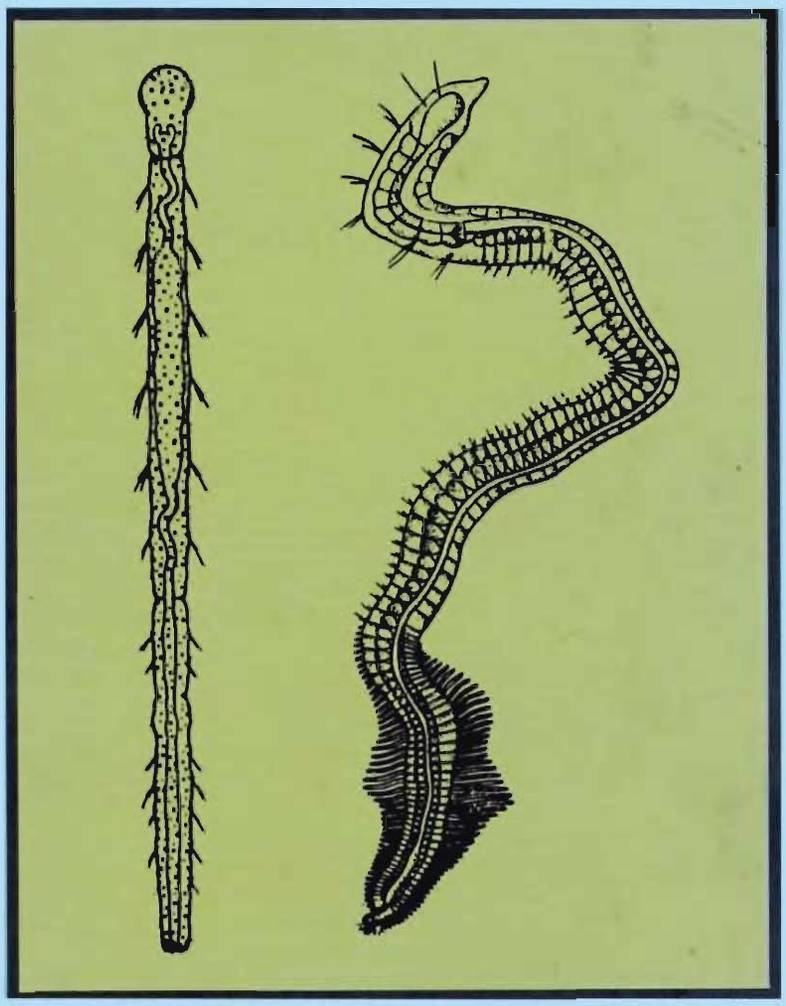
Fauna of India



AQUATIC OLIGOCHAETA

K. VANAMALA NAIDU

Aquatic oligochaetes are very common micro-invertebrates in small, medium and large fresh water bodies and running waters of streams and rivers living in algae, aquatic vegetation, floating rotting material and in bottom mud. Dr. Stephenson published several papers on the aquatic and terrestrial oligochaetes of India and published the Fauna of British India volume on Oligochaeta in 1923. Later Dr. Padmmabha Aiyer published some papers on aquatic oligochaetes collected around Trivandrum from 1925-1929. Dr. Mehra published some papers on this group from collections made in and around Agra from 1922-1929. K. Vanamala Naidu published some papers mainly on South Indian fresh water oligochaetes from 1959-1986.

Worms belonging to the family Naididae is well represented in the Indian subcontinent, but those of family Tubificidae living in bottom mud of water sources are ill represented in this subcontinent while they are well represented in Europe and other parts of the world. This short coming in this region should be filled by future researches. Many areas in this subcontinent need extensive and intensive exploration for discovering more species of these oligochaetes.

