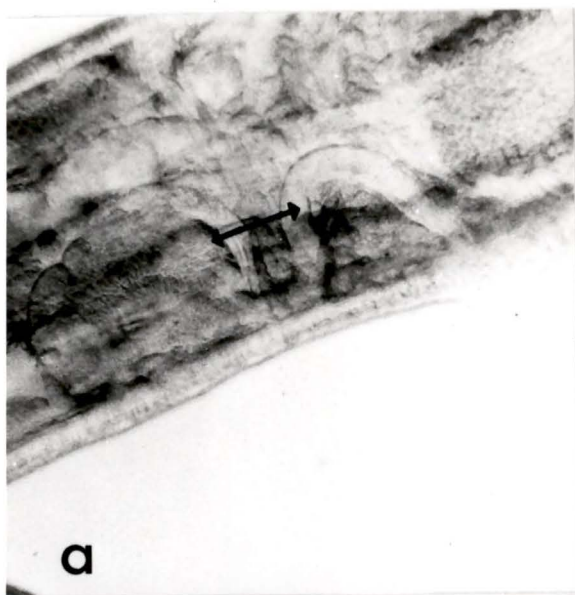


Plate 7. Marionina vancouverensis n. sp.,

- a) light microscope photograph of live specimen, XI-XII, lateral, showing sperm funnel and vas deferens \longleftrightarrow ;
- b) S.E.M., ventral view of XII showing male pores (x695
- c) S.E.M., IV-V, showing spermathecal pore \longrightarrow in inter-segmental groove IV/V and some rows of cutaneous glands \longleftrightarrow (x725).



of M. spicula and therefore M. vancouverensis, populations of which are consistently different in this characteristic, is considered a distinct species.

Possibly there are different habitat preferences shown by specimens of M. vancouverensis and M. spicula. Records of M. spicula (Lasserre, 1971a) from the Atlantic coast of North America are, with only two exceptions, for upper to lower intertidal sites on sandy beaches (exceptions: salt marshes, one each in South Carolina and Massachusetts) whereas M. vancouverensis is herein recorded from primarily mid to lower intertidal habitats of estuarine locations.

Marionina brevis Finogenova, 1972 is not dissimilar from either M. spicula or M. vancouverensis, however, the sperm funnel of M. brevis is not irregularly glandular nor is the ectal duct of the spermatheca surrounded by small glands but instead it is thick walled.

Marionina charlottensis n. sp. Fig. 102-107,
Table 13.

Etymology. Derived from body of water, Queen Charlotte Sound, opening to the Pacific Ocean to the west of Ocean

Falls, the type locality.

Type material. Syntype series of 19 specimens; stained with borax carmine, preserved whole in 70% ethanol with approximately 10% glycerin.

Type locality. Near Ocean Falls, on Cousins Inlet, British Columbia, 52° 21.53'N at 127° 43.12'W, 3.4 m above chart datum; 26 February, 1977.

Material examined. About 140 whole specimens from Alice and Hastings Arms off Portland Channel, 55° 27.38'N at 129° 30.13'W, +5.5 m, collected 18 June, 1977 and 55° 34.85'N at 129° 48.30'W, + 4.1, + 4.6 and + 5.1 m, collected 22 June, 1977, respectively; and from Cousins Inlet near Ocean Falls (Appendix 1).

Description. Small intertidal worms, fixed length 4 to 6 mm, with 25 to 32, 35 segments, usually 26 to 29. Very small cutaneous glands arranged in 4 or 5 transverse rows per anterior segment. Setae straight with an ental hook, robust (Fig.102). Two per bundle, laterals lacking in II and rarely in III, XII lacking lateral and ventral setae. Brain truncate posteriorly. Transition oesophagus to intestine gradual, gut without diverticula. Three pair septal glands present at IV/V, V/VI and VI/VII, first and second pairs united dorsally, second with ventral lobes, third pair with large separate lobes (Fig.103). Lymphocytes few, very granular, nucleate, oval or more elongate (Fig.104), length

about $1/3$ seta length. Chloragocytes present in large numbers from VI, occasionally a few cells in V, large, with many refractile droplets, sometimes gold coloured, length $1/3$ to $1/2$ seta length. Dorsal vessel arises posterior XII or posterior XIII. Blood colourless in fixed specimens. Nephridia not large, long and narrow, present from VII/VIII, not present in all posterior segments. Anteseptale large, up to $1/4$ x length of whole organ, includes funnel and some coils of nephridial canal, efferent duct short, wide, terminal, postseptale pear shaped (Fig.105). Clitellum extends $1/2$ XII to $1/2$ XIII, incomplete ventrally, even in specimens with eggs not very thick, cells large, rectangular, in irregular transverse rows. Testes small, compact at X/XI, seminal vesicle present, extending to X. Sperm funnel outline regular, length of funnel just less than 2 x width (Fig.106), sperm collar prominent, regular, width just less than funnel width. Vas deferens narrow, irregularly coiled in XII. Penial bulb small, round; externally, male pore large. Spermathecae simple, with distinct ectal and ental ducts and ampullae (Fig.107), ectal pore just ventral of lateral setal bundles at IV/V. Ectal duct surrounded by irregularly sized glands, no distinct rosette. Ampullar walls thick, broadly connected by distinct ental canal to oesophagus at $1/2$ V.

Habitat. Northern inlets, intertidal habitats, less than

Marionina charlottensis

Figure 102. Posterior seta.

Figure 103. Dorsal view of whole
mount, IV-VI, showing
septal glands.

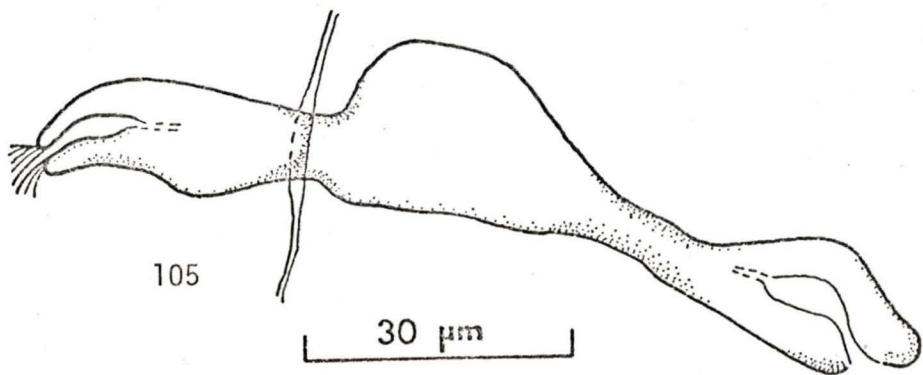
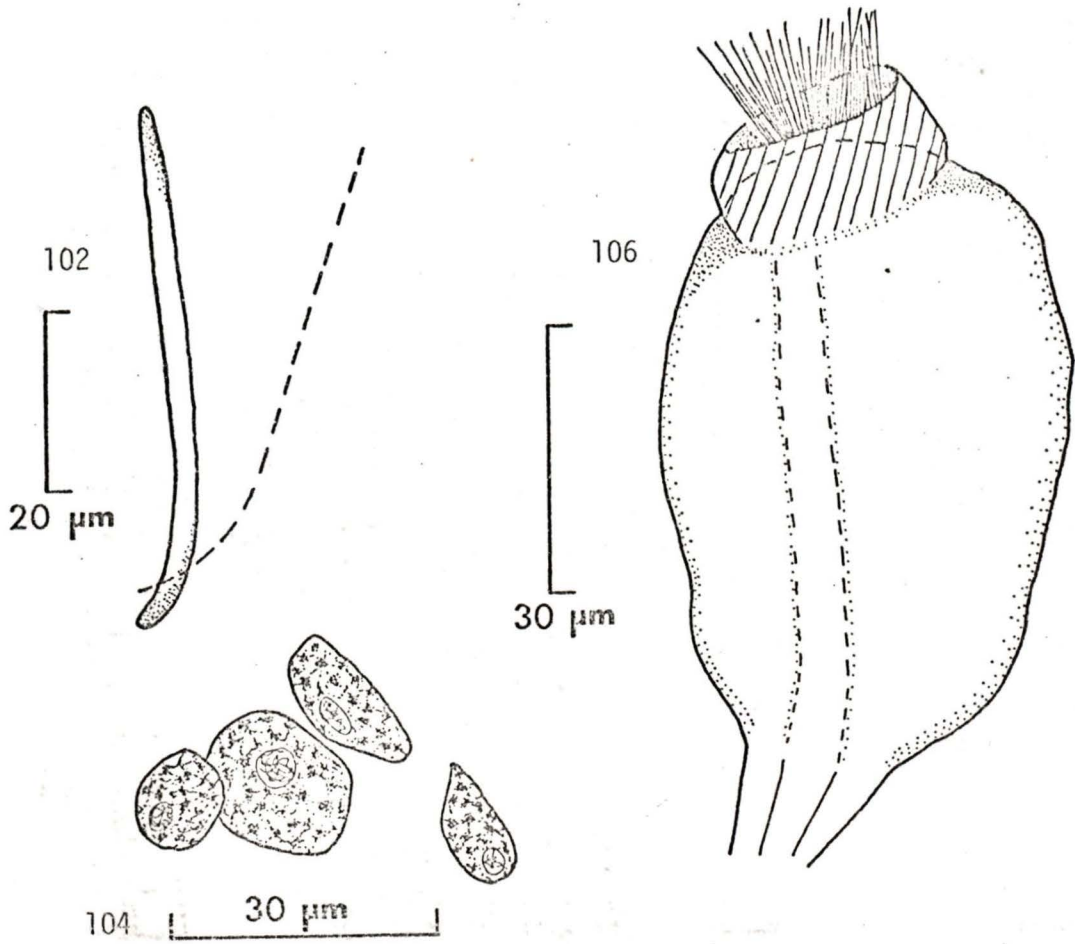
Figure 104. Lymphocytes.

Figure 105. Nephridium.

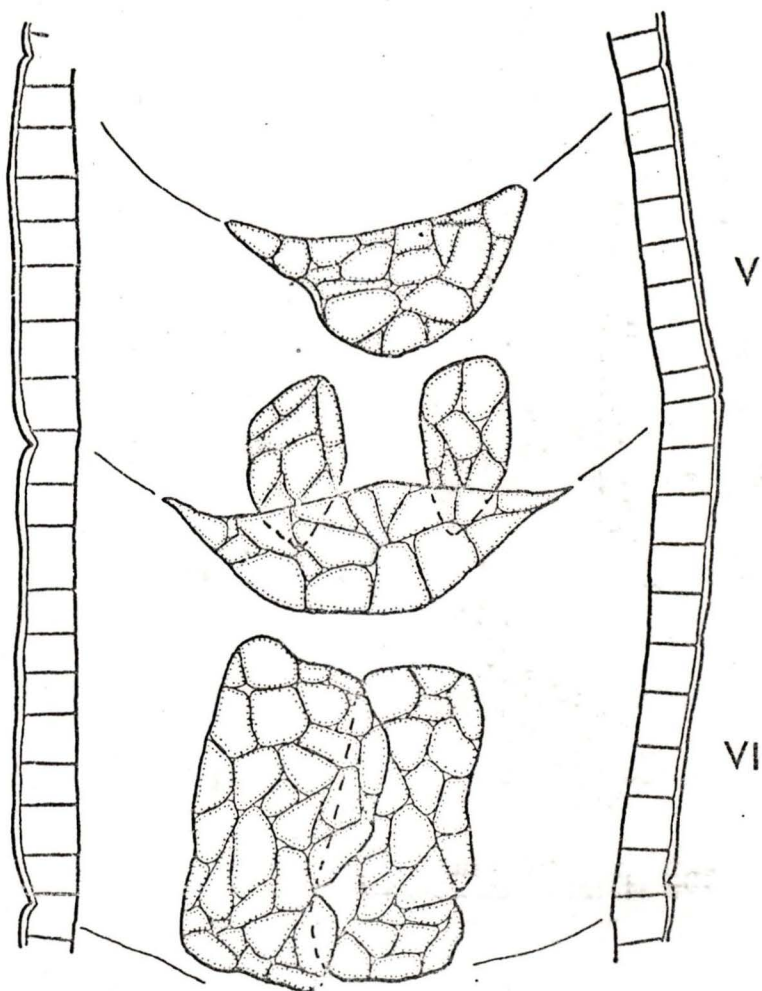
Figure 106. Sperm funnel.

Figure 107. Spermatheca.

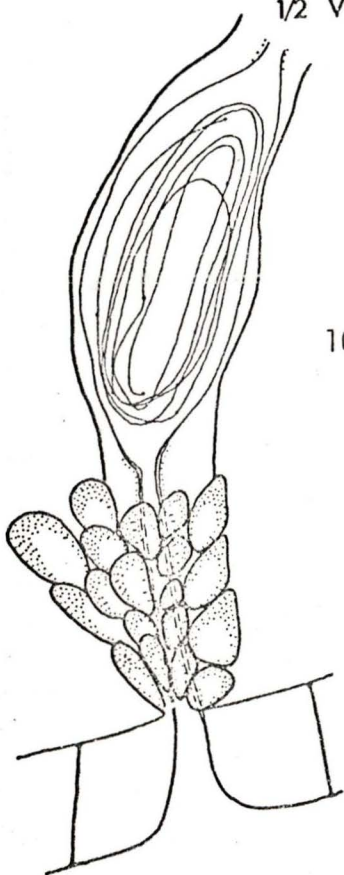
230.



103



1/2 V



maximum coastal salinities; often associated with some attached upper intertidal algae, ie. Fucus sp., Bangia sp. or Enteromorpha sp..

Distribution. Northern mainland coast of British Columbia, as material examined (Alice Arm, Hastings Arm and Cousins Inlet).

Remarks. Of other known Marionina species two, M. southerni (Cernosvitov, 1937a) and M. argentea (Michaelson, 1889), are consistently without setae in lateral bundles of II and have only two (rarely three) straight setae in other bundles (with exception of some clitellar segments). Of these two, only M. southerni has a well developed seminal vesicle. M. charlottensis n. sp. differs from M. southerni most significantly with regards to spermathecal morphology and distribution of sperm in the spermathecal ampulla (Table 13).

On the basis of setal distribution, possession of a well developed seminal vesicle, and morphology of spermathecae and septal glands M. charlottensis is recognized as a distinct species.

Marionina neroutsensis n. sp. Fig.108-114, Table 14.

Etymology. After Neroutsos Inlet, type locality.

Type material. Holotype: whole mounted specimen in Canada balsam stained in borax carmine (nuclear stain).

Paratypes: 1 whole mounted specimen; 54 borax carmine stained, whole specimens in 70% alcohol and 10% by volume glycerin, location as holotype.

Type locality. Neroutsos Inlet, near Port Alice, British Columbia; 50° 31.12'N at 127° 37.10'W (Drake Island), upper intertidal. Collected May 2, 1978.

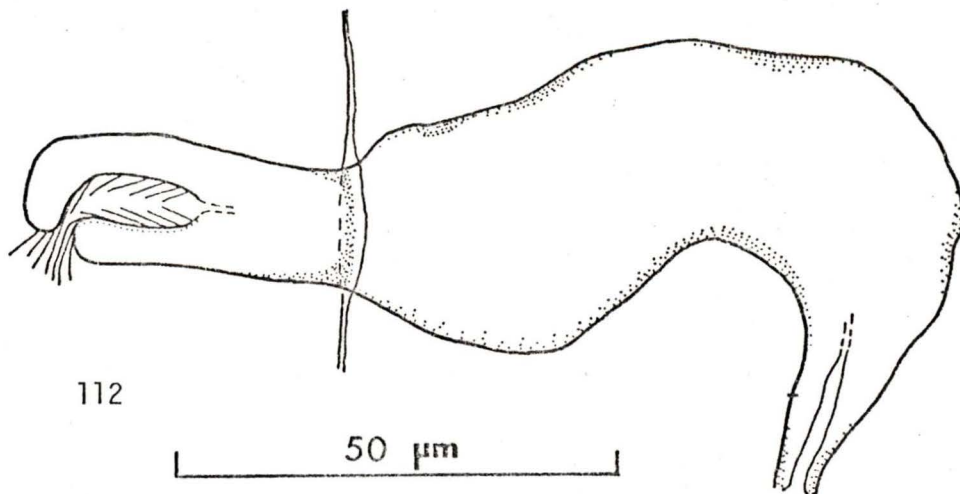
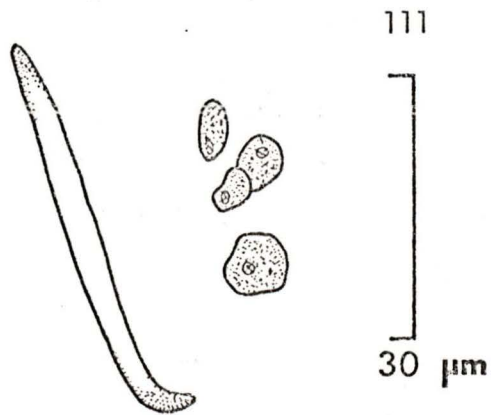
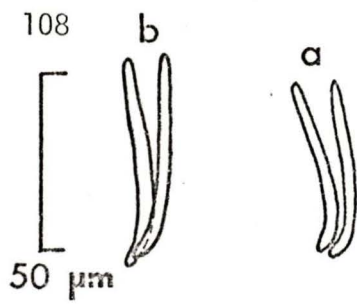
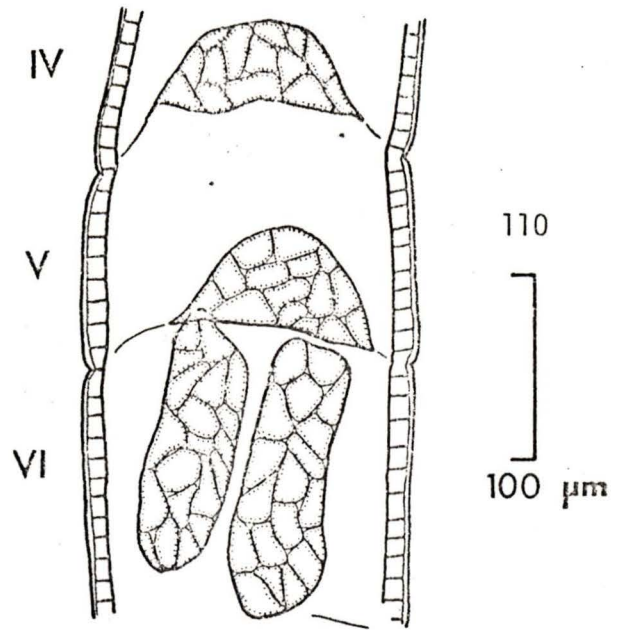
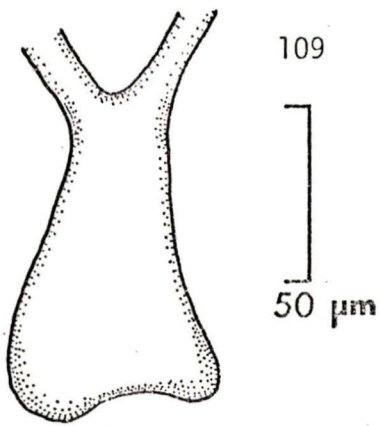
Material Examined. More than 100 mature specimens collected along the shores of Neroutsos Inlet; in addition to holotype and paratypes, Brown's Point, 50° 28.81'N at 127° 34.10'W, Ketchen Island, 50° 22.78'N at 127° 27.40'W and Cayeghle estuary, 50° 20.69'N at 127° 26.05' W, May 2 to 4, 1978 and Port Alice, Appendix 1, June 13, 1976.