Present work gives methods of collection, anatomical section dealing with internal anatomy, diagnoses of order, families, subfamilies and genera and detailed description of species, their habits, distribution in India and world with figures for each of 102 taxa of Aeolosomatidae, Naididae, Tubificidae, Enchytraeidae, Phreodrilidae, Lumbriculidae and Microchaetidae covered here. It is hoped that this work will be very useful in understanding the basic diversity of aquatic oligochaetes and inspire further research in this field in unexplored and underexplored regions of the subcontinent. This book deserves a place on the library shelf of all research and academic institutions of higher learning in this country and elsewhere.

FAUNA OF INDIA
AND
THE ADJACENT COUNTRIES

AQUATIC OLIGOCHAETA

K. VANAMALA NAIDU
Retired Principal
7, First Main, Nandagokulam Extension, Gokulam III Stage, Mysore–570002

Edited by the Director, Zoological Survey of India, Kolkata

Zoological Survey of India
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FOREWORD

The book entitled "Fauna of India and the adjacent countries : Aquatic Oligochaeta" by Shri. K. Vanamala Naidu is the outcome of a very impressive and pain taking effort to update our knowledge on the aquatic species of oligochaetes from the Indian subcontinent. It comprises a total of 101 species and 1 subspecies belonging to the families Aeolosomatidae, Naididae, Tubificidae, Phreodrilidae, Enchytraeidae, Lumbriculidae and Microchaetidae. The author has to his credit several species systematically identified and published by him from time to time. He has distinguished himself as one among a few authorities on the aquatic oligochaetes of our country. This compilation covers a relevant literature as well. The illustrations are impressive clearly depict to meet the customary standards of publication. The keys for the identification of species serve as ready reckoner for the students of taxonomy.

Hopefully, this compendium provides an insight into the trends in systematic studies based on habits, morphology, anatomy and distribution of species. The existing record of 102 taxa brought to light that the aquatic oligochaetes significantly constitute to the biodiversity of the Indian subcontinent.

Mysore
15th July, 2004

N. H. Gopal Dutt, M.Sc., Ph.D.,
Retired Professor and Chairman
Department of Zoology
University of Mysore
799, 2nd Cross, Manujapatha Road
Kuvempunagar, Mysore-570 023

PREFACE

This is an attempt to bring together all the information available in the literature of the aquatic oligochaetes known from the Indian subcontinent. Stephenson (1923) in his Fauna of British India volume on Oligochaeta described 4 species from Aeolosomatidae, 29 species from Naididae, 6 species from Tubificidae, 1 species from Phreodrilidae and 3 species from Enchytraeidae, 3 species of Microchaetidae, a total of 46 species. As a result of their labours, Stephenson (1907-1924), Mehra (1920-1927), Aiyer (1924-1929 a, b), Cernosvitov (1942a, b), Sperber (1958-1960), Naidu (1961-1981a, b), Costa (1967), Ali, 1971, 1973, Radhakrishna & Saibaba (1977), Sobhana & Nair (1983a, b), Khatoon & Ali, 1993, Battish and Sharma, 1997 and Mukhopadhyay, 1998 have added several species to the Microdrili and Gates (1945-1958) to Megadrili of this subcontinent. A total of 101 species and 1 subspecies comprising of 8 species of Aeolosomatidae, 59 species and 1 subspecies of Naididae, 15 species of Tubificidae, 1 species of Phreodrilidae, 8 species of Enchytraeidae, 1 species of Lumbriculidae of Microdrili and 7 species of Microchaetidae of Megadrili are known from the subcontinent. This number is more than double the number of species known in Stephenson's time. All these 102 taxa are described here together with figures. Every effort is made to give the correct name to each of the species described here.

In the introductory part methods of collection and observation of Microdrili, under the section techniques, in External Anatomy section, the structure of the setae, different parts of the alimentary canal, the position, etc. of dorsal vessel and commissural vessels of the vascular system, respiration and respiratory organs, reproductive organs: gonads, clitellum, male efferent apparatus, genital setae and spermathecae of the Naididae, Tubificidae, Phreodrilidae, Enchytraeidae and Lumbriculidae are discussed. Morphological accounts of nephridial system and nervous system of Aeolosomatidae, Naididae, Tubificidae and Enchytraeidae are given. A general account of asexual reproduction is also given.