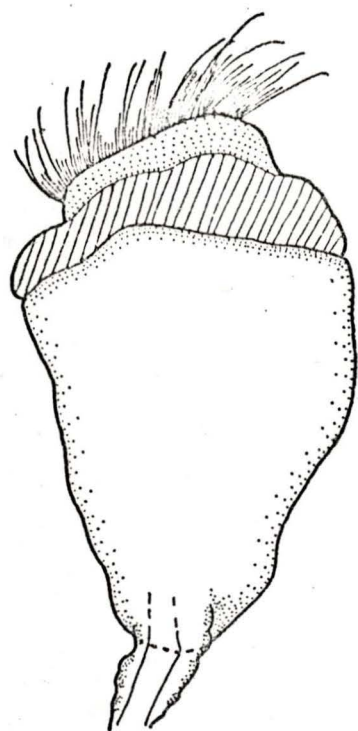
Description. Small, pale intertidal worms, 2 to 4 mm long, with 26 to 33 segments, usually 27 to 29. Cutaneous glands in 10 or 11 faint transverse rows per segment. Setae straight with ental hook, two per bundle throughout, rarely 3, ventral and lateral bundles lacking in XII of mature worms. Posterior setae just slightly longer than anterior (Fig.108). Brain concave posteriorly, lateral margins converge anteriorly, maximum length about 1.6 x maximum width (Fig.109). Transition oesophagus to intestine gradual, gut without diverticula. Three pair septal glands present, IV/V and V/VI compact, without ventral lobes,

united dorsally, third pair as elongate ventral lobes in VI (Fig.110). Lymphocytes coarsely granular, nucleate, irregular ovoid to disc-shaped, length about $1/6$ seta length (Fig.111). Chloragocytes also small, pale golden-brown or colourless, possibly a few cells present in V, dense from VI. Dorsal vessel arises intraclitellar at XII/XIII or in XIII. Blood colourless, living and fixed specimens. Dorsal vessel does not extend forward under brain, branches into two lateral loops in III, loops may extend forward into II lateral to brain (see also Giere, 1974). Anteseptale large, comprised of funnel plus some loops of nephridial canal, length may be $1/3$ total length of nephridium excluding efferent duct (Fig.112). Efferent duct exits postero-ventrally, not precisely demarcated from postseptale. Clitellum extends XII to $1/2$ XIII, gland cells rectangular, in approximately regular rows, incomplete ventrally. Seminal vesicle present, extending forward to X. Sperm funnel length about $1.5 \times$ maximum width, length approximately $2/3$ body width XI, funnel tapering toward vas deferens (somewhat pear shaped), collar width equal or just greater than funnel, sperm attached only in an area at middle of collar (Fig.113). Vas deferens usually in a regular coil in XII. Penial bulb not well defined, with a considerable proportion protruding through male pore. Only one egg in body at a time. Spermathecae (Fig.114) simple,

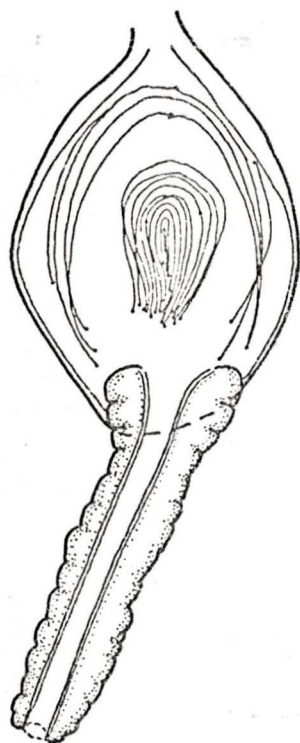
Marionina neroutsensis

- Figure 108. a) Anterior setal bundle;
b) posterior setal bundle.
- Figure 109. Brain.
- Figure 110. Dorsal view of whole mount,
IV-VI, showing septal glands.
- Figure 111. Seta from lateral bundle, XI,
and lymphocytes.
- Figure 112. Anterior nephridium.
- Figure 113. Sperm funnel.
- Figure 114. Spermatheca.

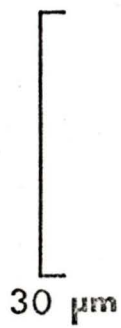




113



114



without diverticula, ampullae round, walls not very thick, connected to oesophagus in posterior one-half of V. Ectal duct distinct, surrounded along entire length by small, fused (?) glands, without distinct rosette. Ectal pore posterior to septum IV/V and just ventral of the line of the ventral setal bundles.

Habitat. Upper intertidal, finer sediments, saturated with water.

Distribution. Only known from Neroutsos Inlet, British Columbia.

Remarks. On the basis of a two character complex, 2 setae in all bundles including lateral bundles of II and glands along the ectal duct of the spermatheca but no distinct rosette present, Marionina neroutsensis n. sp. is determined to be most similar to M. cana Marcus, 1965 and M. elgonensis (Cernosvitov, 1938) (Table 14). From the latter M. neroutsensis can be differentiated by the gestalt of septal glands, nephridial structure (for M. elgonensis the ectal duct is very long and arises sub-terminally, Cernosvitov, 1938, f.37 and 38), and presence of a seminal vesicle (Table 14). The real extent of similarity between M. neroutsensis and M. cana could be resolved most definitely through examination of specimens of M. cana.

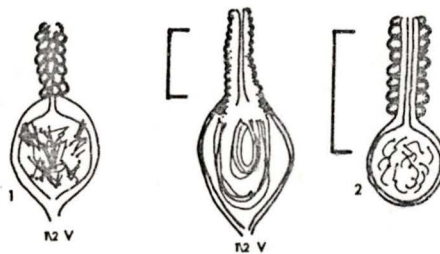
Table 14. Characteristics of *Marionina neroutsensis* n. sp. and two morphologically similar *Marionina* species.

Spermatheca of *M. neroutsensis* drawn from new British Columbia material. Spermathecae of *M. elgonensis* and *M. cana* redrawn after 1. Marcus, 1965; or 2. Cernosvitov, 1938.

CHARACTER	SPECIES		
	<i>cana</i> Marcus	<i>neroutsensis</i> n. sp.	<i>elgonensis</i> (Cernosvitov)
length (mm)	3.5	2-4	1.4
no. segments	28	26-33	21
setal shape	straight with ental hook	straight with ental hook	straight with ental hook
setal distrib.	lateral 2:2(3 rare) ventral 2:2(3 rare)	lateral 2:2(3 rare) ventral 2:2(3 rare)	lateral 2:2 ventral 2:2
origin dorsal blood vessel	IX	XII/XIII or XIII	XII/XIII
sperm funnel L:D	2:1	1.5:1	1:1
seminal vesicles	present (to X)	present (to X)	absent
ecology	in soil on beach; brackish Cananea, Brazil	upper intertidal, fine sediments Neroutsos Inlet, B.C., Canada	sediments of 2 small lake Koitobos Peak, near Mount Elgon, Uganda



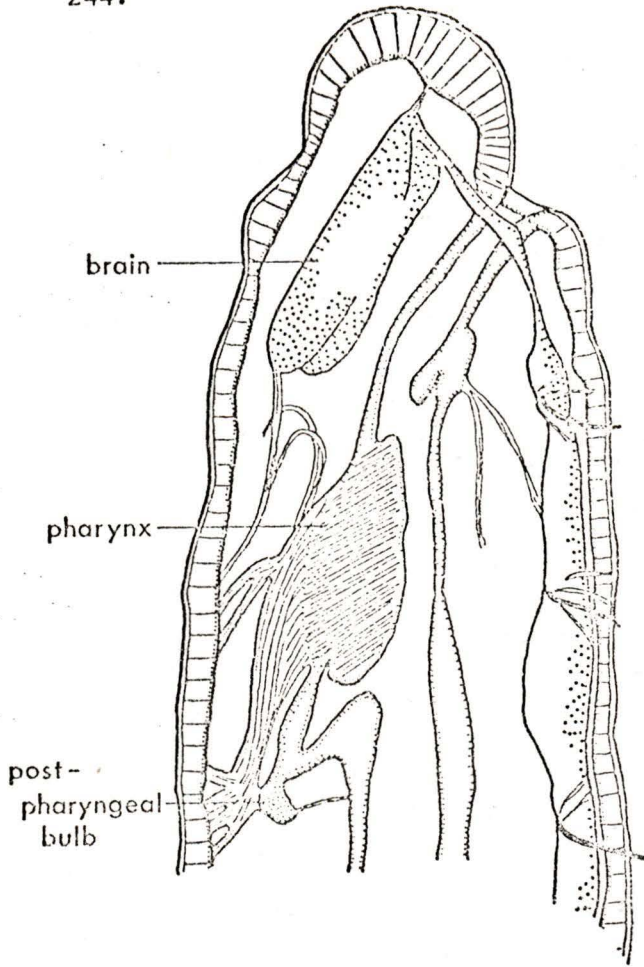
spermathecae
(each scale line equals 25 μm)



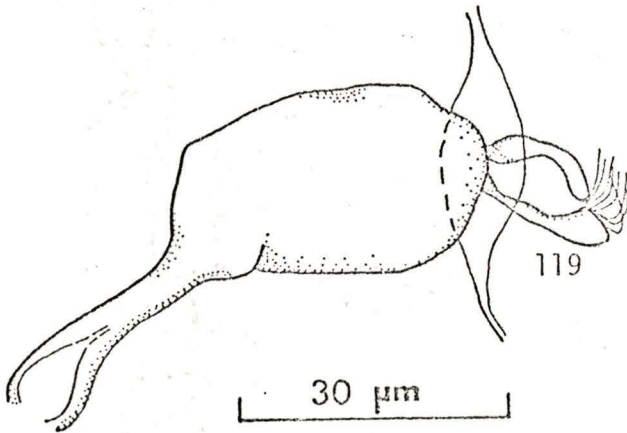
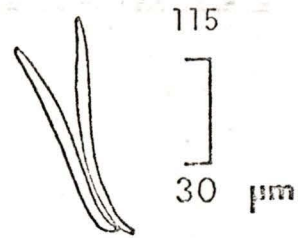
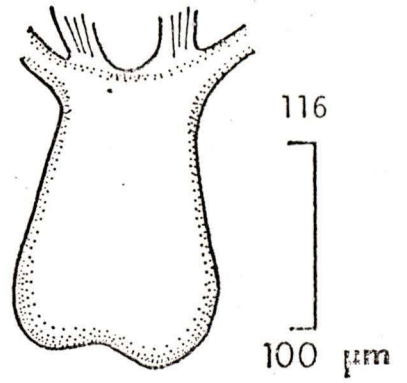
1974) present dorsally in IV (Fig.117). Three pairs of septal glands present, IV/V to VI/VII, all joined dorsally, third pair only narrowly, all with distinct, almost separate ventral lobes (Fig.118). Lymphocytes granular, nucleate, spindle shaped, length greater than 1/2 seta length. Chloragocytes dense from VII, cells not granular, posteriorly cell height just greater than seta length. Dorsal blood vessel arises intraclitellar at about 1/2XIII, blood not coloured in fixed specimens. Nephridia present from VI/VII, absent in clitellar and many postclitellar segments. Anteseptale consists of nephrostome only, postseptale relatively large, with a distinctly demarcated, terminal ectal duct, duct length just less than length of postseptale (Fig.119). Clitellum extends posterior XI to XIII, irregular shaped cells, arranged in more or less regular transverse rows. Seminal vesicle well developed, extends posteriorly, dorsal to gut, from X to XIV. Sperm funnel (Fig.120) length just greater than 2 x width, collar width equals funnel width. Vas deferens irregularly wound in XII, narrow. Penial bulb very small, a glandular thickening of the body wall only, protrudes slightly internally and externally. Three or four eggs present at one time, extending posteriorly to XVI. Spermathecae (Fig.121) unusual for Marionina; not attached to oesophagus but confined to V, ectal pore at IV/V. Ectal duct narrow, muscular (?), aglandular, with four large, hyaline glands

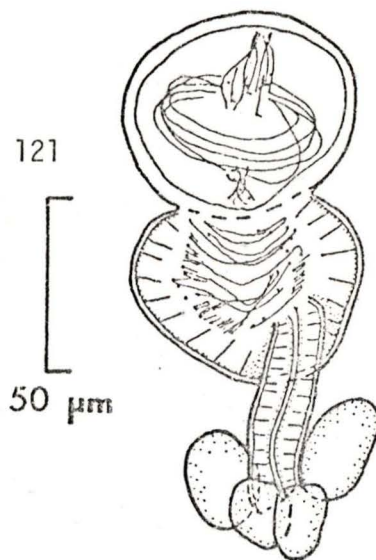
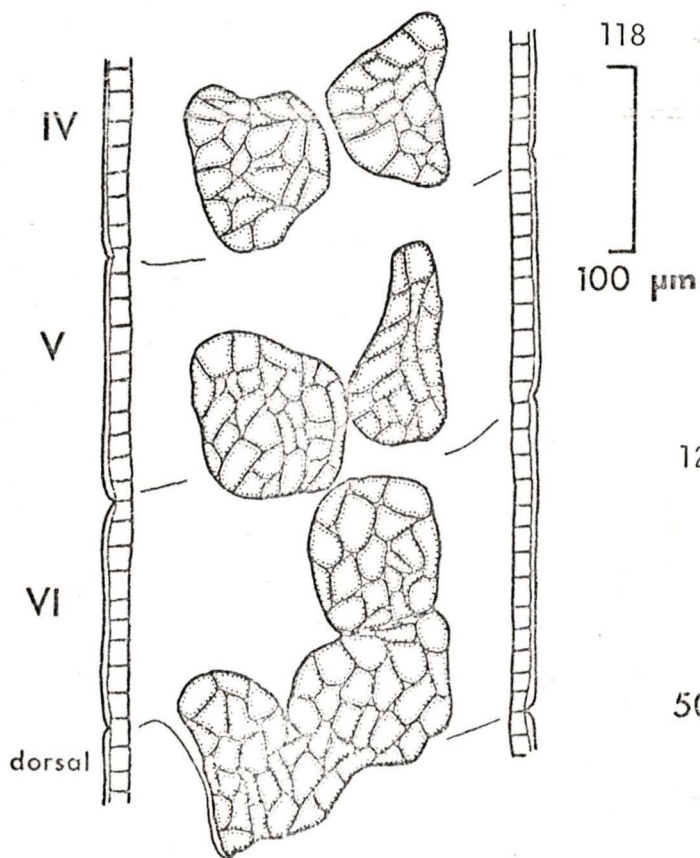
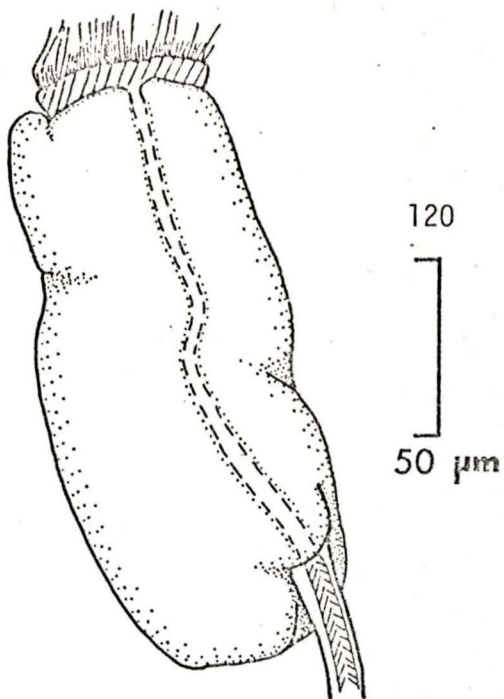
Marionina trevori

- Figure 115. Lateral setal bundle, XI.
- Figure 116. Brain.
- Figure 117. Lateral view of whole mount,
O/I-IV, showing nervous
system and oesophagus with
solid "post-pharyngeal bulb".
- Figure 118. Lateral view of whole mount,
IV-VI, showing septal glands.
- Figure 119. Anterior nephridium.
- Figure 120. Sperm funnel.
- Figure 121. Spermatheca.



117
100 μm





around ectal end. Ampulla of spermatheca as two sequential spherical or heart shaped chambers, ectal with thick walls and no distinct cavity, ental with a thin wall and spermatozoa arranged in an approximately regular central ring.

Habitat. Upper intertidal, in coarse sand mixed with and under decaying algal debris, near a freshwater outfall (beach nearby posted as polluted by domestic effluent).

Distribution. Known only from type locality.

Remarks. Marionina trevori n. sp. has some rather unusual characteristics for a member of Marionina. A particular one of these is a posteriorly extending seminal vesicle. It also is uncommon in Marionina for the anteseptale of the nephridia to consist of only the funnel (exceptions are M. aberrans, Finogenova, 1973; M. cambrensis, O'Connor, 1964; and M. tubifera, Nielsen and Christensen, 1959), and there are only a few species of Marionina that are without the spermathecae attached to the oesophagus. M. trevori was placed in Marionina in account of the character combination oesophageal-intestinal transition gradual + no diverticula on gut + no peptonephridia + distinct, compact seminal vesicle + testes small and compact + setae almost straight without nodulus + nephridial efferent duct terminal.

The genus Marionina Michaelsen, 1889 is at present a rather ill-defined genus allowing various mutually

exclusive characteristics. Addition of M. trevori adds slightly to the variability because of the posteriorly extending, well developed seminal vesicle.

The general morphology of the spermathecae of M. trevori is reminiscent of that described for M. americana by Eisen (1904), a naked, muscular duct with a few individual glands at the ectal pore and ampulla not attached to the oesophagus. M. americana requires revision, as will be noted. Possibly M. trevori and M. americana are part of an homogenous morphological group which should be separated from Marionina as typified by Pachydrilus georgianus.

C. Status of other taxa previously recorded from Alaska to California.

Specimens of the following taxa were not found in samples collected for this survey.

Marionina alaskae Eisen, 1904

Marionina alaskae Eisen, 1904, pp. 91-92, f.60, pl.XIV f.26.

Pachydrilus (Marionina) alaskae: Cernosvitov, 1937a, p. 293.

Marionina alaskae: Nielsen and Christensen, 1959, p.109.

Type material. NHRS, a single specimen.

Type locality. Port Clarence, Alaska; 26th July, 1878.

Habitat. Not stated.

Distribution. As type locality.

Remarks. Eisen's description of Marionina alaskae is based on a single specimen, mature to some extent, although seminal vesicles and testes, eggs and sperm in the ampullae of the spermathecae were not indicated to have been present. The posterior extent of the spermathecae and the presence (questionable) of dorsal pores in II to IV are, respectively, unusual and excluded characteristics for the genus Marionina.

Absence of peptonephridia and presence of undivided testes are assumed for this species because Eisen (1904, p.90) indicated that these were definitive generic characteristics. The conformation of the septal glands was not stated.

This species may be a distinguishable taxon based on Eisen's description and illustrations of nephridia and spermatheca; however, there is some possibility that the species does not belong in Marionina and careful redescription of the species is necessary. The status of the species as described is genus inquirendus.

Marionina americana Eisen, 1904

Marionina americana Eisen, 1904, pp.93-94,
f.61-62, pl.XIV f.1.

M. americana: Tynen, 1975, p.8.

Lumbricillus eiseni nom. nov. pro Marionina americana Eisen, 1904 non Ude, 1896 Cernosvitov, 1937a, p.292.

L. eiseni: Nielsen and Christensen, 1959, p.96.

Type material. NHRS, a single specimen.

Type locality. Port Clarence, Alaska; 23 to 27 July, 1879.

Habitat. Not stated.

Distribution. As type locality.

Remarks. Eisen (1904) described this species from a single specimen of unstated maturity, which he reported to be in a poor state of preservation. Many taxonomically important characters were not described in detail.

The structure of the setal bundles was lumbricilline (Eisen, 1904, pp.93-94) but the seminal vesicles were not lobed and the spermathecae were not attached to the oesophagus (Eisen, 1904, f.61) which are not lumbricilline characteristics. The nephridia were not described.

It is apparent why Cernosvitov (1937) on the basis of his subgeneric definitions for Pachydrilus (=in part Lumbricillus and in part Marionina) transferred this species to Pachydrilus (Pachydrilus) (=in part Lumbricillus):

"Hodenkorper..., selten nur gelappt oder

langsgespalten, noch seltener einfach ... Hoden von einer zarten, peritonealen Membran umgeben, ..." (Cernosvitov, 1937a, p.292);

whereas for Pachydrilus (Marionina) (=in part Marionina):
 "Hoden ohne Peritonealmembran". (Cernosvitov, 1937a, p.293).

But it is not apparent why Nielsen and Christensen (1959) maintained this generic revision. They diagnosed Lumbricillus as always having lobed seminal vesicles (Nielsen and Christensen, 1959, p.96) and Marionina as usually, but not always, being without a well developed seminal vesicle (Nielsen and Christensen, 1959, p.109).

Marionina americana might be distinguishable from other species of the genus on the basis of its unusual spermathecal structure; however, in consideration of the paucity of available morphological information it should be considered a species inquirendum within Marionina.

Marionina citrina (Eisen, 1904)

Enchytraeus citrinus Eisen, 1904, pp.72-73, f.42.

E. citrinus: Cernosvitov, 1937a, p.293.

Marionina citrina: Nielsen and Christensen, 1959, p.109.

Type material. USNM 5151.; one specimen which has been completely dried out while in storage. Due to the condition of the specimen no observations have been made.

Type locality. Lowe Inlet, British Columbia; 3 June, 1899.

Habitat. With Marionina saxicola (Eisen, 1904); under rocks at high tide.

Distribution. As type locality.

Remarks. Eisen (1904, p.61) in diagnosing Enchytraeus allows either presence or absence of peptonephridia. Cernosvitov (1937a) and Nielsen and Christensen (1959) restrict species of Enchytraeus to those which, as the type species, Enchytraeus albidus, possess paired, unbranched peptonephridia. Such structures are possibly absent in Marionina citrina. Cernosvitov (1937a) considered Enchytraeus citrinus to be of dubious generic status, belonging either in Pachydrilus (Pachydrilus) or in P. (Marionina) (see preceeding Remarks). Nielsen and Christensen (1959) in consideration of Eisen's diagnosis of Enchytraeus regarding morphology of testes and seminal vesicles have placed this taxon in Marionina, as they revised the genus.

The specimens for which Eisen defined the species were of an unstated level of maturity and details of some important taxonomic characteristics were not given. Eisen considered this taxon to be very similar to Enchytraeus saxicola also removed to Marionina by Nielsen and Christensen (1959), which as noted in Table 4 bears many similarities to Enchytraeus kincaidi. Many of the taxonomic problems with Eisen's west coast taxa probably

arise from the fact that he described specimens at non-comparable states of maturity. Marionina citrina is not consistent in many characteristics including size and penial bulb structure with known species of intertidal Marionina, and, therefore, without further study of new material, it is considered as a taxon genus inquirendus.

Marionina metlakatensis (Eisen, 1904)

Enchytraeus metlakatensis Eisen, 1904, pp.64-66, f.34-36, pl.XVIII f.5, pl.XIX f.1.

Enchytraeus metlakatensis: Cernosvitov, 1937a, p.293.

Marionina metlakatensis: Nielsen and Christensen, 1959, p.109.

Type material. CASF - typus amissus (Appendix 5).

Type locality. Metlakatla, Alaska; 4 June, 1899.

Habitat. Under seaweed (? intertidal).

Distribution. As type locality.

Remarks. For want of descriptive detail and due to alterations in generic definitions Cernosvitov (1937a) considered Enchytraeus metlakatensis as one of many "species incerti generis Enchytraeinarum". Nielsen and Christensen (1959) placed it in Marionina.

Details concerning the shape of the setae, the

morphology of the septal glands, the exact morphology of the testes and the state of maturity of the specimens examined are not known. The taxonomic value of Eisen's (1904) figures 36a&b of the spermathecae is indeterminable since the specimen figured was probably not mature (no spermatozoa in the ampullae of the spermathecae). The status of the taxon is genus inquirendus and due to loss of the type material will remain that way until new material can be found.

Marionina saxicola (Eisen, 1904)

Enchytraeus saxicola Eisen, 1904, pp. 70-71, f.41,
pl.XVIII f. 6.

Enchytraeus saxicola: Cernosvitov, 1937a, p. 293.

Marionina saxicola: Nielsen and Christensen,
1959, p.109

Type material. USNM 5150/32921. Both lot numbers represent the same syntype specimens. As the M. citrina syntypes, these specimens have been dried out while in storage and consequently have not been examined.

Type locality. Lowe Inlet, British Columbia; 3 June, 1899.

Habitat. Under rocks, at high tide.

Distribution. As type locality.

Remarks. Considered by Cernosvitov (1937a) and Nielsen and Christensen (1959) similarly to the two preceding taxa.

It is apparent from the illustrations (Eisen, 1904, f.41) and the description, including habitat, available for M. saxicola (Eisen, 1904 pp.70-71) that in many morphological and other characteristics it is similar to Enchytraeus kincaidi (Table 4). It is improbable that internal structures such as peptonephridia and nephridia characterizing both Enchytraeus and E. kincaidi would be clearly discernible in specimens that have dried.

If the species were replaced in Enchytraeus it still would not be possible to establish its specific position. The spermatheca illustrated by Eisen (1904, f.41b) resembles that of E. multiannulatus which is without a small ectal rosette; however, Eisen states that the ampulla had only a simple diverticulum, like E. kincaidi.

Unless further studies can be made of material from Lowe Inlet, Enchytraeus saxicola should practically be considered genus inquirendus.

Keys to intertidal genera and species of Enchytraeidae found in British Columbia

The following keys can be used with either living or fixed and cleared mature specimens. Identifications should be confirmed by reference to detailed species descriptions. Taxa, other than Enchytraeus albidus, not found in this British Columbia survey are not included because most of their specific descriptions are incomplete and their taxonomic status are uncertain.

A. Generic key

1. Seminal vesicles present or absent, if present, not divided into numerous regular, often pear-shaped lobes 2
 - Seminal vesicles well-developed, distinctly lobed into more or less regular parts Lumbricillus
2. Setae absent from at least the most anterior segments, where present, only one seta per bundle Grania
 - Setae otherwise 3
3. Paired, unbranched peptonephridia present Enchytraeus
 - Peptonephridia absent, usually small specimens with few setae per bundle Marionina

B. Specific keys

Enchytraeus

1. Specimens large, greater in length than 10 mm and with segment number greater than 40 (unbroken specimens) 2

- Small specimens, length less than 10 mm, segment numbers between 20 and 35 Enchytraeus bonus
- 2. Spermatheca with distinct, small rosette at ectal pore, only a few gland cells scattered along the ectal duct; with a single, large, distinct diverticulum from ampulla of spermatheca
..... Enchytraeus kincaidi
- Spermatheca without distinct rosette at ectal pore, with dense glands along at least ectal 1/2 of ectal duct; diverticula otherwise.....3
- 3. Spermathecal ampulla with two large diverticula, one directed dorsally the other directed ventrally; 3, rarely 4, setae per ventral bundle Enchytraeus multiannulatus
- Spermatheca without distinct diverticula on the ampulla, however, the ampulla may be laterally dilated or pinched into a few sequential chambers; usually more than 3 setae per ventral bundle
..... Enchytraeus albidus

Grania

- 1. Ventral setae present from IV, lateral setae present from XIII-XVII; sperm funnel length 3 to 5 x width Grania paucispina
- Ventral setae present from IV, rarely V, lateral setae present from XVII-XIX; sperm funnel length 13 to 15 x width
..... Grania n. sp.

Lumbricillus

1. Spermatheca with glands surrounding ectal duct, with or without a rosette at ectal pore 2
 - Spermatheca with only a rosette of glands at ectal pore 8

2. Spermatheca with a small ectal rosette; ampulla thick-walled with spermatozoa embedded in the walls Lumbricillus tsimpseansis
 - Spermathecal rosette relatively large and obvious; ampulla not thick-walled, spermatozoa distributed otherwise 3

3. Diameter of spermathecal ampulla of mature worm (with spermatozoa in ampulla) less than or just equal to ectal duct width; ectal duct 3 to 4 x as long as ampulla Lumbricillus annulatus
 - Diameter of spermathecal ampulla greater than that of ectal duct; ectal duct 3 or fewer x length of ampulla 4

4. Anterior setae straight; ampulla of spermatheca elongate, onion-shaped; collar of sperm funnel highly convoluted in mature worms .. Lumbricillus mirabilis
 - Setae at least slightly sigmoid throughout; ampulla of spermatheca more or less round; sperm funnel collar not convoluted 5

5. Nephridia present from II/III, absent only from X/XI and XII/XIII .. Lumbricillus sp. - with many nephridia
 - First pair of nephridia in VI/VII or VI/VIII or otherwise, but not more anteriorly 6

6. Spermathecae attached to gut at 1/2V; sperm duct short, in loose, irregular loops in XII Lumbricillus curtus
- Spermathecae attached to gut at V/VI; sperm duct long, in a regular or an irregular coil in XII 7
7. Sperm funnel collar constricted, approximately 1/2 diameter of funnel Lumbricillus qualicumensis
- Sperm funnel collar equal in diameter to funnel (large, robust worms)..... Lumbricillus pagenstecheri
8. Spermatheca without distinct ampullar cavity 9
- Spermatheca with distinct, relatively thin-walled ampulla 10
9. Spermatheca with distinct, short ectal duct; with sperm funnel cylindrical, length 2.5 to 5 x width Lumbricillus lineatus
- Spermatheca without distinct ectal duct; sperm funnel tapered towards vas deferens, length approximately 1.5 x maximum width ...
..... Lumbricillus rupertensis
10. Ectal duct of spermatheca widening gradually into ampulla, ectal canal distinct, polar regions of ampulla with thick walls, equatorially thin; spermatozoa arranged in a ring in equatorial region Lumbricillus tuba
- Both ectal duct and canal of spermatheca distinct from ampulla, ampulla large, thin-walled, onion-shaped; spermatozoa in an irregular ring or barrel shapeLumbricillus cf. helgolandicus

Marionina

1. With well-developed seminal vesicles containing sperm morulae2
 - Without seminal vesicles, sperm morulae free in coelom 5

2. Anteseptale of nephridia consisting of nephrostome only;
 - spermathecae not attached to oesophagus Marionina trevori
 - Anteseptale of nephridia large, including some coils of nephridial canal; spermathecae attached or connected to oesophagus 3

3. Lateral setae absent, ventrals straight with ental hook, 2 per bundle Marionina subterranea
 - Lateral setae lacking in II, XII with no setal bundles, other segments with 2 setae per bundle, setae straight with ental hook Marionina charlottensis
 - Setae 2 per bundle, straight with ental hook, laterals present in II 4

4. Spermatheca with glands along ectal duct and with distinct rosette, spermatozoa distributed in rings in walls of spermathecal ampulla Marionina sjaelandica
 - With small glands along ectal duct of spermatheca, no rosette at ectal pore (ectal pore of spermatheca posterior to septum IV/V).....
..... Marionina neroutsensis

5. Setae straight, numbers per bundle variable, to 4 or 5
- Marionina vancouverensis
- Setae sigmoid, as many as 5 or 6 in an anterior bundle
- Marionina appendiculata

2.3 Habitat and geographical distributions

Habitat distribution in British Columbia

The small size and low powers of locomotion of intertidal enchytraeids may make these (and other meiofaunal animals) good tools for probing an environment which, because of its spatial and temporal heterogeneity, cannot be adequately described on the basis of a few measurements of chemical and physical variables.

With respect to some factors of their habitat, species may live very close to the limits of their capabilities whereas, with respect to others, they may be "buffered by wider safety margins" (Wieser, 1975). The limits within which survival of the species is possible can be determined by: 1) studying its distribution in time and space, 2) measuring the important ecological variables in the habitat and 3) analyzing, in the laboratory, the responses of species to single variables and combinations of variables.

Determining, in these ways, interacting factors that govern the distribution of a given species (Giere, 1977b) allows prediction of the effects of disturbance of the environment--for example, through pollution--on the composition of the fauna.

For the British Columbia survey, distribution in horizontal space relative to some roughly determined ecological variables--pulp mill pollution, sediment type and intertidal elevation--has been examined. Laboratory responses to important ecological variables remain to be studied.

Species from each of Lumbricillus, Enchytraeus and Marionina were found at most intertidal elevations in all of the major intertidal habitats discriminated according to freshwater input, estuaries vs. others, then to

estuaries with vs. without organic loading from pulp mill effluents; according to sediments, beaches vs. mudflats; and according to energy input, exposed vs. non-exposed beaches (Table 15).

Grania species were much more restricted in habitat range (Table 15).

Enchytraeus species were not found in any locations with high densities. E. kincaidi was found in a pulp mill inlet (station locality number 28, see Table 15), on an unpolluted estuary (11) and in beach samples (2,17,18), in and under coarse sediment components, associated either with algal strand at the upper intertidal line or with living algae in the upper-mid intertidal or with some unnatural organic pollutant.

E. multiannulatus and E. bonus were found on a low salinity, mud flat immediately opposite an effluent of the Port Edward (35) kraft-process pulp mill.

The known Grania component of the British Columbia enchytraeid fauna consists of one subtidal species, collected incidentally, found in Victoria Harbour and near Rennison Island in Camano Strait and one low intertidal species found on a mud-shell flat in Burrard Inlet (16). These species are not frequent members of the intertidal enchytraeid faunae occurring between average tide levels. The habitat of the new Grania species from Vancouver, heterogeneous, fine sediments, is unusual but not unknown for the genus (see also G. macrochaeta pusilla and G. variochaeta, in Erséus and Lasserre, 1976).

In most habitats, Lumbricillus was the most diverse and abundant genus. Lumbricillus tuba, found in abundance in samples taken at some distance from Port Edward (35) and Port Alice (28) pulp mill effluents, was a dominant enchytraeid of northern shorelines near Ocean Falls (33)

and was also very abundant in some samples taken on the intertidal sand flat of the Tsitika River estuary (11). It has not yet been identified from samples taken in more southern habitats. European records of this species are restricted to more northern habitats in Finland (Nurminen, 1967), Denmark (Nielsen and Christensen, 1959), Scotland (Stephenson, 1911), Wales (Tynen, 1972) and Greenland (Nurminen, 1970a), usually near higher water mark of coarse sediment beaches.

L. cf. helgolandicus was found to have a northern habitat distribution similar to but more restricted than L. tuba. Specimens of L. cf. helgolandicus were found only in samples taken near Prince Rupert (35), Port Alice (28) and Ocean Falls (33) in organically enriched sites. L. cf. helgolandicus is recorded from drift-line algae, beach habitats in northern Europe. The restriction of L. cf. helgolandicus in British Columbia to human-disturbed habitats may be an indication that it is a recently introduced component of the intertidal fauna; certainly the species would have evolved long before such habitats existed and would therefore be expected in a native zone as at least an occasional component of naturally enriched habitats, as seen in Europe.

L. lineatus presents a more extreme case of the possible introduced status discussed with regard to L. cf. helgolandicus. L. lineatus was found as an abundant component of the enchytraeid fauna only in grossly polluted habitats (28, 33, 35) where what sediments existed were reduced (black) almost to the sediment/air or sediment/water interface and where the activity of sulfur bacteria was obvious.

Pulp mills being not only associated with pollution but also with world-wide transport by sea of industrial products constitute areas with a high probability of introduction by man of marine species. If

the introduced species could tolerate the chemical and physical environment around the mill, the depauperate habitats there would offer ideal conditions for proliferation. The resistant reproductive stage and entirely benthic life history of an aquatic oligochaete would enhance its probabilities of surviving human transport and of establishing dense, localized populations.

In the areas adjacent to pulp mills, L. lineatus was frequently associated with the tubificid oligochaetes Monopylephorus irroratus and/or M. ruboniveus (Prince Rupert samples 35.3 and 35.4 and Ocean Falls sample 33.5 - see Appendix 1) or with Monopylephorus pacificus (Port Alice sample 28.1) (Brinkhurst, 1979).

L. annulatus, as it is now synonymized, has a very wide range of distribution along the British Columbia coast. It is most frequently found in abundance under decaying strandline algal wash on coarse sediment beaches (Eisen, 1904, Tynen, 1969a and personal observation (Table 15)). Mature specimens of L. annulatus attain very high densities in enriched upper intertidal beach habitats during the warm summer months (Altman, 1931 and personal observation). In May, 1978, L. annulatus was found to be the numerically dominant and a very abundant species at a Neroutsos Inlet sample site, Rumble Beach. This was a coarse sand-gravel beach with only a small amount of algal wash but it was subject to organic loading from domestic effluents.

L. pagenstecheri has been found in small numbers with L. annulatus and more abundantly in some locations on the mainland coast (33) where L. annulatus was not found. L. pagenstecheri was collected in a range of sediments from fine to coarse, in locations subject to a wide variation in salinity (33 and Port Alice).

L. mirabilis has only been found around Vancouver Island. It is most frequently found associated with L. annulatus on coarse sand beaches such as Mt. Douglas (3), near Elk Falls (15) and Long Beach (30). L. mirabilis was not collected from more northern localities including Port Alice (28), Ocean Falls (33) and Kitimat (34). At these sample sites L. pagenstecheri, a morphologically similar species, was found.

L. annulatus, L. pagenstecheri and L. mirabilis were not found in disturbed areas very near pulp mills.

L. qualicumensis has, as yet, only been found in the sand-silt (Port Alice) or coarse sand (17, 3) beach habitats of more southern regions.

Other Lumbricillus species were found in very small numbers in at most two locations. L. curtus is recorded only from the shores of two northern inlets, Alice Arm on Portland Canal and Neroutsos Inlet (28); L. tsimpseanis and L. rupertensis, only from enriched habitats near Port Edward pulp mill (35) and an unnamed Lumbricillus sp., from coarser sediments of Qualicum Beach (17) on the east coast of Vancouver Island.

Of the Marionina species identified, M. sjaelandica occupies the greatest variety of habitats. These habitats include a range of sediments from coarse sand on beaches (3, 30) to fine compact silt of estuaries (11, 15, 28). On an estuary adjacent to the Elk Falls pulp mill (15), thought to be nutrient enriched because of an extensive bloom of filamentous green algae, M. sjaelandica was the only oligochaete found and was present in very high numbers. European records for this species (Nielsen and Christensen, 1959 and Tynen, 1972) only exist from

coarse sand-gravel beach habitats.

M. vancouverensis was less abundant and occurred less frequently than M. sjaelandica in pulp mill polluted sites (Table 15) but was very abundant on an unpolluted southern estuary at the Tsitika River (11) and on the Cayeghle Creek estuary at the head of Neroutsos Inlet (Table 20). M. vancouverensis was not found in coarse beach sediments. The most northern locations in which M. vancouverensis has been found are near Ocean Falls (33).

In some northern locations (33), M. vancouverensis was found with another small Marionina species, M. charlottensis. At Ocean Falls, M. charlottensis was collected from sand-silt and sand-silt-gravel sediments from lower mid to upper intertidal elevations. In Alice Arm off Portland Canal, M. charlottensis was absent from samples taken at lower intertidal elevations (Sheila Byers, Dobrocky Seatech Ltd., personal communication).

M. appendiculata was obtained in small numbers from silty upper intertidal habitats on the Tsitika River estuary (11) and from silty, estuarine and non-estuarine habitats of Neroutsos Inlet, at some distance from the Port Alice mill outfall (Table 20). Tynen (1972) recorded the presence of this species in littoral habitats of Anglesey and Menai Straits from samples taken in "stabilized mud" habitats high between the tide marks, which were well-drained and bore grasses and other flowering plants. Such a compacted mud would probably be comparable to the fine-grained sediments recorded at the British Columbia locations where M. appendiculata was collected.

M. subterranea was collected in only one location, a coarse gravel-sand beach at the upper intertidal strand (15), where wash algae was mixed

10 cm down into the sediments. This species has not been recorded in British Columbia from estuaries or finer sediment habitats. Lasserre (1971a) and Tynen (1972) also reported M. subterranea only from sandy habitats in France and northern Wales, respectively,

M. trevori also was found in only one location, Qualicum Beach (17), in a habitat similar to that known for M. subterranea.

M. neroutsensis was collected in most abundance from the fine, upper intertidal sediments of a non-estuarine habitat in Neroutsos Inlet (Table 20). Few or no specimens were found in similar sediments near stream outflows into the inlet.

Habitat distributions of the species as illustrated in Table 15, according to the major habitats discriminated, obscure some information that is obvious from more detailed sample site descriptions given in Appendix 1. This results because some of the broad sample locations such as Prince Rupert (35), Ocean Falls (33), Port Alice (28) and Elk Falls (15) encompass a range of habitats from very disturbed, organically enriched, to only slightly disturbed and from silty sediments to coarse sediments. Thus, Marionina subterranea and Lumbricillus annulatus seem to occur in polluted pulp mill locations but were in fact collected on gravel-sand beaches not subject to the influence of concentrated pulp mill effluents.

With such problems of the general habitat discrimination in mind, it can be determined from Table 15 that L. annulatus, L. mirabilis and M. trevori are usually found in 'beach' habitats and that other species, including M. vancouverensis, L. lineatus, L. cf. helgolandicus and L. tuba are usually found in 'estuarine' habitats.

Geographically, the species seem to be divided into a group which occurs north of and including Tsitika River (11) and/or Neroutsos Inlet (28) or south of and including the above locations (Table 15). Only Lumbricillus pagenstecheri, as synonymized, L. annulatus, including Eisen's (1904) and Altman's (1931) records, Enchytraeus multiannulatus and E. kincaidi, as synonymized, are reported from North American Pacific habitats north and south of Neroutsos-Tsitika.