For each species length and diameter 'l' and 'd' of living worm or length and diameter 'l(p.)' and 'd(p.)' of preserved worm, the number of segments of adult fully grown worm, 's', and the number of segments behind which the budding zone develops, 'n' are given. The morphological description, include the shape of prostomium, presence or absence of eyes and branchial fossa, the shape, number and position of the setae, the shape and position of different parts of the alimentary canal, the position of the dorsal vessel, the position and number of lateral commissural vessels, the shape of the brain, the position and shape of the nephridia and the position and shape of various sex organs, and the position and shape of penial setae. A brief description of asexual reproduction by the formation of budding zone or by fragmentation as it

occurs in Aeolosomatidae and Naididae is included. Observations on the locomotion, etc., are given under habits of the species.

From Sperber's (1948) "A taxonomical study of the Naididae", and Brinkhurst and Jamieson's "The aquatic Oligochaeta of the World:, and Nielsen and Christensen's (1959) "Enchytraeidae critical revision and taxonomy of European species", the author has heavily relied and used the descriptions in the Anatomical and Internal Anatomy sections as well as diagnoses of of some taxa and description of some species and also used Sperber's figures of some species, for which the author gratefully thanks them. In this work, the author has used a large number of figures of several authors, whose names are mentioned in the figures and the author gratefully thanks them all.

CONTENTS

INTRODUCTION 1
ANATOMICAL SECTION 3
INTERNAL ANATOMY 8
ALIMENTARY CANAL 9
VASCULAR SYSTEM 15
RESPIRATION AND RESPIRATORY ORGANS 17
INTESTINAL RESPIRATION 18
NEPHRIDIAL SYSTEM 18
NERVOUS SYSTEM 20
SENSE ORGANS 21
REPRODUCTIVE ORGANS 22
ASEXUAL REPRODUCTION 31
CLASSIFICATION 33
SYSTEMATIC SECTION 35
Subclass APHANONEURA 35
Order AEOLOSOMATIDA 35
Family AEOLOSOMATIDAE 35
Genus *Aeolosoma* Ehrenberg, 1831 36
Key to Indian species of genus *Aeolosoma* 36
A. beddardi Michaelsen, 1900 37
A. headleyi Beddard, 1888 38
A. hemprichii Ehrenberg, 1828 40
A. hyalinum Bunke, 1967 43
A. niveum Leydig, 1865 45
A. travancorense Aiyer, 1926 45
A. viride Stephenson, 1911 49
A. ternarium Schmarda, 1861 51
Subclass OLIGOCHAETA 51
Family NAIDIDAE 52
Key to Indian subfamilies of family Naididae 52

Subfamily Chaetogastrinae Sperber, 1948 53
Genus *Chaetogaster* von Baer, 1827 53
Key to Indian species of genus *Chaetogaster* 54
C. cristallinus Vejdovsky, 1883 54
C. diaphanus (Gruithuisen, 1828) 57
C. diastrophus (Gruithuisen, 1828) 59
C. langi Bretscher, 1896 61
C. limnaei bengalensis Annandale, 1905 63
C. limnaei limnaei von Baer, 1827 64
Subfamily NAIDINAE 66
Key to Indian genera of subfamily Naidinae 66
Genus *Nais* Müller, 1773 67
Key to Indian species of genus *Nais* 67
N. andhrensis Naidu & Naidu, 1981 68
N. andina Cernosvitov, 1939 71
N. barbata Müller, 1773 73
N. bretrscheri Michaelsen, 1899 75
N. communis Piguet, 1906 76
N. elinguis Müller, 1773 79
N. pardalis Piguet, 1906 81
N. pseudobtusa Piguet, 1906 83
N. simplex Piguet, 1906 84
N. variabilis Piguet, 1906 86
Genus *Slavina* Vejdovsky, 1883 88
S. appendiculata (d'Udekem, 1855) 88
Genus *Stylaria* Lamarck, 1816 91
S. fossularis Leidy, 1852 91
Genus *Haemonais* Bretscher, 1900 93
H. waldvogeli Bretscher, 1900 94
Genus *Branchiodrilus* Michaelsen, 1900 96
Key to Indian species of genus *Branchiodrilus* 96
B. hortensis (Stephenson, 1910) 96
B. semperi (Bourne, 1890) 99