Three species, L. lineatus, L. cf. helgolandicus and L. tuba, occur consistently at northern and Port Alice pulp mill stations. Detailed information in Appendix 1 shows that L. lineatus is found in the most disturbed locations, L. cf. helgolandicus in less disturbed and L. tuba only at some distance from the mill effluents. Marionina sjaelandica was the only, very abundant, enchytraeid found on a nutrient enriched estuary near a southern pulp mill, Elk Falls (11).

A probable evolutionary consequence of the adaptive strategies required to survive in high stress environments would be a broad distribution and considerable evolutionary stability. Thus, L. lineatus, L. cf. helgolandicus and L. tuba, found in stressed environments in British Columbia, are morphologically indistinguishable from their physically distant European counterparts. Only a few species have achieved the degree of eurytopy required to survive in stressed environments and therefore the eurytopic species are found to live in low diversity associations (after Jackson, 1974).

Geographical distributions

Distributional range is a very important component of a species realized niche. It is influenced by the species' geological age, genetic variability, physiological tolerance and mode of reproduction and dispersal, as well as by the arrangement of geographic barriers (Hesse, et al, 1951: in Jackson, 1974).

In the marine realm the environmental factor most often referred to as controlling geographic distributions of species is temperature (Hedgpeth, 1957 and Kinne, 1970). However, Wieser (1975) illustrated that, for beach locations, the temperature maxima reached in approximately the upper two cm of sediment on sunny days are virtually independent of the geographical locations of the beaches; temperature minima and ranges of temperature are not independent. Consequently, the ranges of temperature and related factors such as pO_2 and alkalinity experienced by an intertidal species in a single location are much greater than those experienced over the entire geographic range of another, deeper water marine species (Jackson, 1974). Distributions of intertidal species would not necessarily fit into the faunal provinces based on temperature maxima and minima conceived for other marine habitats.

Intertidal marine environments, estuaries, beaches and mudflats, are physically more discontinuous than deeper benthic environments. Therefore, intertidal species without adequate means of long distance dispersal should display considerable endemism.

Competition for available resources does not seem to be a principal limiting factor to geographic distribution of intertidal enchytraeids as there is considerable overlap of congeneric species, particularly within Lumbricillus, living in similar environments. Predation, one other

biological interaction which could limit organism distributions, hasn't yet been shown to be very significant in the life histories of meiofaunal oligochaetes.

Three species of Enchytraeus were recognized among the British Columbia enchytraeid specimens examined. E. bonus, a new species, is known only from the type locality; E. multiannulatus and E. kincaidi are known from Puget Sound and the British Columbia coast, or Vancouver Island and the coast, respectively. E. multiannulatus is presently recorded from two locations, one near Seattle, Washington and one near Prince Rupert, B. C.. The essentially identical morphologies of the two disjunct populations suggests that they are not geographically or genetically isolated and that there are unlocated populations at intermediate locations.

All of the British Columbia Enchytraeus species are morphologically similar to either a widely distributed group of other Enchytraeus species or to individual cosmopolitan, holarctic or amphi-Atlantic species, as E. multiannulatus is to the intertidal species E. capitatus and E. albidus. The group of species to which E. bonus is similar is comprised of several species with narrow, known geographic ranges, only few of which include intertidal habitats.

Enchytraeus consists of a group of widely distributed species occupying a variety of habitats, exclusive of subtidal marine. E. multiannulatus and E. kincaidi occupy intertidal habitats the same as those of the more widely distributed species to which they are morphologically similar. This group of large intertidal Enchytraeus species, shown in Table 4, is probably closely related, possibly with a monophyletic intertidal

origin; although, the structure of the penial bulb of E. capitatus is aberrant within the group (Table 4). However, E. bonus is most closely related to a group dominated by wet soil species, some of which have specifically moved into intertidal habitats. In consideration of the probable terrestrial origins of Enchytraeus and of the evidence that a few incursions, with varying evolutionary successes, into the marine environment have occurred it is not surprising that Enchytraeus species do not show Pacific regional diversities as displayed by other marine fauna (Briggs, 1974).

The British Columbia Enchytraeus fauna appears to have been genetically isolated from old world genetic input for a sufficient time to allow distinct species to evolve but insufficient to disguise all morphological similarities to other marine Enchytraeus species. Further investigations relating to the possible presence and habitat distribution of E. albidus, a cosmopolitan species known from naturally enriched, intertidal habitats and from sewage beds and effluents, could yield more information about dispersal and speciation of Enchytraeus in British Columbia and the North Pacific.

At least two species of Grania are present in British Columbia. The confirmation of the presence of Grania species in the northern Pacific and in the southern hemisphere (Erséus and Lasserre, 1977 and Jamieson, 1977) indicate that the genus probably has a cosmopolitan distribution. Limited, known species distributions within this genus primarily reflect the limited number of taxonomic surveys of oligochaetes done in low intertidal and subtidal habitats.

Erséus and Lasserre (1976) have treated allopatric populations of Grania of doubtful rank as subspecies, after the opinion of Mayr (1969).

New records of sympatric Grania taxa (Erséus, 1977) with morphological dissimilarities at the level previously considered (Erséus and Lasserre, 1976) to merit only subspecific rank differentiation, have initiated a reconsideration of the taxonomy of Grania (Erséus, personal communication).

The distribution of Grania species in the Pacific is so poorly investigated and the taxonomic relationships between the various forms within the genus are so poorly understood that it is not possible to deduce any hypotheses about evolutionary centres of origin for Grania, an entirely marine genus. The history of this genus is expected to differ considerably from the other intertidal genera of Enchytraeidae discussed.

Lumbricillus shows the greatest diversity of species as well as the highest degree of intraspecific variability of all of the intertidal genera recorded in British Columbia. The genus has colonized a variety of intertidal habitats and attained a cosmopolitan distribution. Eleven of twenty-three species (including one unidentified species) recorded from this collection were of Lumbricillus, three of the eleven were recognized as species new to science.

Four of the Lumbricillus species found have very broad distributional ranges (Table 16). L. lineatus is probably cosmopolitan, with existing records from north and south Atlantic coasts, the northern seas of Europe and Russia, and the Canadian Arctic (Welch, 1919). L. pagenstecheri, L. tuba and L. cf. helgolandicus, including the new distribution records, are holarctic.

Table 16. Geographic distributions of Lumbricillus species found in the North Pacific.

North Pacific			Cosmopolitan or Holarctic
east	west	east and west	
qualicumensis* ^o	kamtschatkanus	annulatus* ^o	lineatus*
belli ^o	yamaguchi ^o	mirabilis* ^o	cf helgolandicus*
rupertensis*	corallinae ^o		tuba*
tsimpseansis*	pinquis ^o		pagenstecheri* ^o
curtus* ^o	similis ^o		
sp. -with many nephridia*	kurilensis ^o		
	alaricus		
	orientalis ^o		
	rufulus ^o		
	ignotus ^o		

* Species found in the British Columbia survey

o Species with 'typical' spermathecal glandular morphology

Note: Only those Lumbricillus species with recent complete descriptions have been included, consequently, much of Eisen's material is excluded.

Of the several north Pacific intertidal Lumbricillus species (Eisen, 1904 (in part), Yamaguchi, 1937, Tynen, 1969a, Shurova, 1974 and 1977 and this report), only two (Table 16) are reported from both east and west Pacific coasts. L. annulatus and L. mirabilis were recorded by Shurova (1974) in intertidal collections made on the Kurile Islands. Another possible amphi-Pacific species is L. qualicumensis, with L. ignotus Shurova, 1977 a probable synonym.

Tynen (1969a) noted that of known North American Pacific coast Lumbricillus species, all but L. santaclarae Eisen, 1904 (not known from an intertidal habitat) were characterized by a similar spermathecal gland cell distribution. All had dense, prominent glands along the ectal duct plus a distinct rosette of glands at the ectal pore. Shurova (1974 and 1977) has since described eight new intertidal species of Lumbricillus from the Kurile Islands and the far eastern seas of the U.S.S.R.. Only one of these, L. alaricus Shurova, 1974, is lacking the glands along the duct. Of the eleven Lumbricillus species recorded from the new British Columbia material, five, L. rupertensis, L. tsimpseanis, L. lineatus, L. cf. helgolandicus and L. tuba, are either without glands surrounding the length of the ectal duct or without a distinct basal rosette. North Pacific Lumbricillus species with the characteristic gland cell distribution recognized by Tynen are indicated in Table 16.

Only a few of the, approximately, thirty known European, amphi-Atlantic or cosmopolitan species have this same gland cell distribution around the spermathecal ectal duct. L. pagenstecheri and L. kalatdlitus Nurminen, 1970a (?=L. pagenstecheri, Erséus, 1976a) from European coasts and Greenland and Canadian Arctic coasts, respectively, have the same spermathecal morphology as the Pacific group. L. semifuscus

(Claparède, 1861) and L. algensis Erséus, 1977 from northern Europe and the west coast of Sweden, respectively, have the same glandular arrangement as the Pacific group but the cells surrounding the ectal duct are not prominent. This particular spermathecal morphology appears to be characteristic for north Pacific Lumbricillus species and may be highly relevant to the interpretation of their peculiar evolutionary history. At present, how the Pacific complex evolved is a matter for speculation. If the north Pacific coast is considered as peripheral to the primary evolutionary centre of Enchytraeidae, then the north Pacific complex possibly arose through very active speciation after immigration of L. pagenstecheri (or a L. pagenstecheri-like taxon), a frequent and abundant species in northern European intertidal habitats.

Marionina is a somewhat inhomogeneous taxon. The species are found in a wide variety of habitats including marine intertidal and shallow subtidal, limnic and terrestrial. A few species are found in abundance in widely distributed marine intertidal habitats. Seven adequately described species of Marionina are recorded from the north Pacific and all of these species records are from the north-east. M. sjaelandica and M. appendiculata are both well known from intertidal habitats of northern Europe, as is M. subterranea, which is also recorded from California (Cook and Brinkhurst, 1975 and Locy, personal communication). The new records from the north-east Pacific would indicate that these three species are probably holarctic. However, the significance of the lack of records of Marionina species from the northwest Pacific is not fully understood.

Three of the four new Marionina species described in the taxonomic results are morphologically similar to other intertidal species and the

intertidal component of Marionina would seem to be quite homogeneous. The resemblance of M. vancouverensis to M. spicula is particularly pronounced. M. neroutsensis is similar to M. cana Marcus, 1965, a species known only from one, high intertidal location on the Atlantic coast of South America. These latter two species fall within a well-defined, intertidal subgroup of Marionina, characterized by small size, two straight setae per bundle and well-developed seminal vesicles, which also includes M. subterranea and M. charlottensis. M. aberrans Finogenova, 1973 from the Caspian Sea at depths to 193 m, and M. swedmarki Lasserre and Erséus, 1976 from Bermuda are two differently distributed species that also fall within this geographically widespread, morphologically similar, species group.

M. trevori does not show a high degree of morphological affinity to species other than Eisen's (1904) poorly defined, eastern Pacific species M. americana and M. alaskae.

The British Columbia Marionina fauna probably has evolved from other forms as a result of slow allopatric speciation. Morphological similarities of individual British Columbia species to other individual species of the global fauna indicates that the British Columbia fauna has not arisen monophyletically but subsequent to numerous instances of old world genetic input. Elucidation of northern and southern distribution limits of Marionina species in North America would reveal substantially more information about their zoogeographic histories.

With regard to amphi-north Pacific relationships in marine intertidal and subtidal Enchytraeidae of Enchytraeus, Grania and Marionina no conclusions can be drawn. Essentially no information is available about these genera in the north-west Pacific. Only Enchytraeus albidus (Zenkevich, 1963 and Altman, 1931) is recorded both from the northern seas of the U.S.S.R. and from the north-east Pacific.

As discussed previously, Lumbricillus faunae of the north-east and north-west Pacific coastlines are similar with regard to spermathecal morphologies but the species are, in large part, distinct. Limited dispersal capabilities combined with broken distributions of suitable intertidal habitats may be responsible for such specific endemism.

Gross qualitative and quantitative taxonomic differences between marine enchytraeid faunae of the Atlantic and Pacific coasts of North America can be seen in Table 17. Illustrated are differences in the numbers of genera and species found on each coast as well as the differences in numbers of known endemic species and/or subspecies.

Three genera known from intertidal habitats of the Atlantic are not yet recorded from the Pacific. Stephensoniella Cernosvitov, 1936, a genus requiring further studies, includes only two geographically remote species, S. marina (Moore, 1902) from Bermuda and S. barkudensis (Stephenson, 1915) from India. Henlea Michaelsen, 1889 and Cernosvitiella Nielsen and Christensen, 1959 would not be unexpected as

Table 17. Comparison of intertidal enchytraeid diversities of the Atlantic and Pacific coasts of North America.

genus	Atlantic (inc. Bermuda)	genus	Pacific
	No. of taxa (endemics)		No. of taxa (endemics)
Lumbricillus	3 (2)	Lumbricillus	11+?1 (6)
Enchytraeus	2	Enchytraeus	4 (3)
Marionina	7 (2)	Marionina	7 (4)
Grania*	3+?1	Grania*	2 (2)
Cernosvitoviella	1		
Henlea	1		
Stephensoniella	1 (1)		
total taxa	18 (8)	total taxa	25 (15)
% endemic	44%	% endemic	60%

* Grania taxa include both subtidal and intertidal components

Note: species of uncertain taxonomic status have not been included, i.e. many of Eisen's (1904) species and varieties.

components of upper intertidal and saltmarsh faunae of the Pacific coast. Several species of Henlea (Eisen, 1904 and Altman, 1936) are already known from terrestrial habitats along the Pacific coast of North America and probably only the limited range of intertidal habitats investigated has caused it to be overlooked there.

No endemic intertidal genera of Enchytraeidae have been recognized from Pacific North America and none are expected because of the global homogeneity, availability and, on a geographic scale, continuity of littoral habitat. This allows a considerable range of geographic mobility for eurytopic species of the intertidal genera, like Lumbricillus lineatus.

Comparison within genera allows detection of other differences between Pacific and Atlantic coasts. The most striking contrast exists within Lumbricillus. The Pacific coast relative to the Atlantic is a centre of high diversity and endemism (Table 17). This higher degree of endemism and to a lesser extent diversity along the Pacific coast is just discernible in Enchytraeus and Marionina. The principal habitat, subtidal, for Grania has been poorly investigated on the Pacific coast and Atlantic-Pacific differences probably reflect differences in search effort rather than actual differences in the faunae.

From other North American investigations of total marine invertebrate faunae, it has been estimated that at comparable latitudes the number of Pacific species may be as many as three times that of the Atlantic. These faunal differences imply that a greater diversity of marine intertidal and subtidal niches exists along the Pacific coast. Greater numbers of endemics may be indicative for understandably lower genetic exchange rates

between Pacific and old world faunae than between N. A. Atlantic and old world faunae.

In this taxonomic survey of British Columbia intertidal enchytraeids, endemic taxa outnumber cosmopolitan, holarctic and amphi-north Pacific taxa combined (Table 17). Nurminen (1973a) proposed that the intertidal enchytraeid fauna of Pacific North America would not be noticeably distinct from other intertidal faunae because of the global homogeneity of the intertidal habitat. Evidence is given here that, specifically, the North American Pacific fauna is distinct, reflecting high resource and niche availability, and generally underdeveloped dispersal mechanisms.

3. ENVIRONMENTAL MONITORING

3.1 Introduction

There are about 12 active pulp mills, of kraft or sulphite process, with marine outfalls into nearshore waters of mainland British Columbia or Vancouver Island. Consistent with utilized pollution abatement systems, including the physical location of the outfalls, the various mill effluents have environmental impacts of different degrees on shoreline communities.

The primary outfall of Port Alice pulp mill discharges into the surface waters near the head of Neroutsos Inlet (Fig. 122) and has a very noticeable perturbative impact on the shoreline flora and fauna (Ellis, Cross, Coates and McKinnel, 1978).

Pulp mill production at Port Alice accompanied by mill waste disposal into Neroutsos Inlet commenced in 1917. Early oceanographic studies of Neroutsos Inlet (Hutchinson and Lucas, 1927 Ms.) by the Canadian Federal Fisheries Department indicated no obvious changes in water chemical or plankton characteristics after some ten years of waste disposal. Through a detailed study made 1956 to 1957 Waldichuk (1958) recorded surface oxygen depletion in Neroutsos Inlet. Further physical and chemical surveys (Waldichuk, Markert and Meikle, 1968) were carried out by representatives of the Fisheries Research Board of Canada over the succeeding nine year period, 1957 to 1967, and these documented deterioration of water quality in the area as mill production increased.

Figure 122. Chart of Neroutsos Inlet with environmental monitoring survey stations indicated. Station names corresponding to letter designations are given in Table 18.

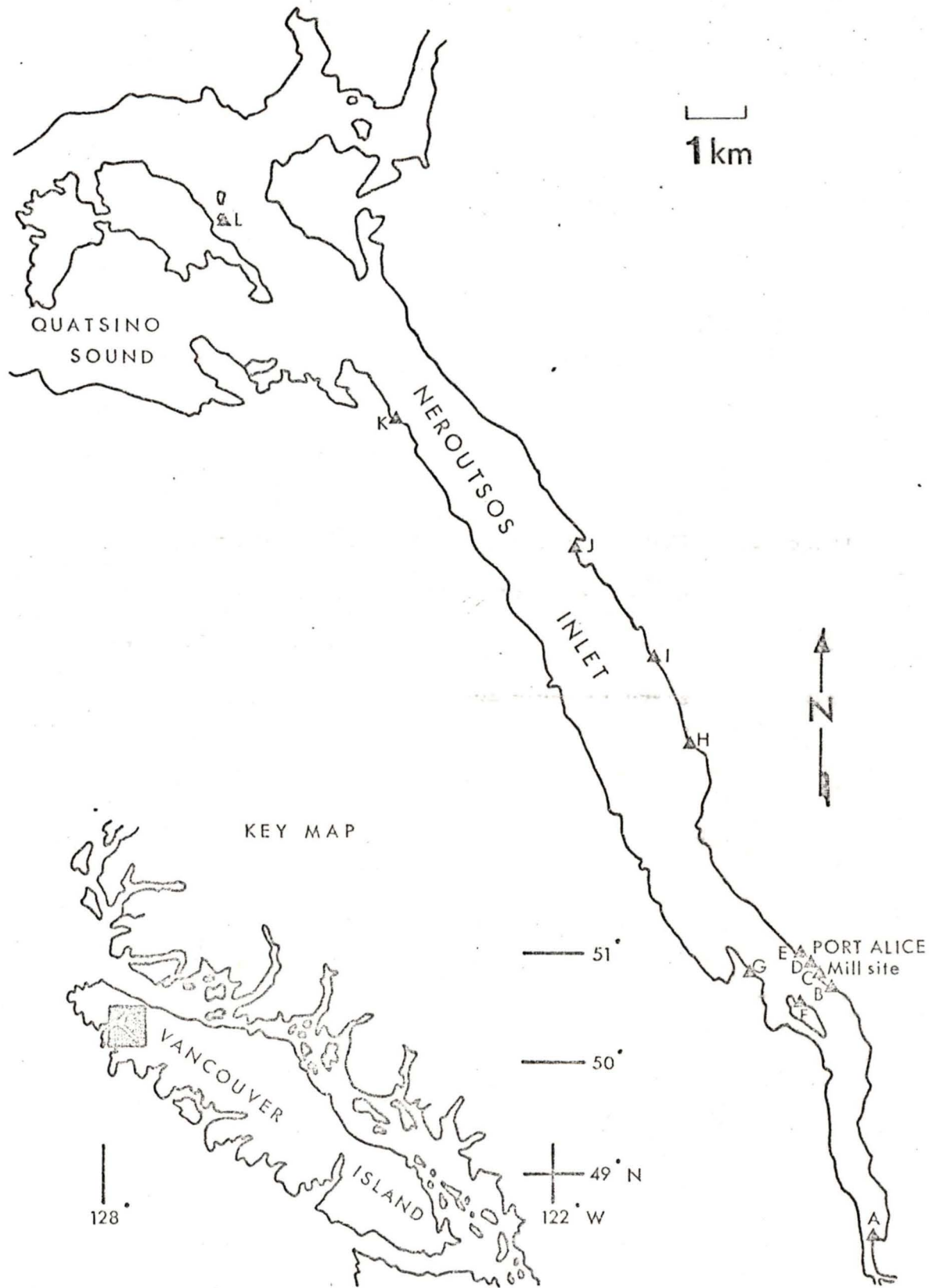


Table 18. Station Designations in Neroutsos Inlet

Letter desig. of Fig. 122	Station Name	Corresponding Sample #, Appendix 1	Distance from mill outfall (km)
A	Cayeghle estuary		4.5 (S)
B	Mill South		0
C	Mill North		.2(N)
D	Old Park site		.4(N)
E	Boat dock (N. of mill)	28.1	.6(N)
F	Ketchen Island	28.2	.5(S)
G	Cayuse estuary	28.3, 28.4, 28.5	1.4(N)
H	Rumble Beach		5.8(N)
I	Jeune Landing	28.6, 28.7	7.6(N)
J	Rock Quarry		11.4(N)
K	Brown's Point		15.7(N)
L	Drake Island Rock		17.9(N)

The Olympic Research Division of I.T.T. Rayonier Incorporated continued the hydrographic survey with two exploratory series in 1966 and 1967 and two detailed series, designed to more adequately describe the biology as well as hydrology of Neroutsos Inlet, in 1969 and 1973 (Stoll, 1975).