Genus *Dero* Oken, 1815 101
Key to Indian species of genus *Dero* 102
D. cooperi Stephenson, 1932 103
D. digitata (Müller, 1773) 105
D. dorsalis Ferronière, 1899 108
D. indica Naidu 1962 110
D. nivea Aiyer, 1929 112
D. obtusa d'Udekem, 1855 113
D. palmata Aiyer, 1929 114
D. pectinata Aiyer, 1929 117
D. plumosa Naidu, 1962 118
D. raviensis (Stephenson, 1914) 120
D. sawayai Marcus, 1943 122
D. zeylanica Stephenson, 1913 124
Genus *Aulophorus* Schmarda, 1861 126
Key to Indian species of genus *Aulophorus* 126
A. carteri Stephenson, 1931 127
A. flabelliger Stephenson, 1931 129
A. furcatus (Müller, 1773) 131
A. gravelyi Stephenson, 1925 134
A. hymani Naidu 1962 135
A. indicus Naidu, 1962 137
A. michaelseni Stephenson, 1923 139
A. moghei Naidu & Srivastava, 1980 141
A. tonkinensis (Vejdovsky, 1894) 142
Genus *Allonais* Sperber, 1948 144
Key to Indian species of genus *Allonais* 145
A. gwaliorensis (Stephenson, 1920) 145
A. inaequalis (Stephenson, 1911) 147
A. praguayensis paraguayensis (Michaelsen, 1905) 149
A. pectinata (Stephenson, 1910) 152
A. rayaslaseemensis Naidu, 1963 154
Subfamily STEPHENSONIANINAE 156

Genus *Stephensoniana* Cernosvitov, 1938 156
S. trivandrana (Aiyer, 1926) 156
Subfamily PRISTININAE 159
Key to genera of subfamily Pristininae 159
Genus *Pristina* Ehrenberg, 1828 159
Key to Indian species of genus *Pristina* 160
P. aequiseta Bourne, 1891 161
P. breviseta Bourne, 1891 162
P. evelinae Marcus, 1943 164
P. foreli Piguet, 1906 167
P. longiseta longiseta Ehrenberg, 1828 168
P. macrochaeta Stephenson, 1931 172
P. proboscidea Beddard, 1896 173
P. sperberae Naidu, 1963 175
P. synclites Stephenson, 1925 177
Genus *Pristinella* Brinkhurst, 1985 179
Key to Indian species of genus *Pristinella* 179
P. acuminata (Liang, 1958) 180
P. jenkinae Stephenson, 1931 181
P. menoni (Aiyer, 1929) 182
P. minuta (Stephenson, 1914) 184
Family TUBIFICIDAE 185
Key to Indian subfamilies of family Tubificidae 186
Subfamily TUBIFICINAE 186
Key to Indian genera of subfamily Tubificinae 187
Genus *Tubifex* Lamarck. 1816 187
T tubifex (Müller, 1774) 187
Genus *Limnodrilus* Claparède, 1862 190
Key to Indian species of genus *Limnodrilus* 190
L. claparedianus Ratzel, 1868 191
L. hoffmeisteri Claparède, 1862 192
L. silvani Eisen, 1879 195
L. udekemianus Claparède, 1862 197