Since 1975, a continuous program that provides information about the aquatic system through the seasons has been instituted by I.T.T. Rayonier (Stoll, 1975 and 1976 and Stoll and Vandermeulen, 1977). In particular, data collected in 1976 provided background biological and hydrological information for a period just prior to the implementation of a major pollution abatement system in the Port Alice ammonia-base sulfite pulp mill. Late 1977 saw start-up of a spent sulfite-liquor recovery furnace which burned up large quantities of liquor constituents that were previously dumped into Neroutsos Inlet or, post-1973, partially disposed of by barging to the open ocean. Obvious changes in water quality and organism distributions and abundances with respect to the background data collected were expected to occur within, at most, a two year period following furnace start-up.

The Marine Environmental Group at the University of Victoria became involved with the mill problem in developing a test program for monitoring rehabilitation on the shore around the mill outfall. One of the tests included was species associational analyses of enchytraeid oligochaetes (Ellis, et al, 1978). Changes in relative species abundances ~~and in~~ ~~relative species abundances~~ and in species composition of the worm communities were expected to correspond to changing levels of effluent

concentration in the waters flowing past the shoreline habitat, that is, most basically, to distance from the mill effluent.

3.2 Methods

Sampling

Sediment samples containing enchytraeids were collected from the vicinity of Port Alice pulp mill, on the shores of Neroutsos Inlet, in June, 1976, May, 1978 and June, 1978. A sampling program was continued through summer and winter 1978/79 but the enchytraeid faunae of these later samples have not yet been analyzed.

A. Spatial design

Changes in intertidal enchytraeid oligochaete communities were expected to correspond to reductions in effluent concentrations at increasing distances from mill outfall. Water quality surveys (Stoll, 1975) and initial visual shoreline surveys around Neroutsos Inlet (Ellis, et al, 1978) indicated that the most extreme impact on the shoreline communities occurred along the east shore of Neroutsos Inlet around the mill. The shoreline communities were progressively more normal in appearance toward the head of the inlet and towards Quatsino Sound, the mouth of the inlet. Due to river discharge the net surface flow in Neroutsos Inlet is towards Quatsino Sound, primarily along the east shore. Consequently, impact on the shoreline communities towards the head of the inlet and along the west shore only extends for a short distance from the outfall.

The following is a list of the names of the persons who have been appointed to the various positions in the office of the Secretary of the State of New York, for the term ending on the 31st day of December, 1901.

SECRETARY OF STATE: J. B. ALLEN, Jr.

DEPUTY SECRETARY OF STATE: J. B. ALLEN, Jr.

CLERK OF THE OFFICE: J. B. ALLEN, Jr.

CHIEF CLERK: J. B. ALLEN, Jr.

ASSISTANT CLERKS: J. B. ALLEN, Jr.

RECORDS AND CORRESPONDENCE: J. B. ALLEN, Jr.

GENERAL INVESTIGATION: J. B. ALLEN, Jr.

LEGISLATION: J. B. ALLEN, Jr.

CONSTITUTIONAL LAW: J. B. ALLEN, Jr.

ADMINISTRATIVE LAW: J. B. ALLEN, Jr.

FINANCE: J. B. ALLEN, Jr.

LAND OFFICES: J. B. ALLEN, Jr.

NAVY AND MILITARY AFFAIRS: J. B. ALLEN, Jr.

FOREIGN AFFAIRS: J. B. ALLEN, Jr.

INDUSTRIAL AFFAIRS: J. B. ALLEN, Jr.

LABOR: J. B. ALLEN, Jr.

AGRICULTURE: J. B. ALLEN, Jr.

MINES AND GEOLOGY: J. B. ALLEN, Jr.

WATERWAYS AND CANALS: J. B. ALLEN, Jr.

RAILROADS: J. B. ALLEN, Jr.

TELEGRAPHS AND TELEPHONS: J. B. ALLEN, Jr.

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STATIONERY: J. B. ALLEN, Jr.

RECORDS: J. B. ALLEN, Jr.

CORRESPONDENCE: J. B. ALLEN, Jr.

GENERAL INVESTIGATION: J. B. ALLEN, Jr.

LEGISLATION: J. B. ALLEN, Jr.

CONSTITUTIONAL LAW: J. B. ALLEN, Jr.

ADMINISTRATIVE LAW: J. B. ALLEN, Jr.

FINANCE: J. B. ALLEN, Jr.

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RECORDS: J. B. ALLEN, Jr.

CORRESPONDENCE: J. B. ALLEN, Jr.

Intertidal sample stations were accordingly located along the east shore of Neroutsos Inlet from the mill to a point where water quality and intertidal responses appeared the same on both east and west shores (Fig. 122 and Table 18). To allow for infrequent but possible upstream and eddy effects sample stations were also located on the west shore of the inlet, on an island immediately opposite the mill and on the Cayeghle estuary at the head of the inlet (Fig. 122).

B. Habitats sampled

Enchytraeids, in particular of genus Lumbricillus, were known to be common and often abundant members of the fauna of upper intertidal, algal strand beach habitats (Nielsen and Christensen, 1959; Giere, 1975 and personal observation). Such a habitat, where large numbers of organisms could be consistently obtained, was considered a practical type for an ecological study and monitoring program such as that proposed for Port Alice (Ellis, et al, 1978). The upper intertidal habitats also were accessible under all but extreme high tide conditions thus avoiding night sampling which would be necessary at certain times of the year for all lower intertidal elevations.

The locations of appropriate beach habitats that were sampled are indicated on Figure 122. Intertidal flats at estuaries, Cayeghle and Cayuse, were also sampled (Fig. 122 and Table 18).

Collecting techniques

May, 1976 samples taken at Port Alice (Appendix 1) were non-quantitative and were obtained and processed as indicated in methods for

the general British Columbia survey material.

May, June and later 1978 samples were obtained with a plexiglass core tube, I.D. 5.0 cm and length 6.0 cm (sample area = 19.6 cm^2 , sample volume = 117.8 cm^3), pressed into appropriate beach sediments just below high water line. A representative sample of the enchytraeid population was probably obtained (Giere, 1973 and 1975). Deeper quantitative samples, and occasionally even samples to this depth, could not always be obtained due to the gravelly nature of some of the substrates.

The samples were transferred quantitatively to storage containers and either fixed immediately with 10% buffered formalin in seawater or kept alive in an incubator at 4°C until the specimens could be sorted out for immediate identifications.

Three (an absolute minimum) replicate core samples were obtained from each quantitative sample site.

Extraction techniques

Quantitative samples were in all cases sorted without filtration. Fixing fluids were decanted from preserved samples and then the sample was sorted in an appropriate volume of seawater. After sorting, the sediments or residue of all samples were preserved in order that estimates of sorting efficiencies could be made. Retention of unfiltered sediments would also allow, as necessary, determination of some of the physical characteristics of the worms' habitats. Physical habitat characteristics such as sorting coefficient and distribution of sediment particle size are of, at least, some limited importance in habitat selection (Jansson, 1971).

After identification, specimens were stored in 70% ethanol with 10% by volume glycerin to minimize the deleterious effects of accidental drying during storage.

3.3 Preliminary Results and Discussion

Species found

An enchytraeid species list (Table 19) precedes the species station matrices for the three surveys June, 1976 (Table 20a), May, 1978 (Table 20b) and June, 1978 (Table 20c). Ten of eleven species identified in Neroutsos Inlet were already known from the other British Columbia material examined. Additional records of Lumbricillus curtus n. sp. and Marionina appendiculata Nielsen and Christensen, 1959 confirmed the previous identifications. One new species of Marionina, M. neroutsensis, was distinguished. A very few specimens of mature avesculate (parthenogenetic triploid) (Christensen, Beng and Jelnes, 1976) Lumbricillus lineatus were found in May, 1978 at the mill South station.

Spatial differences in species complexes

A. Density

The sampling design used did not produce average densities useful for station to station comparisons due to very high within station variances. For example, June, 1978 duplicate samples were enumerated for mill South and mill North stations. The results for the mill South samples, mature specimens, are shown in Table 20c; for total enchytraeids results were 357 in the first sample and 175 in the second (first and second as sequence in Table 20c). For the mill North samples, one sample

Table 19. Intertidal enchytraeid species-list for Neroutsos Inlet

- 1 Lumbricillus lineatus (O. F. Muller, 1774).
- 2 Lumbricillus cf. helgolandicus (Michaelson, 1927) aff.
 Nielsen and Christensen, 1959.
- 3 Lumbricillus qualicumensis Tynen, 1969.
- 4 Lumbricillus tuba Stephenson, 1911.
- 5 Lumbricillus annulatus Eisen, 1904.
- 6 Lumbricillus pagenstecheri (Ratzel, 1869).
- 7 Lumbricillus curtus n. sp.
- 8 Marionina vancouverensis n. sp.
- 9 Marionina sjaelandica Nielsen and Christensen, 1961.
- 10 Marionina neroutsensis n. sp.
- 11 Marionina appendiculata Nielsen and Christensen, 1959.
- 12 Enchytraeus cryptosetosus Tynen, 1969.

Table 20a. Enchytraeid species-station matrix, June, 1976
 indicating numbers of mature specimens. Species
 number designations correspond to those in Table 19.

Species													
Stations		1	2	3	4	5	6	7	8	9	10	11	12
<u>Name</u>	<u>Distance from mill outfall (km)</u>												
Cayeghle	4.5 S					not	sampled						
Ketchen	.5 S	11	7	1						3	3	1	algal HT
Mill S.	0					not	sampled						
Mill N.	0.2 N					not	sampled						
Old Park	0.4 N					not	sampled						
Boat Dock	0.6 N	6	1										
Cayuse	1.4 N	1	2	6	1				15	21	3	2	
		15	7	2									
		1*	1*										
Rumble	5.8 N					not	sampled						
Jeune L.	7.6 N			5					3	4	1		4
			16	66	1				4	2	36		4
Quarry	11.4 N					not	sampled						
Brown's	15.7 N					not	sampled						
Drake I.	17.9 N					not	sampled						

* Low tide sample

Table 20b. Enchytraeid species-station matrix May, 1978
 indicating numbers of mature specimens. Species
 number designations correspond to those in Table 19.

Species		(upper shoreline samples)											
		1	2	3	4	5	6	7	8	9	10	11	12
Stations													
<u>Name</u>	<u>Distance from mill outfall (km)</u>												
Cayeghle	4.5 S		3	49	46				98	2	4		
Ketchen	0.5 S	71							1		1	(low tide)	
Mill S.	0	19			1								6
Mill N.	0.2 N								1				1
Old Park	0.4 N	8		28	28		12			7		2	
Boat Dock	0.6 N (most immature)										1		
Cayuse	1.4 N	1		6	13				1	2			
Rumble	5.8 N	3		10		134	1						
Jeune L.	7.6 N						4						
Quarry	11.4 N	1?					1						
Brown's	15.7 N											2	
Drake I.	17.9 N			43					3	1	64	18	

contained two specimens neither of which was mature, the other sample contained 200 specimens, with 16 mature (Table 20c). Statistical analysis of density variance between stations by a parametric test is not valid when very high variance between sample densities exist for each station (Zar, 1974). Before a non-parametric test could be applied many more samples would need to be analyzed.

The value of total density in station to station comparison, in fact, is probably of limited application when different species will have success peaks (as measured by abundance) at different levels of the environmental variable considered, i.e., concentration of pulp mill effluent (Green and Vascotto, 1978).

B. Diversity

The concept of diversity combines two often independently varying components: number of species and equitability of abundance among them (Green and Vascotto, 1978). In Tables 20b, and 20c it can be seen that no consistent trends, over all surveys, in numbers of species relative to distance from the mill outfall exist that would support an hypothesis that high concentrations of pollutant in the surface waters adjacent to the mill had severely disturbed the intertidal fauna. However, it is particularly clearly seen in May, 1978 and June, 1978 results (Table 20b and 20c) that one species, Lumbricillus lineatus exists as the numerically dominant enchytraeid only at stations very near the mill effluent and is not found, except very rarely, in minimally disturbed habitats.

With particular caution, due to the within-station variability, some inference may be drawn from the apparent faunal diversity change at Boat

dock station between June, 1976 and June, 1978. There occurred in this time both a change in the faunal equitability and in the numbers of species present. Since implementation of the sulphite-liquor burning furnace in later 1977 there has been some substantial change in surface water quality near the mill. These changes are illustrated particularly well by dissolved oxygen levels measured by the Rayonier I.T.T. monitoring group (Fig. 123). (Locations of Rayonier I.T.T. water quality monitoring stations are shown in Figure 124.) The faunal changes recorded at the Boat dock station could represent the beginning of recovery of the intertidal communities, with species characteristic for perturbed faunae becoming restricted to sites nearer to the actual point of effusing.

Ecological Associations

A. Lumbricillus lineatus (Muller, 1774)

Both the 1978 surveys agree in documenting the presence of one predominating species at mill stations North and South. The change in predominance of mature Lumbricillus lineatus, expressed as a % of total mature specimens per sample (averaged when replicate samples were examined), is shown in Figure 125. From the mill site to between 6 or 7 kilometres north of the mill % L. lineatus drops from 73-98 to 0. Only in May, 1978 was a mature specimen tentatively ascribed to L. lineatus found at a distance greater than 7 kilometres north of the mill site. Per cent L. lineatus drops off even more rapidly, to the south of the mill site.

L. lineatus, as discussed previously, is a cosmopolitan littoral species, frequently found in abundance in wrack beds at European locations.

Figure 123. Improvement in water quality of Neroutsos Inlet. Dissolved oxygen-mean values of July, August, September and October - p.p.m. - top 2 metres (after Rayonier Canada. December, 1978. Environmental Improvement at Neroutsos Inlet. Volume 1. Figure 9.)

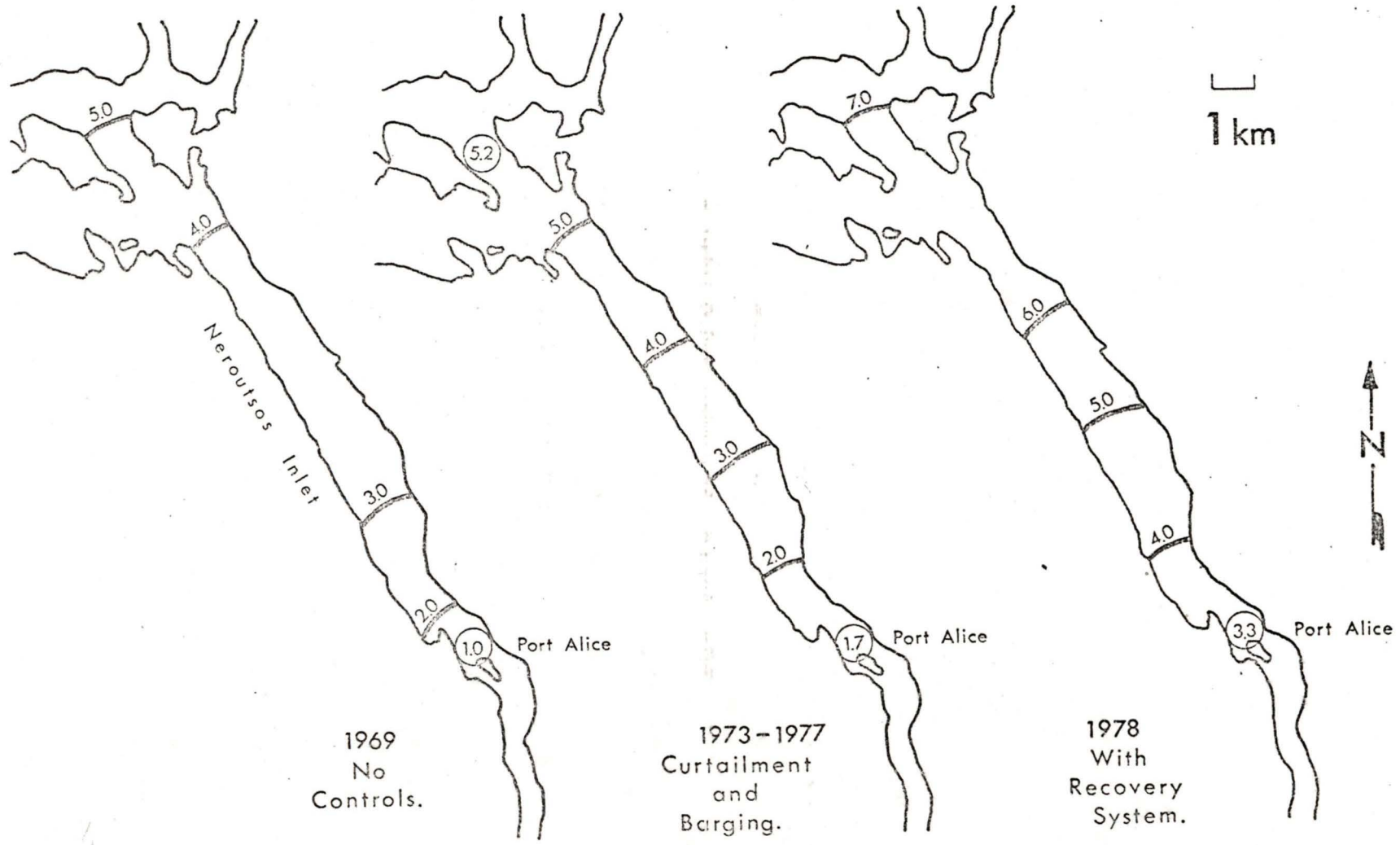


Figure 124. Locations in Neroutsos Inlet of Rayonier I.T.T. water quality monitoring stations; ● daily water quality stations, ▲ monthly hydrocast stations (after Rayonier Canada. December 1978. Environmental Improvement at Neroutsos Inlet. Volume 1. Figure 2.)

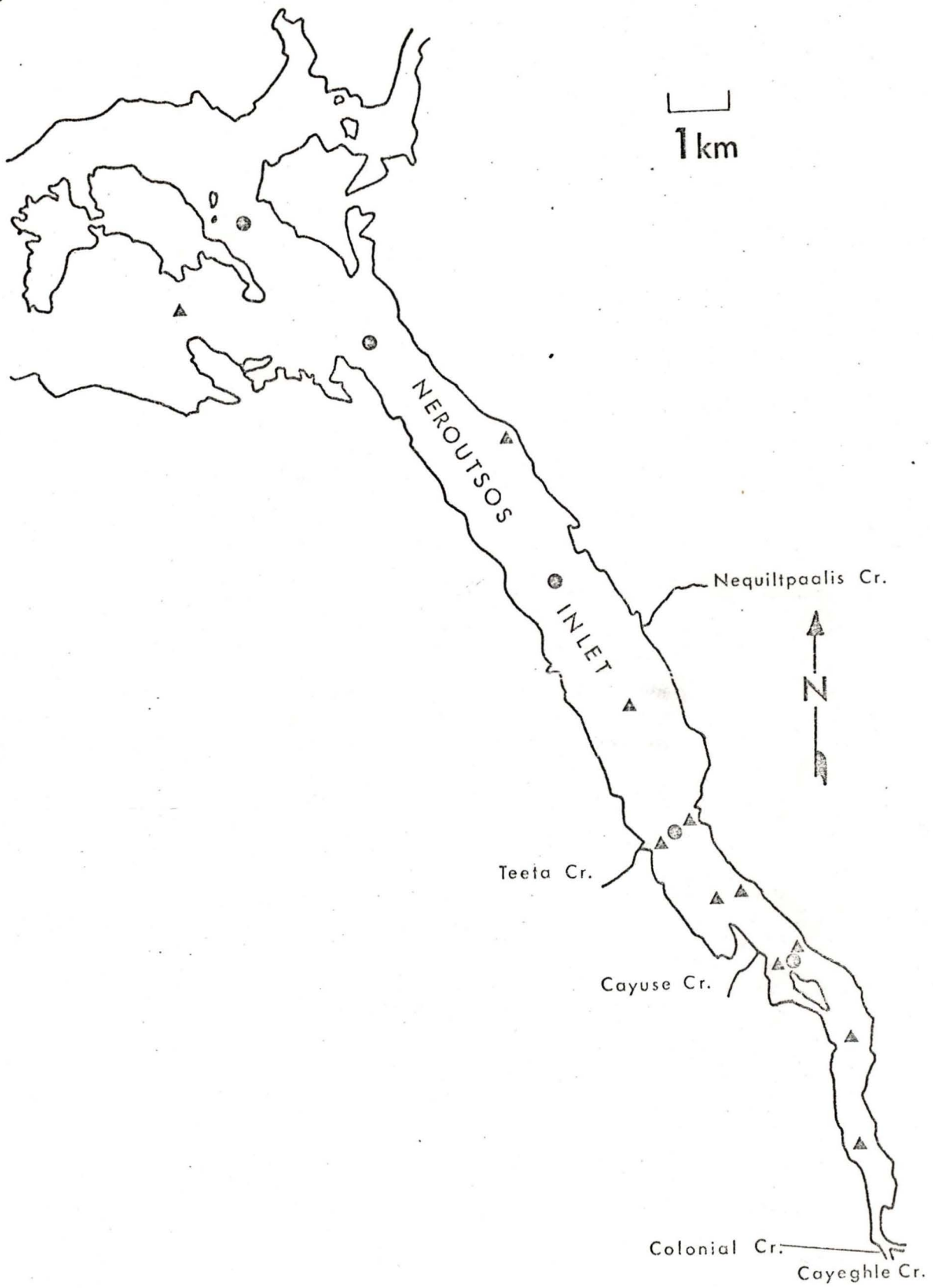


Figure 125. % composition of enchytraeid fauna by Lumbricillus lineatus (Müller) relative to distance from the Port Alice mill effluent, June, 1976, May, 1978 and June, 1978.

It has not yet been found on the British Columbia coast in abundance in any but the most grossly human-polluted, littoral habitats. Reliable, recent British Columbia records of the species exist only for locations near Prince Rupert, Ocean Falls and Port Alice. It is a genetically variable species (Christensen, Beng and Jelnes, 1976) and as such possibly preadapted for colonization of the vacant, modified niches of very disturbed habitats. The life history and initial responses to disturbed conditions of L. lineatus are, unfortunately, virtually unstudied.

That L. lineatus is a recently introduced, not a native, species for British Columbia is interpreted from its consistent absence from naturally enriched habitats. L. annulatus and L. pagenstecheri, in northern localities, occupy in abundance, in British Columbia, the 'typical' European habitat of L. lineatus.

For this widespread (cosmopolitan?), genetically variable species occupying diverse habitats, the possibilities of sibling species with different reproductive strategies should be investigated (Christensen and Jelnes, 1976 and Grassle and Grassle, 1976).

B. Other taxa

Non-enchytraeid - enchytraeid associations which deserve more attention are those occurring between tubificids and enchytraeids in artificially polluted locations. As pointed out previously, L. lineatus, when found in high numbers, was consistently associated with one or two of three Monopylephorus species, M. irroratus and/or M. ruboniveus or, at Port Alice, M. pacificus. Similar associations are not known from non-polluted locales, although the Monopylephorus species are not as restricted as L. lineatus in niche realization on the British Columbia coast (Brinkhurst, in preparation, 1979).

4. Conclusion and Summary

Taxonomy

On the basis of material examined for this taxonomic survey, twenty-two marine enchytraeid species of four genera, Enchytraeus, Lumbricillus, Grania and Marionina, were reported from British Columbia. A twenty-third species, Enchytraeus albidus, is also predicted to occur in British Columbia intertidal habitats. Nine of the taxa, Enchytraeus bonus n. sp., Grania n. sp., Lumbricillus tsimpseanis n. sp., L. curtus n. sp., L. rupertensis n. sp., Marionina vancouverensis n. sp., M. charlottensis n. sp., M. neroutsensis n. sp. and M. trevori n. sp., are new to science. Another Lumbricillus species with an unusual distribution of nephridia is of uncertain taxonomic status due both to the small number of specimens collected and to an overall morphological resemblance to L. qualicumensis. For previously described species the synonymies of L. georgiensis Tynen, 1969 and L. ritteri Eisen (in part), 1904 to L. pagenstecheri (Ratzel, 1869) sensu Nielsen and Christensen, 1959; and of Enchytraeus pugetensis Altman, 1931 and Lumbricillus vancouverensis Tynen, 1969 to L. annulatus Eisen, 1904; and of Enchytraeus cryptosetosus Tynen, 1969, E. alaskae Eisen, 1904 and E. modestus Eisen, 1904 to E. kincaidi Eisen, 1904 were proposed. The generic status of E. multiannulatus Altman, 1936 and E. multiannulatoides Altman, 1936 and of Grania paucispina (Eisen, 1904) were confirmed through study of recent and/or available type material.

A number of taxa recorded from British Columbia are still considered to be taxa inquirenda, in many cases, because type materials have

been lost or damaged and new material was not found. This is indicative of the amount of taxonomic study that remains to be done on the Enchytraeidae of British Columbia.

No new genera were described from British Columbia although slight modifications were made to the diagnoses of Grania and Marionina. Nielsen and Christensen (1959) recognized that Marionina was not a homogeneous generic grouping and this has been further pointed out by the addition to the genus of M. trevori and replacement in the genus of M. americana Eisen, 1904. Detailed study of morphologies of terrestrial, limnic and marine species of Marionina is required before taxonomic revisions can be proposed.

The taxonomic investigations of British Columbia species were done on fixed specimens stained with a nuclear stain, Grenacher's alcoholic borax carmine. Contrary to the frequently repeated opinion of Nielsen and Christensen (1959, etc) that live specimens are essential for morphological investigations, well-fixed specimens, properly prepared for light microscopy, were more than adequate. Specimens observed alive were easily recognizable as taxa identified from fixed material and vice versa.

Only external surficial observations of specimens were made using the scanning electron microscope. However, the potential for internal observations exists and should be investigated. S.E.M. photomicrographs duplicate the three dimensional attributes of organs and organ systems more quickly than drawings and are vastly superior to light photomicrographs in both resolution and depth of field.

Habitat distribution

For species previously recorded from Europe, only the habitat range of Marionina sjaelandica was substantially extended. In British Columbia it is found both on beaches and in estuaries whereas European records (Nielsen and Christensen, 1961 and Tynen, 1972) are so far restricted to sandy beaches.

Most interesting from an environmental assessment point of view was the very restricted habitat distribution in British Columbia of Lumbricillus lineatus. It was concluded that competitively well-balanced intertidal enchytraeid faunae have established themselves in British Columbia and that L. lineatus, recently introduced, is competitively excluded from these natural habitats. However, when an unnatural environmental stress, a pollutant, disturbs the organism-environment balance at a location physically accessible to L. lineatus, it soon establishes itself as a faunal component. Possibly, the degree of dominance of the fauna by L. lineatus would reflect the amount and type of stress being experienced by the habitat. As a result of Lumbricillus lineatus' recent introduction to British Columbia a situation has developed where an eurytopic, widely distributed taxon can possibly be used to predict by its presence or absence even minor environmental disturbance.

The intertidal enchytraeid fauna of British Columbia could be discriminated into fairly consistent northern estuarine, southern estuarine and beach habitat species complexes. Between northern and southern species complexes there is apparently a zone of overlap along the shore of Vancouver Island, very roughly at latitude 50° 30'N. Intertidal habitats at and about this latitude should be more

extensively studied in terms of zoogeographic distributions of intertidal species.

Geographical distribution

Zoogeographic distributions of the species found were discussed both in terms of the individual species and in terms of uniform morphological species complexes within the four marine genera studied.

Sixty percent of the intertidal species recorded from Pacific North America, including species found in this collection and other validly described species, are presently known only as endemics. No endemic genera are recorded. Before amphi-Pacific relationships can be adequately described much more extensive distributional studies, particularly in the north-west Pacific, must be done.

It was concluded that it was inappropriate to elucidate the zoogeography of the Enchytraeidae on the basis of only marine species distributions since many of the genera are apparently of terrestrial origin and have many more terrestrial species than marine or limnic. Knowledge about the zoogeography of the completely marine genus Grania is still in an embryonic state and the taxonomic relationships between allopatric as well as sympatric populations are poorly understood.

It is concluded, with some reservation due to limited information, that the north-east Pacific is not an important evolutionary centre, in the sense of a phyletic future (Briggs, 1974, p.446), for the Enchytraeidae.

Environmental survey at Port Alice

Taxonomically, the Port Alice survey was useful for providing specimens of two previously recorded but infrequently encountered species, Lumbricillus curtus and Marionina appendiculata. The presence of a previously unrecorded species, Marionina neroutsensis, in Port Alice samples indicated that the enchytraeid species list obtained from the British Columbia survey was only partially complete.

Environmentally, the Port Alice survey showed that species distributions of enchytraeid communities was very different in shoreline habitats near a marine pulp mill effluent than in shoreline habitats minimally impacted by marine effluents.

The numbers of species and the numbers of individuals in quantitative samples of the enchytraeid communities were not found to be as predictive for perturbation as a simple measure of the % composition by Lumbricillus lineatus of the communities. Other species, where present, were found only in small numbers at stations along the east shore of Neroutsos Inlet adjacent to the mill effluent.

Numerical species and community data useful for statistical analyses have not yet been obtained. Variability between replicate samples, reflecting the inherent variability of the system sampled, was very high and the number of replicates taken was very small.

As a result of these initial surveys at Port Alice identifications of intertidal enchytraeids found in the mill area can now be made very quickly. The environmental impact information yielded by specific identifications more than compensate for any additional expenses incurred by the identification procedures.

It was found that if specimens were identified while alive, which eliminated staining, destaining and dehydration procedures, identification time comprised only a small fraction of the total time required for sorting and identifying. Once a familiarity with the species found in Neroutsos Inlet was established specific recognition of mature specimens required virtually the same amount of time as familial or generic recognitions.

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Appendix 1. Alphabetical station list and detailed records of
samples and specimens.

Alphabetical Station List.

<u>name</u>	<u>number</u>	<u>name</u>	<u>number</u>
Ashlee Bay	2	Patricia Bay	4
Brooks Peninsula Beach	31	Portage Inlet	6
Brooks Peninsula Estuary	24	Port Alberni	27
Burrard Inlet	16	Port Alice	28
Chemainus R. Estuary	13	Powell River	14
Clover Point	1	Prince Rupert	35
Cluxewe River	19	Qualicum Beach	17
Elk Falls	15	Salmon River	10
Fraser River	7	San Juan River	20
Jordon River	29	Shuttleworth Bight	32
Kingcome River	12	Squamish River	8
Kitimat	34	Stranby River	26
Klaskish River	25	Sydney River	22
Long Beach	30	Tasish River	23
Miracle Beach	18	Tsable River	9
Mount Douglas Beach	3	Tsehum Harbour	5
Moyeha River	21	Tsitika River	11
Ocean Falls	33		

Area: Juan de Fuca and Haro Straits

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Clover Pt. 1	1.1 48°24'N 123°21'W	8 Jan. 76	rocky, sand beach near outfall	ext. high +2.7m	0	-	-
Ashlee Bay 2	2.1 48°29.2'N 123°18.0'W	3 May 77	sand, gravel beach algal strand <u>Ulva</u> and eelgrass	high 2.4 - 2.7m	100+		
Mt. Douglas 3	3.1 48°30.18'N 123°20.5'W	26 Sept., 1976	sand, gravel beach abundant <u>Ulva</u> wood chips	high 2.8m	33	0	
	3.2 48°30.18'N 123°20.4'W	"	rocks, mud, sand beach	mid 2.4m	3	0	

Area: Juan de Fuca and Haro Straits

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Mt. Douglas 3	3.3	26 Sept., 1976	sand, mud beach wood chips <u>Ulva</u> , brown algae	mid-tide 2.4m	6	0	
	48°30.18'N 123°20.4'N						
	3.4	"	sand, mud pebbles, <u>Enteromorpha</u> beach/est.	low 1.8m	4	0	
	48°29.9'N 123°20.05'W						
	3.5	"	sand, mud shell, pebbles <u>Ulva</u> beach/est.	low 1.8m	40	5	<i>Lumbricillus mirabilis</i> 1 <i>L. annulatus</i> 2 <i>L. qualicumensis</i> 2
	48°29.95'N 123°20.05'W						
	3.6	"	coarse sand stone beach <u>Ulva</u> wash	high 2.8m	(1024) ~4000*	(39 Cocoons) 60	<i>Lumbricillus mirabilis</i> 46 <i>L. annulatus</i> 4 <i>Marionina sjaelandica</i> 10
	48°27.85'N 123°20.05'W						

Area: Juan de Fuca and Haro Straits (inc. Saanich Inlet)

Sample data					Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Mt. Douglas 3	3.7	26 Sept.,	fine mud	low	43	1	Marionina sjaelandica 1
	48°29.80'N	1976	sand	+6.2			
	123°19.75'W		beach	1.9m			
	3.8	"	fine mud	low	5	1	Lumbricillus annulatus
	48°29.80'N		silt	+6.2			
	123°19.75'W		beach	1.9m			
			in warm pool <u>Ulva</u> , browns				
	3.9	"	coarse sand	high-1.5'	65	8	Lumbricillus qualicumensis
	48°29.85'N		stone	+8			
	123°19.85'W		a little <u>Ulva</u>	2.4m			
Patricia Bay 4	4.3	24 May	large rocks	high	2	1	-
	48°39.3'N	1976	sand, shell	3-3.4m			
	123°26.7'W		beach				
			outfall <u>Ulva</u> , eelgrass, <u>Enteromorpha</u>				

Area: Juan de Fuca and Haro Straits (inc. Saanich Inlet)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Patricia Bay 4	4.4	24 May	rocks, fine	mid	4	3	-
	48°39.2'N 123°26.8'W	1976	sand beach near outfall <u>Ulva</u> , brown paper frags.	2.4m			
	4.5	"	stones, mud	mid	1	0	-
	48°39.6'N 123°26.9'W		<u>Enteromorpha</u> beach	2.4m			
Tsehum Harbour 5	5.1	2 Feb.,	fine mud	ext. high	3	0	-
	48°40'N 123°25'W	1976	estuarine mud flat sod clump (terrestrial)	3.5m			
	5.3	"	sand, silt	high	29	4,2	
	48°40'N 123°25'W		emergent veg estuarine mud flat	3.5m			

Area: Juan de Fuca and Haro Straits (inc. Saanich Inlet)

Sample data					Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Tsehum Harbour	5.4	2 Feb.,	fine mud	low	1	0	-
5	48°40'N 123°25'W	1976	estuarine mudflat	1.0m			
Portage Inlet	6.1	8 Jan.,	fine mud	high	1	1	Lumbricillus
6	48°24'N 123°21'W	1976	brackish inlet leaf debris	≈2.7m			
	6.3	11 Jan.,	fine mud	high	15	3	-
	48°24'N 123°21'W	1976	brackish inlet leaf debris	≈2.7m			
Fraser River	7.4	22 Nov.,	coarse sand	high	1	0	-
7	49°11.10'N 122°58.02'W	1976	brackish to fresh	1.8m			
	7.9	"	sand, mud	high	2	1	
	49°11.31'N 122°57.78'W		compact clay brackish to fresh	1.8m			

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Fraser River	7.10	22 Nov.,	mud	low	1	0	
7	49°11.31'N 122°57.78'W	1976	woodchips brackish to fresh	0.2m			
	7.15	23 Nov.,	mud, sand	low	1	0	
	49°11.97'N 122°56.50'W	1976	wood debris brackish to fresh	0.2m			
	7.21	"	mud compact clay	low	1	1	
	49°10.64'N 122°55.55'W		brackish to fresh	0.2m			
Squamish	8.2	19 Feb.,	mud	high	3	2	
8	49°41.85'N 123°10.03'W	1976	estuarine	4.9m			

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Squamish 8	8.4	19 Feb.,	mud, sand	high	11	2	
	49°41.95'N	1976	decaying	5.0m			
	123°10.06'W		leaves saltmarsh				
	8.7	"	sand	lower	6	3	(Enchytraeus cryptosetosus?)
	49°41.75'N		estuarine	4.6m			
	123°10.06'W						
	8.10	"	coarse clean	lower	16	3	(Enchytraeus cryptosetosus?)
	49°41.03'N		sand	4.6m			
	123°09.08'W		no visible debris estuarine				
Tsable River 9	9.3	11 June 1976	silt, sand estuarine emergent veg. <u>Fucus, Ulva,</u> <u>Enteromorpha</u>	high 4.9m	55	numerous	

Area: Strait of Georgia (inc. Fraser River)

locality name and number	Sample data			Specimen data		
	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
Salmon River 10	10.1 50°23.4'N 125°57.1'W	12 June 1976	coarse sand silt estuarine <u>Ulva</u> , brown algae	low-mid 1.2m	13	numerous some
	10.2 50°23.4'N 125°57.2'W	"	fine sand estuarine <u>Ulva</u> , brown filamentous green, eelgrass, <u>Fucus</u> woodchips	low-mid 1.2	1	
	10.3 50°23.3'N 125°57.2'W	"	stones, coarse sand, silt abundant <u>Fucus</u> estuarine	mid 1.8m	50	

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
Salmon River	10.4	12 June	sand, silt	mid	10+	
10	50°23.3'N 125°57.2'W	1976	<u>Fucus</u> , brown, red estuarine	1.8m		
	10.5	"	stone, coarse sand green unicell estuarine	low 0.8m	20	
	10.7	"	sandy, wood some <u>Fucus</u> emergents estuarine	high 5.0m	100+	
	10.8	"	silt, wood emergent root mat estuarine	high 5.0m	9	

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Tsitika River	11.1	18 July	stone, sand	low	42	28	Lumbricillus tuba 27
11	50°29.02'N 126°35.05'W	1976	estuarine abund. mussels, barnacles	2.2m			Marionina vancouverensis 1
	11.2	"	stone, gravel, sand	mid 2.7m	51	8	Lumbricillus tuba 6 Marionina vancouverensis 1 Enchytraeus kincaidi
	50°28.97'N 126°35.00'W		dense <u>Fucus</u> estuarine				
	11.3	"	sand, stone <u>Fucus</u>	mid 3.0m	128	52	Lumbricillus tuba 32 Marionina vancouverensis 12 Enchytraeus kincaidi 8
	50°28.92'N 126°34.98'W		barnacles, winkles estuarine				

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Tsitika River	11.4	18 July	gravel, sand	high	17	6	Lumbricillus tuba 1
11	50°28.85'N 126°35.02'W	1976	emergent veg (<u>Deschampsia</u>)	4.3m			Marionina vancouverensis 1 Enchytraeus kincaidi 4
"	11.5 50°28.95'N 126°34.91'W	"	sand, stone shell wood debris estuarine	mid 3.0	7	0	
"	11.6 50°28.85'N 126°34.79'W	"	soily silt emergent root mat estuarine	high 4.9	8	3	Marionina sjaelandica 1 Enchytraeus kincaidi 2
"	11.7 50°24.87'N 126°34.90'W	"	fine silt pool <u>Rhodomelia</u> , <u>Fucus</u> brackish	high 4.6m	40	22	Marionina vancouverensis 2 Marionina sjaelandica 18 Marionina appendiculata 2

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Tsitika River	11.8	18 July	sand, gravel	mid	46	6	Lumbricillus tuba 4
11	50°28.96'N 126°34.70'W	1976	<u>Fucus</u> and leafy red estuarine	3.0m			Enchytraeus kincaidi 2
	11.9	"	sand, wood	high-mid	19	6	Lumbricillus tuba 4
	50°28.81'N 126°35.15'W		<u>Fucus</u> , emergents estuarine	3.7m			Marionina vancouverensis 2
Kingcome River	12.1	19 July	sand, silt	high-mid	1		
12	50°55.85'N 126°11.46'W	1976	shell, fine wood debris estuarine	2.7m			
	12.2	"	compact	high-mid	1		
	50°56.17'N 126°12.12'W		silt, sand wood, and some unicellular green estuarine	2.9m			