Subfamily RHYACODRILINAE 200
Key to Indian genera of subfamily Rhyacodrilinae 200
Genus *Rhyacodrilus* Bretscher, 1901 200
R. stephensoni Cernosvitov, 1942 201
Genus *Monopylephorus* Levinsen, 1884 203
Key to Indian species of genus *Monopylephorus* 203
M. limosus (Hatai, 1898) 204
M. parvus Ditlevsen, 1904 206
Genus *Bothrioneurum* Stolc, 1888 208
Key to Indian species of *genus Bothrioneurum* 208
B. iris Beddard, 1901 209
B. vejdovskyanum Stolc, 1886 211
Subfamily *Branchiurinae* Beddard, 1892 213
Genus *Branchiura* Beddard, 1892 213
B. sowerbyi Beddard, 1892 213
Subfamily AULODRILINAE 216
Genus *Aulodrilus* Bretscher, 1899 217
Key to Indian species of genus *Aulodrilus* 217
A. pectinatus Aiyer, 1928 218
A. pigueti Kowalewski, 1914 220
A. pluriseta (Piguet, 1906) 222
Subfamily TELMATODRILINAE 225
Genus *Telmatodrilus* Eisen, 1879 225
Key to Indian species of genus *Telmatodrilus* 225
T. multiprostatus Brinkhurst & Jamieson, 1971 226
Genus *Alexandrovia* Hrabe, 1962 227
Alexandrovia onegensis Hrabe, 1962 227
Family PHREODRILIDAE 229
Subfamily PHREODRILOIDINAE 229
Genus *Phreodriloides* Benham, 1907 229
P. zeylanicus (Stephenson, 1913) 230
Family ENCHYTRAEIDAE 231
Key to Indian genera of family Enchytraeidae 232
Genus *Enchytraeus* Henle, 1837 232

Key to Indian species of genus *Enchytraeus* 233
E. albidus Henle, 1837 233
E. indicus Stephenson, 1912 235
Genus *Fridericia* Michaelsen, 1889 237
F. bulbosa (Rosa, 1887) 237
Genus *Hemienchytraeus* Cernosvitov, 1935 239
H. stephensoni (Cognetti,1927) 239
Genus *Henlea* Michaelsen, 1889 241
Key to Indian species of genus *Henlea* .....
H. harurami (Stephenson, 1914) 242
H. ventriculosa (d'Udekem, 1854) 243
Genus *Marionina* Michaelsen, 1889 245
M. subterranea (Knöllner,1935) 246
Genus *Stephensoniella* Cernosvitov, 1934 246
S. marina (Moore, 1902) 248
Family LUMBRICULIDAE 250
Genus *Lumbriculus* Grube, 1844 251
L. variegatus (Müller, 1773) 251
Family MICROCHAETIDAE 253
Genus *Glyphidrilus* Horst, 1889 254
Key to Indian species of genus *Glyphidrilus* 255
G. annandalei Michaelsen, 1910 256
G. birmanicus Gates, 1958 257
G. ceylonicus Gates, 1945 258
G. gangeticus Gates, 1958 258
G. papillatus (Rosa, 1890) 260
G. spelaeotes Stephenson, 1924 260
G. tuberosus Stephenson, 1916 261
SUMMAY 262
ACKNOWLEDGEMENTS 262
REFERENCES 264
ALPHABETICAL INDEX 287

DEDICATED TO

THE MEMORY OF

W MICHAELSEN,

J. STEPHENSON,

K. S. PADMANABHA AIYER,

CHRISTINA SPERBER.

INTRODUCTION

The aquatic oligochaetes are small, microscopic invertebrates, mainly belong to the families Aeolosomatidae, Naididae, Tubificidae, Phreodrilidae, Haplotaxidae, Lumbriculidae and Enchytraeidae of Microdrili and large worms of Microcheatidae of Megadrili.