Area: Strait of Georgia (inc. Fraser River)

locality name and number	Sample data		description	Specimen data		
	station no.	date		tide level	no. of specimens	no. mature specimens
Kingcome River	12.3	19 July	compact	high-mid	1	
12	50°56.20'N 126°11.91'W	1976	silt, clay green algae surface cover estuarine	2.7m		
	12.7	"	compact clay wood and plant debris some algae cover estuarine	high 4.0m	7	
	12.9	"	sand bar course mobile? estuarine	high-mid 2.9	10+	
	50°26.01'N 126°12.46'W					

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Kingcome River	12.11	19 July	sand, clay	high-mid	12		
12	50°55.82'N	1976	filamentous	2.7m			
	126°12.65'W		algae wash				
			wood debris				
			estuarine				
	12.12	"	stony, sand	mid	35		
	50°55.51'N		wood debris	3.0m			
	126°11.20'W		<u>Fucus</u> abund.				
			estuarine				
	12.13	"	course sand,	high-mid	5		
	50°55.59'N		stone	3.4m			
	126°11.09'W		estuarine				
			little/no				
			debris				
Chemainus River	13.10	4 May	silt, soil	high			
13	48°54.2'N	1976	sedge root mat	3.1m			
	123°40.9'W		estuarine				
			some pulp influence				

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Chemainus River 13	13.11 48°53.9'N 123°40.1'W	4 May 1976	coarse sand, silt some emerg. veg estuarine some pulp	high 3.0m	2	1	
	13.12 48°54.5'N 123°41.5'W	"	silt, shell estuarine some pulp	mid 2.1m	10		
	13.13 48°54.5'N 123°41.5'W	"	mud, silt compact estuarine some pulp	low 0.9m	1	0	
	13.14 48°54.5'N 123°41.5'W	"	mud, sand green algae estuarine some pulp	low 0.9m	10		

Area: Strait of Georgia (inc. Fraser River)

locality name and number	Sample data			Specimen data		
	station no.	date	description	tide level	no. of specimens	no. species names and no. of mature specimens
Chemainus River 13	13.15 48°54.4'N 123°41.4'W	4 May 1976	sand, gravel, shell estuarine some pulp	mid 2.4m	10	
	13.16 48°54.4'N 123°41.4'W	"	coarse sand, shell emerg. veg estuarine some pulp	high 3.0m	11	2
	13.17 48°54.4'N 123°41.4'W	"	sand no debris vis. estuarine some pulp	high 2.4m	5	
	13.18 48°54.4'N 123°41.4'W	"	clay, compact salt marsh estuarine some pulp	high 3.0m	7	2

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Chemainus River	13.19	1 June	silt estuarine	low	19		
13	48°54.5'N 123°41.4'W	1976	some pulp	0.8m			
	13.21	"	silt, and decay-	low	2+		
	48°54.5'N 123°41.0'W		ing leaves estuarine some pulp	0.5m			
	13.22	"	sand, shell	high	1		
	48°54.5'N 123°41.4'W		emerg. veg. estuarine	3.0m			
Powell River	14.1	17 July	sand, wood	mid	200+	2, many	
14	49°51.56'N 124°32.72'W	1976	debris algae wash <u>Fucus, Enter-</u> <u>omorpha</u> estuarine pulp mill	2.7m			

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Powell River 14	14.2 49°51.54'N 124°32.76'W	17 July 1976	fine sand, mud, soft estuarine pulp mill	low 2.4m	45	12	
	14.3 49°51.57'N 124°32.83'W	"	stony, sand <u>Enteromorpha</u> on rocks estuarine and pulp mill	mid 3.0m	90	24	
	14.4 49°51.59'N 124°32.84'W	"	sand, mud, little stone <u>Fucus</u> and <u>Enteromorpha</u> debris estuarine pulp mill	low 2.4m	157	27,40	

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Powell River	14.5	17 July	sand, stone	low	13	2	
14	49°52.51'N 124°33.71'W	1976	some <u>Fucus</u> much wood debris estuarine pulp mill	2.4m			
	14.6	"	sand, stone, shell	low	148	4,6	
	49°52.49'N 124°33.58'W		<u>Fucus</u> much wood debris estuarine pulp mill	2.4m			
	14.7	"	rocks	mid	15	2	
	49°52.50'N 124°33.83'W		<u>Fucus</u> , little <u>Enteromorpha</u> wood debris estuarine, pulp mill	3.0m			

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Elk Falls	15.1	11 June	coarse sand,	high	34	9	Lumbricillus mirabilis 3
15	50°04.34'N	1976	stones	4.4m			Lumbricillus annulatus 1
	125°16.40'W		algae wash				Marionina subterranea 4
			near pulp mill				Marionina sjaelandica 1
			estuarine				
	15.2	"	coarse sand,	high	570	27	Lumbricillus mirabilis 5
	50°04.29'N		stone	4.4m			Marionina subterranea 21
	125°16.40'W		abund. algae wash				Marionina sjaelandica 1
			near pulp mill				
			estuarine				
	15.3	"	fine sand,	high	59	15	Lumbricillus mirabilis 4
	50°04.24'N		stone	4.4m			Enchytraeus kincaidi 11
	125°16.40'W		abundant				
			green, brown				
			and red algae				
			wash				
			near pulp mill				

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Elk Falls 15	15.4 50°04.48'N 125°17.89'W	17 July 1976	fine sand algae wash abundant wood debris some large estuarine and pulp mill	high 4.3m	13	8	Marionina sjaelandica
	15.7 50°04.64'N 125°18.01'W	"	sand <u>Enteromorpha</u> much wood debris estuarine and pulp mill	high 4.3m	241	129	Marionina sjaelandica
	15.9 50°04.34'N 125°17.50'W	"	reduced silt fine wood chips <u>Enteromorpha</u> mat estuarine and pulp mill	mid 3.4m	54	48	Marionina sjaelandica

Area: Strait of Georgia (inc. Fraser River)

locality name and number	Sample data			Specimen data			
	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Elk Falls	15.10	17 July	reduced silt	mid	5	2	Marionina sjaelandica
15	50°04.30'N 125°17.50'W	1976	wood chips a filamentous green algae estuarine and pulp mill	3.4m			
	15.11	"	v. fine sand over wood chips (reduced) estuarine and pulp mill	low-mid 3.0m	79	49	Marionina sjaelandica
Burrard Inlet	16.1	21 Nov.,	sand, shell,	high	15		
16	49°18.17'N 123°07.62'W	1976	stone a little algae debris beach, brackish	3.7m			

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Burrard Inlet	16.3	21 Nov.,	mud, sand	mid	4		
16	49°18.19'N 123°07.60'W	1976	<u>Fucus</u> , some greens beach	2.1m			
	16.6	"	stony, mud, shell much live algae, reds, greens, browns beach	low 0.2m	28	28	Grania n. sp.
	16.12	22 Nov.,	shell, mud, sand beach brackish	mid 1.8m	4	2	Grania n. sp.
Qualicum Beach	17.1	10 June	coarse sand	high	75	43	Lumbricillus mirabilis 9
17	49°21.38'N 124° 26.50'W	1976	decaying algae debris beach	4.8m			Lumbricillus sp. (neph.) 1 Marionina trevori 27 Enchytraeus kincaidi 6

Area: Strait of Georgia (inc. Fraser River)

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Qualicum Beach	17.2	10 June	coarse sand,	high	110	9	Lumbricillus qualicumensis 3
17	49°24.03'N	1976	pebbles	4.6m			Enchytraeus kincaidi 6
	124°37.92'W		under wash				
			algae				
			estuarine				
			beach				
			near Qualicum				
Miracle Beach	18.1	11 June	stony beach,	high	264	83	Lumbricillus mirabilis 7
18	49°49.78'N	1976	sand patches	4.3-			Lumbricillus annulatus 48
	125°02.90'W		under wash	4.6m			Enchytraeus kincaidi 27
			algae				
Cluxewe River	19.1	14 June	clean coarse	high	100+		
19	50°36.80'N	1976	sand	5.0-			
	123°10.2'W		decaying	5.2m			
			algae wash				
			reds, browns,				
			greens				

Area: Vancouver Island North and West Coasts

Sample data				Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
San Juan River	20.1	30 May	sand	high	4	
20	48°35.1'N 124°23.0'W	1976	much wood debris, chips estuarine	3.4m		
Moyeha River	21.1	27 July	sand and	low	2	
21	49°24.47'N 125°54.45'W	1976	wood debris eelgrass bed estuarine	0.5m		
	21.3	"	sand	low	50+	
	49°25.02'N 125°54.42'W		<u>Enteromorpha</u> , eelgrass, <u>Bangia</u> <u>fuscopurpurea</u> estuarine	0.5m		
	21.4	"	gravel, sand	mid	50+	
	49°25.09'N 125°54.39'W		<u>Enteromorpha</u> , little <u>Fucus</u> estuarine	2.1m		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Moyeha River	21.5	27 July	gravel, coarse	low	50+		
21	49°25.07'N 125°54.30'W	1976	sand no algae estuarine	0.7m			
	21.6	"	sand, gravel	mid	50+		
	49°25.11'N 124°54.26'W		<u>Bangia</u> , little <u>Fucus</u> estuarine	1.8m			
	21.7	"	sand, little	mid	50+		
	49°25.13'N 125°54.49'W		gravel filamentous green algae some <u>Fucus</u> , <u>Bangia</u> estuarine	1.8m			

Area: Vancouver Island North and West Coasts

Sample data				Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
Moyeha River	21.8	27 July	sand,	high	59	
21	49°25.16'N 125°54.58'W	1976	emergent veg., <u>Fucus</u> , <u>Enteromorpha</u> estuarine	3.5m		
Sydney River	22.2	26 July	sand	low	30	
22	49°30.55'N 126°17.59'W	1976	some <u>Enter-</u> <u>omorpha</u> , a little wood estuarine	0.6m		
	22.4	"	sand, silt	mid	35	
	49°30.68'N 126°17.60'W		abundant <u>Fucus</u> , a little <u>Bangia</u> estuarine	1.8m		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
Sydney River	22.5	26 July	gravel, sand	low-high	56	
22	49°30.72'N 126°17.65'W	1976	<u>Fucus</u> , emer- gents estuarine	3.0m		
	22.6	"	sand, soil	high	28	
	49°30.90'N 126°17.81'W		rootmat <u>Fucus</u> , <u>Pelvetiopsis</u> , emergents estuarine	3.5m		
Tasish River	23.1	25 July	stone, mud,	low	2	
23	50°08.45'N 127°06.05'W	1976	shell <u>Bangia</u> , abundant <u>Leathesia</u> estuarine	0.5m		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Tasish River	23.2	25 July	gravel, mud,	low-mid	17		
23	50°08.40'N	1976	sand	1.2m			
	127°06.15'W		mussels				
			estuarine				
	23.3	"	gravel, mud,	mid	10+		
	50°08.40'N		sand	2.1m			
	127°06.29'W		<u>Fucus</u> abund.,				
			<u>Enteromorpha</u>				
			estuarine				
	23.4	"	sand, mud,	low-mid	50+		
	50°08.40'N		shell	1.2m			
	127°06.38'W		wood debris,				
			<u>Fucus</u> , <u>Ent-</u>				
			<u>eromorpha</u>				
			estuarine				

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Tasish River	23.5	25 July	gravel over	high	40		
23	50°08.45'N 127°06.40'W	1976	sand, silt <u>Enteromorpha</u> , other fil. green algae, some <u>Fucus</u> , some emerg. estuarine	3.4m			
	23.6	"	sand, wood debris	low-mid	10+		
	50°08.50'N 127°06.55'W		<u>Bangia</u> , <u>Fucus</u> , <u>Enteromorpha</u> estuarine	1.8m			
	23.7	"	sand	high	10+		
	50°08.52'N 127°06.51'W		just below emergent root mat estuarine	3.5m			

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Brooks Estuary 24	24.1 50°12.04'N 128°47.65'W	24 July 1976	fine sand some wood debris some <u>Fucus</u> estuarine	low 1.8m	33		
	24.2 50°11.95'N 128°47.8'W	"	sand, gravel, shell abund. <u>Fucus</u> estuarine	low-mid 2.1m	68		
	24.3 50°11.87'N 128°47.9'W	"	sand, gravel, shell estuarine	low-mid 2.1	14		
	24.4 50°11.87'N 128°47.9'W	"	sand, gravel, much shell debris <u>Fucus</u> estuarine	low 1.8m	39		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Brooks Estuary 24	24.5 50°12.02'N 128°47.95'W	24 July 1976	sand, mud; soft <u>Enter-</u> <u>omorpha</u> <u>Endocladia</u> Intertidal pool estuarine	high 3.8m	1000+		
	24.7 50°11.86'N 128°47.25'W	"	silt, root mat emergent veg., <u>Fucus</u> abundant, <u>Ent-</u> <u>eromorpha</u> estuarine	high 3.7m	16		
Klaskish River 25	25.2 50°15.95'N 127°43.05'W	23 July 1976	sand, silt, gravel emergent veg. barnacles estuarine	high 3.7m	24		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data		
locality name and number	station no.	date	description	tide level	no. of specimens	no. species names and no. of specimens
Klaskish River	25.3	23 July	sand, silt,	high	38	
25	50°15.94'N 127°43.08'W	1976	wood debris emergent, <u>Pelvetiopsis</u> estuarine	3.7m		
	25.4	"	sand, silt; soft <u>Fucus</u> fibrous organic estuarine	mid 2.4m	100+	
	25.5	"	sand, gravel some <u>Enter-</u> <u>morpha</u> estuarine	mid 2.4m	10+	
	50°15.90'N 127°43.01'W					

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Klaskish River 25	25.6 50°15.81'N 127°43.40'W	23 July 1976	sand, silt, stones fine wood (organic) debris <u>Fucus</u> estuarine	mid 2.4m	100+		
	25.7 50°15.79'N 127°43.36'W	"	gravel bar algae debris estuarine	high 3.7m	1		
	25.8 50°15.82'N 127°43.33'W	"	gravel bar abundant wash algae, <u>Xostera</u> <u>maritima</u> (eelgrass) estuarine	high 3.7m	20		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Stranby River	26.1	22 July	shell sand	low	12		
26	50°50.30'N 128°08.60'W	1976	little plant debris estuarine	1.7m			
	26.2	"	rocks, sand, silt <u>Fucus</u> , <u>Enteromorpha</u> estuarine	mid 2.3m	2		
	26.3	"	stone, little sand <u>Fucus</u> , a little <u>Enteromorpha</u> estuarine	mid 2.3m	116		
	26.4	"	saltmarsh lagoon gravel, little sand-little <u>Fucus</u> - estuarine	high 4.0m	~25		

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Stranby River	26.5	22 July	sand, gravel,	low	~25		
26	50°50.40'N 128°08.78'W	1976	shell <u>Fucus</u> , <u>Enteromorpha</u> <u>Bangia</u> ; all abundant estuarine	1.8m			
	26.6	"	gravel, shell	high	100+		
	50°50.40'N 128°08.83'W		algae wash estuarine	3.4m			
	26.7	"	stone,	low	10+		
	50°50.40'N 128°08.78'W		coarse sand intertidal pools	1.8m			

Area: Vancouver Island North and West Coasts

locality name and number	Sample data		description	tide level	Specimen data		species names and no. of specimens
	station no.	date			no. of specimens	no. mature	
Port Alberni 27	27.1 49°15.40'N 124°48.83'W	15 May 1976	sand under stones green fil. algae on stones estuarine and pulp mill	high 4.0m	not counted	1	
	27.2 49°15.40'N 124°48.83'W	"	algae, scraped off stones estuarine pulp mill	high 4.0m	2	0	
	27.3 49°14.60'N 124°49.10'W	"	v. fine silt few pebbles and shells estuarine pulp mill	low 0.7m	5	3	

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Port Alberni	27.4	15 May	sand, silt	low	not counted	9	
27	49°14.20'N 125°00.00'W	1976	filamentous green algae, some <u>Fucus</u> estuarine with pulp mill	0.7m			
	27.5	"	rock	mid	3	0	
	49°14.20'N 125°00.00'W		filamentous green algae shaley rock chips estuarine with pulp mill	2.4m			

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Port Alberni	27.6	15 May	coarse sand,	mid	10	1	
27	49°12.95'N 124°58.90'W	1976	gravel, rocks green algae on rocks water brown, smell estuarine with pulp mill	2.4m			
	27.7	"	rock, coarse sand brown water estuarine and pulp mill	low 1.8m	6	some	
	27.8	"	sand, gravel <u>Fucus</u> , sedge small stream estuarine and pulp mill	mid 2.7m			
	49°11.30'N 124°59.40'W						

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Port Alberni 27	27.9 49°11.30'N 124°59.40'W	15 May 1976	mud, root mat-small stream-estuarine and pulp mill	high 3.4m	3	0	
Port Alice 28	28.1 50°23.25'N 127°27.33'W	13 June 1976	shale, coarse sand- <u>Enteromorpha</u> on rocks - sulphurish smell - pulp mill	high 4.1m	29	7	Lumbricillus lineatus 6 Lunbricillus cf. helgolandicus 1
	28.2 50°22.76'N 127°27.36'W	"	rocks, sand in crevices abundant <u>Enteromorpha</u> estuarine and pulp mill	mid 2.1m	59	26	Lumbricillus lineatus 11 L. qualicumensis 1 L. cf. helgolandicus 7 Marionina vancouverensis 1 M. sjaelandica 3 M. neroutsensis 3

Area: Vancouver Island North and West Coasts

Sample data				Specimen data				
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens	
Port Alice	28.3	13 June	mud, sand	high-mid	78	52	Lumbricillus lineatus	1
28	50°22.93'N	1976	<u>Enteromorpha</u>	3.0m			L. qualicumensis	6
	127°27.92'W		mat, wood				L. cf. helgolandicus	2
			chips				L. tuba	1
			estuarine and				Marionina vancouverensis	15
			pulp mill				M. sjaelandica	21
							M. neroutsensis	3
							M. appendiculata	2
	28.4	"	rock, silt,	mid	129	24	Lumbricillus lineatus	15
	50°22.91'N		sand	2.7m			L. qualicumensis	2
	127°27.77'W		<u>Enteromorpha</u>				L. cf. helgolandicus	7
			abund.					
			estuarine					
			and pulp mill					

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Port Alice 28	28.5	13 June	coarse sand,	low	149	2	Lumbricillus? lineatus 1
	50°23.12'N	1976	stone	0.7m			L. cf. helgolandicus 1
	127°28.11'W,		<u>Ulva</u> and <u>Enter-</u> <u>omorpha</u> mat estuarine and pulp mill				
	28.6	"	rocks, sand,	high	30	17	Lumbricillus qualicumensis 5
	50°26.52'N		silt, wood	3.0m			Marionina vancouverensis 3
	127°29.92'W		chips				M. sjaelandica 4
			algae wash				M. neroutsensis 1
			estuarine and pulp mill				Enchytraeus kincaidi 4
	28.7	"	rock, sand,	mid	232	129	Lumbricillus qualicumensis 66
	50°26.57'N		silt	2.4m			L. cf. helgolandicus 16
	127°29.92'W		wood chips,				L. tuba 1
			<u>Fucus</u> , <u>Enter -</u> <u>omorpha</u>				Marionina vancouverensis 4
			estuarine and				M. sjaelandica 2
			pulp mill				M. neroutsensis 36
							Enchytraeus kincaidi 4

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Jordon River 29	29.1 48°25.5'N 124°02.5'W	29 May 1976	composite along beach sandy	high 3.0m	1		
Long Beach 30	30.1 49°03.1'N 125°43.3'W	21 Aug., 1976	coarse sand, gravel abund. algae debris; decaying brown and green beach	high 3.4m	100+	89	Lumbricillus mirabilis 44 L. annulatus 42 Marionina sjaelandica 3
Brooks Beach 31	31.1 50°12.12'N 128°47.95'W	24 July 1976	fine sand shell algae wash, <u>Fucus</u> , reds, eelgrass beach	high 3.8m	5		

(only partially sorted)

Area: Vancouver Island North and West Coasts

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Shuttleworth Bight 32	32.1 50°50.37'N 128°08.45'W	22 July 1976	fine sand, shell algae wash, greens, reds, browns	high 3.7m	50+		
Ocean Falls 33	33.1 52°21.13'N 127°41.10'W	26 Feb., 1977	gravel opp. mill, along river unicellular green estuarine and pulp mill	low 1.8-2.1m	128	73	Marionina charlottensis 10 Lumbricillus tuba 58 L. pagenstecheri 5 Enchytraeus (immature) 2
	33.2 52°21.18'N 127°41.45'W	"	gravel, sand, woodchips <u>Bangia</u> abundant estuarine and pulp mill	low 1.8-2.1m	35	11	Lumbricillus tuba 10 L. lineatus 1

Area: North Coast : Queen Charlotte Sound, Hecate Strait

Sample data				Specimen data				
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens	
Ocean Falls	33.3	26 Feb	coarse	mid	19	8	Lumbricillus tuba 2	
33	52°21.18'N 127°41.45'W	1977	sand, rocks <u>Enteromorpha</u> estuarine and pulp mill	3.4m			L. pagenstecheri 6	
	33.4	"	sand, silt	mid	64	34	Lumbricillus tuba 26	
	52°21.24'N 127°41.67'W		<u>Bangia</u> abundant, some <u>Fucus</u> runoff near estuarine and pulp mill	3.4m			L. pagenstecheri 7 L. sp. unid 1	
	33.5	"	silt	low-mid	52	22	Lumbricillus tuba 1	
	52°21.24'N 127°41.67'W		little <u>Fucus</u> sediments reduced at 2 cm. estuarine and pulp mill	2.7m			(poco mat) L. lineatus 3 L. pagenstecheri 3 Marionina charlottensis 1 L. sp unid 12 L. sp. 2 1	

Area: North Coast: Queen Charlotte Sound, Hecate Strait

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Ocean Falls 33	33.6 52°21.34'N 127°42.58'W	26 Feb., 1977	rocky, little sand some <u>Fucus</u> estuarine and pulp mill	low 1.8-2.1m	30	26	Marionina charlottensis 8 Lumbricillus tuba 17 L. pagenstecheri 1
	33.7 52°21.34'N 127°42.58'W	"	sand, gravel, silt <u>Enteromorpha</u> , little <u>Fucus</u> estuarine and pulp mill	high 4.0m	53	17	Lumbricillus tuba 13 Marionina charlottensis 4
	33.8 52°21.52'N 127°43.14'W	"	sand, silt <u>Bangia</u> and <u>Fucus</u> abundant estuarine and pulp mill	low 2.4m	55	15	Marionina charlottensis 4 Lumbricillus lineatus 2 L. pagenstecheri 6 L. sp. unid 3

Area: North Coast: Queen Charlotte Sound and Hecate Strait

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Ocean Falls 33	33.9 52°21.53'N 127°43.12'W	26 Feb., 1977	sand, gravel, silt <u>Bangia</u> abund., some <u>Enteromorpha</u> estuarine and pulp mill	mid 3.4m	83	48	Marionina sjaelandica (not very mature) 5 M. charlottensis 19 Lumbricillus pagenstecheri 22 L. sp. 2 2
"	33.10 52°21.53'N 127°43.11'W	"	sand, silt some green algae estuarine and pulp mill	low-mid 2.7m	112	12	Marionina sjaelandica (not very mature) 11 M. charlottensis 1
"	33.11 52°21.55'N 127°43.15'W	"	gravel, sand, little silt <u>Bangia</u> abund. estuarine and pulp mill	mid 3.4m	36	27	Marionina charlottensis 18 Lumbricillus tuba 9

Area: North Coast: Queen Charlotte Sound and Hecate Strait

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Ocean Falls 33	33.12 52°21.54'N 127°43.20'W	26 Feb., 1977	sand, gravel <u>Fucus</u> and <u>Bangia</u> estuarine and pulp mill	low 2.1m	82	30	Marionina vancouverensis 7 M. charlottensis 2 Lumbricillus tuba 20 (one lost)
	33.13 52°21.55'N 127°43.21'W	"	fine sand, little gravel <u>Bangia</u> abund., little <u>Fucus</u>	low-mid 2.7m	155	65	Lumbricillus tuba 38 L. sp. unid 1 Marionina vancouverensis 2 M. charlottensis 24
	33.14 52°21.56'N 127°43.23'W	"	sand, silt abund. <u>Fucus</u> and <u>Bangia</u> , little <u>Enter-</u> <u>omorpha</u> estuarine and pulp mill	mid 3.4m	3	3	Lumbricillus pagenstecheri

Area: North Coast: Queen Charlotte Sound and Hecate Sound

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Ocean Falls 33	33.15 52°21.56'N 127°43.23'W	26 Feb., 1977	gravel, coarse sand, silt - <u>Enter-</u> <u>omorpha</u> on rocks, some emergents	high 4.6m	173	73	Marionina vancouverensis 1 M. charlottensis 20 Lumbricillus tuba 52
Kitimat 34	34.1 53°59.80'N 128°41.69'W	2 Sept., 1976	stone, sand, wood chips runoff near estuarine pulp mill	low 2.3m	26	0	inc. Lumbricillus spp. immature
	34.2 53°59.75'N 128°41.67'W	"	silt, sand, fine wood debris filamentous green algae estuarine & pulp mill	low 2.3m	29	0	inc. Lumbricillus spp. immature

Area: North Coast

locality name and number	Sample data			Specimen data			
	station no.	date	description	tide level	no. of specimens	no. mature specimens	species names and no. of specimens
Kitimat 34	34.3 53°59.74'N 128°41.71'W	2 Sept., 1976	sand, rocks, fine wood debris estuarine & pulp mill	mid 3.4m	31	0	
	34.4 53°59.70'N 128°41.71'W	"	silt, sand some <u>Bangia</u> estuarine & pulp mill	low 2.4m	14	0	
	34.5 54°01.23'N 128°37.00'W	"	sand, stone, little silt emergent veg., <u>Fucus</u> & <u>Pelvet-</u> <u>iopsis</u> -estuarine & pulp mill	mid 3.5m	82	0	inc. Lumbricillus spp. immature

Area: North Coast

Sample data			Specimen data				
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Kitimat 34	34.6 54°01.23'N 128°37.00'W	2 Sept., 1976	stone, silt, wood chips emergent veg.-estuar- ine and pulp mill	mid 3.7m	34	0	inc. Lumbricillus spp. immature
	34.7 54°01.23'N 128°37.00'W	"	fine sand emergent veg., <u>Fucus</u> and <u>Pelvetiopsis</u> estuarine and pulp mill	high 4.3m	241	4	inc. Enchytraeus sp. imm. Lumbricillus spp. imm. Lumbricillus pagenstecheri 4
Prince Rupert 35	35.1 54°14.51'N 130°16.40'W	1 Sept., 1976	black seds., stone, sand, silt, runoff nearby wood fibre & chips estuarine and pulp mill	mid 4.3m	59	4	Lumbricillus lineatus 2 L. cf. helgolandicus 2

Area: North Coast

Sample data				Specimen data			
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Prince Rupert 35	35.3 54°14.43'N 130°17.10'W	1 Sept., 1976	some fibre, black muck, rocks, seepage estuarine and pulp mill	high 4.9m	63	13	Lumbricillus lineatus
	35.4 54°14.48'N 130°17.10'W	"	wood chips, wood fibre, rock estuarine and pulp mill	low 3.0m	9	3	Lumbricillus lineatus
	35.5 54°12.89'N 130°17.22'W	"	shell, stone, silt <u>Fucus</u> abund. a little wood fibre in water - estuarine and pulp mill	low-mid 4.3m	56	31	Lumbricillus tuba

Area: North Coast

Sample data			Specimen data				
locality name and number	station no.	date	description	tide level	no. of specimens	no. mature	species names and no. of specimens
Prince Rupert 35	35.6 54°12.89'N 130°17.22'W	1 Sept 1976	<u>Enteromorpha</u> scraped from log and rocks estuarine and pulp mill	high 5.8m	8	3	<i>Lumbricillus</i> cf. <i>helgolandicus</i> 1 <i>L. tsimpseanis</i> 2
	35.7 54°13.91'N 130°17.10'W	"	fibre, silt wood chips some <u>equisetum</u> opposite a warm pulp effluent	mid 4.0m	1	0	
	35.8 54°13.90'N 130°17.20'W	"	rotting wood fibre mat ~ 7 cm. thick red-brown effluent	low 3.6m	21	4	<i>Enchytraeus multiannulatus</i> 3 <i>E. bonus</i> 1

Appendix 2. Details of staining, destaining, dehydrating, clearing
and mounting methods for light microscopy.

Formula for Grenacher's alcoholic borax carmine:

Carmine	3 gm,
Sodium tetraborate	4 gm,
Distilled H ₂ O	100 ml, and
70% ethanol	100 ml.

Boil carmine and sodium tetraborate in distilled water until dissolved then add 70% ethanol.

Let stand for 2 days then filter

Staining procedure

Five minutes submersed in stain is enough time to allow good penetration of stain and good definition of internal structures with a high content of nuclear materials.

Destaining procedures

Specimens are destained to a pale grey-pink (incident light) in acid alcohol (100 ml 70% ethanol with 10 drops con. HCl added). The period of destaining varies with the size of the specimens and the thickness of their cuticle and with the period of time that the specimens have been in preservative. All specimens for this study were destained for at least 8 hours and more often 24 to 36 hours. The destaining process is enhanced by periodically changing the specimens to fresh acid alcohol.

Once sufficient destaining is achieved all traces of acid alcohol must be removed from the animals. Failure to completely flush the acid will result in fading of the stain. Flushing is achieved by passing the specimens through many changes of 70% alcohol.

Dehydrating and Clearing

In order to get the specimens into an hydrocarbon that is miscible with the final mounting media, Canada balsam, all traces of water must be removed from the specimens. An ethanol gradient series is suitable for dehydration. Steps in the gradient series

that can be used are:

1. 70% ethanol	-	5 minutes,
2. 80% "	-	" " ,
3. 90% "	-	" " ,
4. 95% "	-	" " ,
5. 100% "	-	10 minutes, and
6. 100% "	-	" " .

Dehydration is followed by clearing in xylene, two changes.

Specimens for this study were left for one-half hour in the xylene before any morphological observations of internal structures could be made. An excessive length of time in xylene or in high concentrations of alcohol makes the specimens quite brittle - this is one of the disadvantages of xylene as a clearing agent.

Mounting

Specimens to be mounted in Canada are left overnight in xylene.

Slides made with Canada balsam need not be sealed. The media does not completely dry for two or three months so that the slides must be kept in an horizontal position for at least this time.

Occasionally, specimens turned opaque when placed in the mounting media due, apparently, to air trapped under the relatively thick cuticle. In most cases the air would diffuse out of the worm in a few days at the most and the specimens would be

ready for light microscope observations. If after a very long period the specimens were still black it became necessary to remove the specimens from the slides and remount in a dilute mixture of Canada balsam and xylene.

Appendix 3. Details of fixing, dehydrating, drying and gold-coating methods for scanning electron microscopy.

Critical point drying

"This method of drying takes advantage of the fact that at its critical point a fluid passes imperceptively from a liquid to a gas with no evident boundary and no associated distortional forces"

(Kessel and Shih, 1974, p. 12). An OMAR SPC-1500 critical point dryer utilizing liquid carbon dioxide was used.

Processing after drying

Specimens are attached to specimens stubs using a thin layer of silver conducting paint, then transferred to a Technics Hummer III sputtering system vacuum evaporator where a thin layer of gold was evaporated onto the specimens.

Comment.

It is felt that at least one special technique, cryofacture, not utilized herein due to a lack of availability of equipment, might be found particularly useful in conjunction with standard S.E.M. techniques to study the three-dimensional morphology of internal organs, in particular the spermathecae and other reproductive organs.

Appendix 4. Description of Enchytraeus albidus Henle, 1837;
from Nielsen and Christensen, 1959, pp. 91-92 and
figures 95-100.

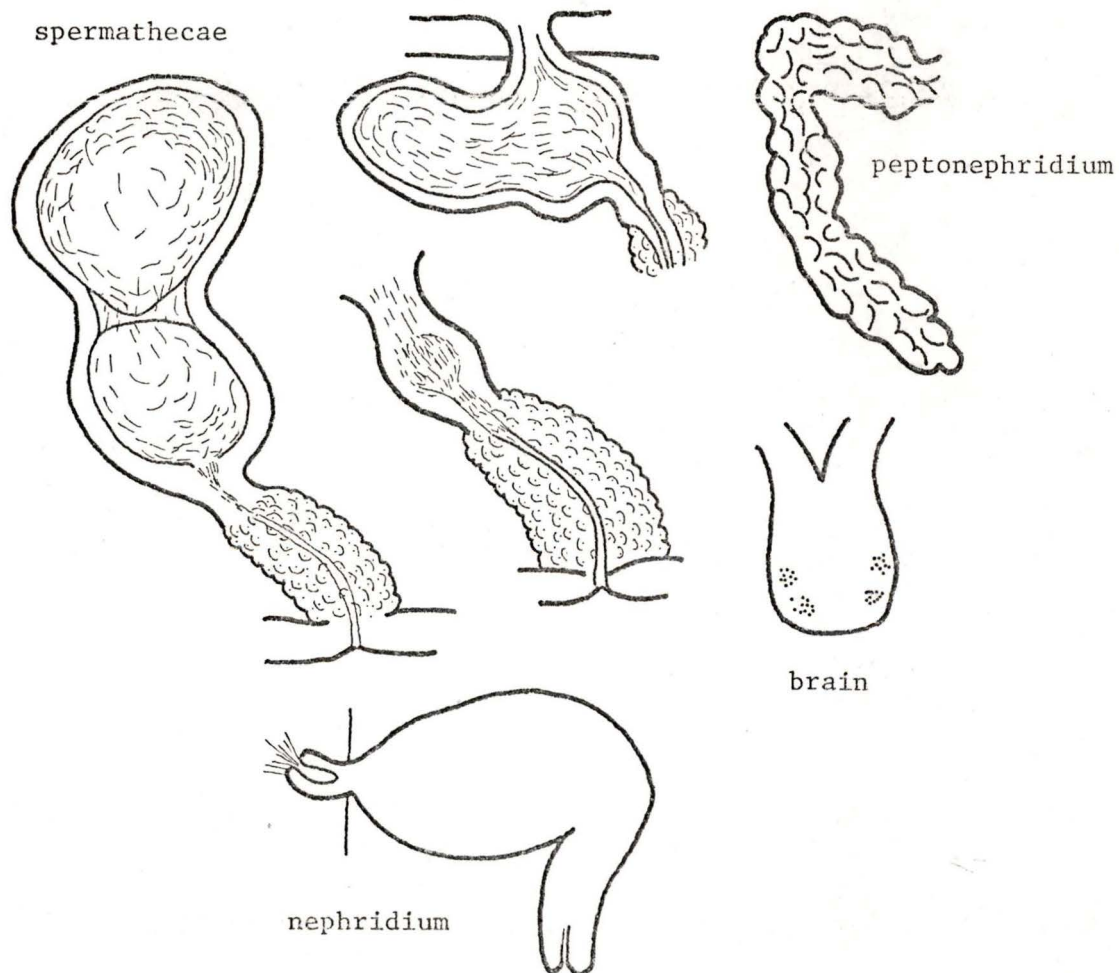
Enchytraeus albidus Henle, 1837

Medium-sized to large species. 20-35 mm long, whitish-yellowish. Segments 46-65. Setae: 2,3,4-2,3 : 3,4,5-2,3,4, straight or slightly curved. Clitellum extending over XII-XIII, the gland cells irregularly scattered. Peptonephridia unbranched tubes of spongy appearance, communicating with the oesophagus immediately behind the pharynx and extending backwards into IV. Three pairs of massive septal glands, all united dorsally; almost separate ventral lobes in IV-VI. Chloragogen cells present from V and forming a dense layer from VI; the cells are rather small, only slightly bigger than the lymphocytes, and contain prominent refractile yellowish-green globules. The brain is about $1\frac{1}{2}$ times longer than wide, the posterior end flattened or slightly concave, in the postero-lateral regions 1-3 small aggregations of refractile globules are usually present on either side. Postseptale oval, the short, efferent duct originates postero-ventrally. The lymphocytes are rather small, irregularly oval or pear-shaped, their lengths respectively $\frac{1}{5}$ and $\frac{1}{3}$ the length of the setae; the pear-shaped cells are attached to the body wall and are often in the process of division; the lymphocytes contain few large refractile granules. The dorsal vessel originates in XIV-XVIII. The blood is colourless or faintly yellowish. The seminal vesicle is large, often bulging forward to reach IX. The sperm funnel cylindrical, 5-8 times longer than wide; the collar is regular and is the same width as the funnel. The sperm duct is very long, often extending as far back as XXI. Penial bulb large. The eggs are rather small, and 6-12 mature eggs may be present at a time. The ectal duct of the spermatheca

rather long and thin and covered by a dense layer of glands of different sizes which fuse completely; the glands grow smaller entally. The shape of the ampulla varies much; it may be small, oval and without dilations; or it may be large and dilated either posteriorly or dorsomedially. To some extent these differences are correlated with the degree of maturity of the worm and with the amount of sperm present. Within a given population one type seems to predominate.

Chromosome number: $n = 21$.

Distribution: almost cosmopolitan, occurring in decaying seaweed, compost heaps, sewage beds and effluents, etc.



Appendix 5. Letter regarding the fate of Eisen (1904) type specimens that were deposited at the California Academy of Science, San Francisco or at the National Museum of Natural History, Smithsonian Institution, Washington, D. C..

CALIFORNIA ACADEMY OF SCIENCES

GOLDEN GATE PARK SAN FRANCISCO CALIFORNIA 94118

(AREA CODE 415) 221-5100

THE SCIENCE MUSEUM

THE ALEXANDER F. MORRISON PLANETARIUM

THE STEINHART AQUARIUM

DEPARTMENT OF INVERTEBRATE ZOOLOGY

May 31, 1977

Ms. Kathryn Coates
 Department of Biology
 University of Victoria
 P.O.Box 1700, Victoria
 British Columbia, Canada
 V8W2Y2

Dear Ms. Coates:


I am very sorry to report that the Gustav Eisen Types were destroyed in the earthquake and fire of 1906. The only pre-1906 collections of any kind saved from the holocaust were a few botanical and geological types retrieved just ahead of the fire; the Galapagos collection aboard the "Schooner Academy" which had just returned and a small amount of loaned material. Unfortunately, the Eisen specimens were not among this material.

It is indeed interesting that this neglected group is at last beginning to receive some attention. In addition to your inquiry we received two letters within as many weeks; one inquiring as to our oligochaet collection in general and the other as to Eisen Types, specifically his Alaskan Enchytraeidae.

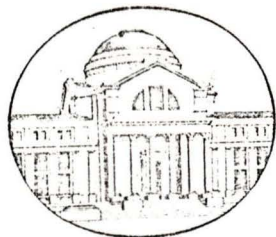
The Enchytraeidae inquiry came from a Mr. Stephen Piper of the Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska 99701.

It would seem the only recourse is the literature until a worker redefines the species and designates a Lectotypic series.

Most Sincerely,


 Dustin D. Chivers
 Senior Scientific
 Assistant

DDC:cjj



National Museum of Natural History · Smithsonian Institution

WASHINGTON, D.C. 20560 • TEL. 202-

February 8, 1979

Ms. Kathryn Coates
 Department of Biology
 University of Victoria
 P.O. Box 1700
 Victoria, British Columbia
 Canada V8W 2Y2

Dear Ms. Coates:

We are sending under separate cover the Eisen Syn-Types that you requested with the following exceptions:

USNM 5151 Enchytraeus citrinus: this one specimen has been completely dried.

USNM 5150/32921 Enchytraeus saxicola: these specimens have also been dried. Also it seems that 5150 & 32921 are the same lot. Sometime in the past it evidently was re-catalogued.

We will send these two lots if you think they could be of any value.

Finally, we have just received the shipment of cotypes of L. annulatus Eisen in good condition. Thank you for their prompt return.

With all best wishes, I am,

Sincerely,

Meredith L. Jones
 Curator, Worms
 Department of Invertebrate
 Zoology

VITA

Surname: COATES Given Names: KATHRYN ANN

Place of Birth: FLIN FLON, MANITOBA Date of Birth: 30 June, 1953

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Honors and Awards:

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Publications:

Ellis, D.V., S. Cross, K. Coates and S. McKinnel. 1978.

Assessment of shoreline rehabilitation at the Port Alice

Pulp Mill. In Environmental Improvement at Neroutsos

Inlet, B.C.. Rayonier Canada, Annual Report, December,

1978. Volume 4. 91 pp.


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Title of Thesis/Dissertation

REVISION OF THE TAXONOMY OF INTERTIDAL ENCHYTRAEIDAE (ANNELIDA, OLIGOCHAETA)
OF BRITISH COLUMBIA WITH A PRELIMINARY DISCUSSION REGARDING USE OF INTERTIDAL
SPECIES ASSOCIATIONS TO ASSESS POLLUTANT IMPACTS

Author


Kathryn Ann Coates

August 13, 1979