Collection : Most members of the families Aeolosomatidae, and Naididae occur mainly among the filamentous algae and aquatic vegetation, or tubes attached to the twigs, decaying leaves, stones and fibrous material, in fresh water sponges and colonies of Polyzoans, etc., submerged in the water or among the floating roots of flowering plants, *Eichhornia crassipes*, *Pistia stratioites*, *Jussiae repens* and aquatic ferns, *Salvinia molesta* and *S. natans*. Successful method of collecting them is by sampling such material from the water. These samples are repeatedly shaken in water in flat glass dishes or trays, whereby the worms are washed out into the water and removed with a pipette. The water is changed repeatedly and the process repeated several times until no worms appear. By this method even smallest species are easily found, if good light and dark background are used. Also when small quantities of filamentous algae, small leaved aquatic plants, *Hydrilla verticillata*, etc., are left in glass beakers submerged in water for a day or two, the worms settle on the walls of the containers, near the surface of the water. The bottom mud-dwelling species are collected by washing mud samples and sieving in trays. The worms are pipetted out and examined under the microscope. In these methods of collecting of worms incompletely full-grown buds are prematurely separated from the parent individual before such characters as eyes, or even an abrupt stomachal dilatation have developed; and such buds may easily be mistaken as belonging to some other species by inexperienced investigators. This has apparently been the cause with some species described as new species in literature.

Length : The length of aquatic oligochaeta belonging to Aeolosomatidae, Naididae, Tubificidae and Enchytracidae varies considerably depending on the conditions under which they are measured (living or fixed specimens). The length of the live worm depends on its movements, locomotary activity; at maximum extension it may reach about four times that of the fully contracted worm. The length of the fixed worm depends on the technique of fixation used; cold Bouin's fluid produces much coiled worms, hot Bouin's fixative produces more straight but somewhat contracted worms.

Observations : These can be made extensively on living material with the help of low powered binocular microscope and an ordinary low powered microscope regarding movements, habits, etc, as also gross internal anatomy. The living material can be stained with neutral red in 0.01% solution.

These worms are highly sensitive, they die and disintegrate when treated with anaesthetics like cocaine, chloral, svedocaine and solutions containing picric acid.

Observations and fixation of worms are beneficially made on non-narcotised worms. Fresh materail is used for study of setae. Setal preparations are made by pressing the freshly killed worm between the slide and cover glass with a small drop of water, removing the excess water coming out with scraps of linen or cotton. Permanent preparations are made by crushing freshly killed worms between cover glass and slide, removing excess water with cotton, then the cover glass sealed off by Canada balsom. Alternately permanent setal preparations are made by using a drop of saturated solution of potassium acetate by gradually adding it to pressed aqueous preparation and excess solution removed. This fluid has a lower refractive index than glycerine or Canada balsom and makes a better medium to study small details and for measurements.

For closer examination of the setae of preserved material fixed in alcohol or formalin, maceration with potassium hydroxide is favourable. The worm is placed on a slide in a drop of saturated solution of potassium hydroxide for a few minutes or for some hours depending on the size of the worm and age of the material. The solution is changed for distilled water, after the body tissues disintegrate. There is a disadvantage in this method due to abnormal flexibility and swelling of the setae. As such the thickness of the setae cannot be judged from such preparations, but setal lengths, and relative lengths of teeth, etc., can be measured.

Haemalum or eosin are used for staining whole mounts and mounted in canada balsom. Methylene blue and silver impregnation for nervous system can be used profitably. For sections, various fixatives, alcohol, formol, sublimate, the fluids of Zenker, Bouin, Flemming, Meves are useful. Fixation with strong fluid of Flemming and staining with Heidenhain's iron haematoxylin, with or without counter-staining with orange G or picrofuchsin is more favourable for histological details, but the stains fade after sometime. Bouin's fixative gives good pictures, but the cell boundaries are not clear. Zenker's fluid is a good alround fixative, with Ehrlick's haemotoxylin and eosin for staining. The thickness of the sections should generally vary from 3 to 5 microns.

Photographs can be made with Zeiss large horizontal micro-camera from both living material and sections.

Measuring : The measurement of the lengths of setae is made in a straight line between the extremities and of the teeth are measured from tip to the extremity of the angle between the teeth. The measurement of teeth are written distal tooth/ proximal tooth. The thickness of the needle setae and ventral setae is measured at a point between the nodulus and the curve at the base of the teeth; where the margins of this type of seta are usually parallel. In *Nais* type, the thickness of needle setae is measured somewhere below the nodulus, as the shaft here is equally broad from the nodulus to the proximal end.

ANATOMICAL SECTION

Prostomium : It is prolobic or zygolobic, usually rounded and approximately as long as wide. It performs a tactile function and this function is enhanced in some species by the development of a narrow proboscis as in *Stylaria* (Naididae) and many species of *Rhynchelmis* and *Kincaidiana hexatheca* (Lumbriculidae). Prostomium may be very small and pointed as in tubifid *Epirodrilus antipodus* (Cernosvitov, 1939) or completely retractable within peristomium as in *Peloscolex variegatus* (Brinkhurst, 1962).

Segmentation : In Microdril families the external appearance range from smooth ascarid-like worms with little of their segmentation as in *Lamprodrilus baicalensis* (Lumbriculidae) to worms with well developed intersegmental furrows as in *Lamprodrilus koretneffi* (Michaelsen, 1901). In addition to this basal segmentatal division, many species of Lumbriculidae and Tubificidae show some form of superficial secondary annulation. This is apparent, to some extent, on the state of contraction of individual. Nomura (1926) reported secondary annulation in *Tubifex* while Dixon (1915) denied their presence. Secondary annulation seems to be a constant feature in most species of lumbriculids *Rhynchelmis* and *Trichodrilus* (Cook, 1971).

Pigmentation : The Microdrlili are usually not pigmented, transparent or translucent but many families appear red due to haemoglobin content in the blood This may be masked by the colour of the gut contents or by the opacity of the choragogen cells. Some species show some pigmentation as the brown pigment in anterior segments of some species of *Nais* and bands of dark pigment located in large cells found in the muscle layers around blood vessels of *Branchiodrilus* species (Stephenson, 1912a). Cook (1967) reported a dark green pigment in the longitudinal muscles of anterior body of *Lumbriculus variegatus*.

Papillae : In most species of tubificid genus *Peloscolex* body wall has heavily cuticularised papallae with or without accumulated foreign matter adhering to them. Large leaf-like structures of about 10-15 μm height found in *P. benedeni* (Stephenson, 1922c). *P. gabriellae* has rings of small granulae (Brinkhurst, 1965b). In *Alexandrovia onegensis* are found sensory papillae covered with secretion layer (Hrabe, 1960).

Branchiae : Opistocystidae, some Naididae, tubificid *Branchiura sowerbyi* and phreodrilid *Preodrilus branchiatus* have extensions of body wall in the form of branchiae or gills which are respiratory in function. Opistocystidae is characterised by the presence of one small dorso-median and two elongate lateral projections of the terminal segment (Cernosvitov, 1936). In Naididae the gills are complex foliate or digitiform extensions of terminal segment. *Dero sawayai* has two pairs of gills (Marcus, 1943, Naidu, 1962b), other species have 3 to 4 pairs of gills and *Dero botrytis* has 50 digitiform gills arranged in six rows running dorso-ventrally (Marcus, 1943). *Branchiodrilus* species possess different form of gills consisting of paired dorso-lateral

digitiform gills, a pair per segment, in anterior half of body (Stephenson, 1912a). *Branchiura* is the only tubificid genus with paired digitiform gills, one pair to each segment in dorso-median and ventro-median position in posterior half of body. The only phreodrilid species, *Phreodrilus branchiatus* has paired cylindrical gills about as long as body width, placed dorso-laterally on about 13 posterior segments (Beddard, 1894).

Clitellum : Sexually mature oligochaetes develop a thickened region in the body wall which is glandular in nature and produces cocoon at the time of oviposition. In the Microdrili the clitellum is one cell thick opaque papillate region, occupying 2 to 6 genital segments bearing the genital organs and their openings.

Cuticle : The cuticle is the external covering of the body. It is colourless, usually very thin, about 3 μm thick.

Epidermis : The epidermis lies beneath the cuticle. It is composed of two types of cells, cuboidal and columnar cells, which are said to have basal processes within the circular muscle layer (Atheston, 1899). The glandular cells containing globules of secretory material are randomly mixed with these supporting cells. The clitellum is one cell thick, characterised by very high proportion of glandular cells, developed in the region of gonads at sexual maturity. In Naididae these cells are upto ten times thicker than normal epithelial cells, filled with secretory globules with a basal nucleus (Sperber, 1948). In *Tubifex tubifex* the clitellar epidermis is 40-45 μm thick while the normal epidermal cells are 6-8 μm thick (Dixon, 1915).

Circular muscle : The fibres of circular muscles are arranged at right angles to long axis of body (Hesse, 1894). The circular muscle is very thin, in a single layer under the epidermis. In some Naididae and Tubificidae the circular muscle layer appears to be more complex than a single band of muscle fibres. In *Nais*, *Chaetogaster* and *Lumbriculus* a layer of diagonal muscle in which fibres cross each other at right angles forming a wide meshed network and which pursue a spiral course around the body. This diagonal layer is absent in *Tubifex* (Bock (1901).

Longitudinal muscle : In longitudinal muscle layer the fibres are arranged parallel to long axis of the body. In *Lumbriculus variegatus*, each muscle fibre is composed of an elongate and very tall contractile element and a nucleus, which lies outside the latter. The contractile elements are situated at the periphery of the fibre. In Naididae and Tubificidae the longitudinal muscle fibres are not as tall as those in *Lumbriculus*, the muscle layer is thinner than in Lumbriculidae (Bock, 1901).

Peritoneum : The peritonium is composed of thin layer of squamous epithelium separating the longitudinal muscle layer from the coelom. In *Monopylephorus limosus* the peritonial epithelium in anterior part of the body is composed of pear-shaped cells with their rounded ends directed towards the coelom. (Nomura, 1915).

Setal sacs : Setae are contained in a tubular invagination of the epidermis. In *Tubifex tubifex* the cuticle extends into the outer part of the sac (Dixon, 1915) and in Lumbriculidae the cuticle extends to the setal node, at which point the epidermis becomes closely applied to the setal shaft. This arrangement allows tractible movements of the setae in Microdrili.

Setae develop from follicles derived from the epidermis by proliferation (Beddard, 1895, Nomura, 1913, Dixon, 1915). The young follicle is syncytial and the seta develops, distal end first, within it (Nomura, 1913, 1915). At the base of the setal sac, a reserve or replacement follicle, often containing a setal rudiment, is usually present.

Setal musculature : The setal movement is performed by inter-follicular muscles, and a number of parito-vaginal or setal retractor muscles (Dixon, 1915, Nomura, 1915). In *Stylaria lacustris* in addition to one inter-follicular and three protractor muscles, two protractor flexors and two muscles which rotate the whole setal bundle are present. (Liebermann, 1932).

Glands of body wall : Apart from the important glands associated with sex organs, there are three major types of glands, unicellular glands, Timm's glands and septal glands in some Haplotaxidae. The large club-shaped unicellular glands with basal nucleus and granular secretory material, project into the coelom in *Haplotaxis glandularis* (Yamaguchi, 1953). A number of pear-shaped gland cells termed Timm's glands open to exterior in mid-ventral line beneath nerve cord in *H. gordioides* (Timm, 1883, Beddard, 1895, Hrabe, 1931). These glands are penetrated by a nerve and hence attributed sensory function, despite their glandular appearance. A pair of sub-spherical bodies, or setal glands, project into body cavity and open immediately dorsal to dorsal setae in *H. glandularis* (Yamaguchi, 1953). These glands have not been described in other Microdrili, except those associated with genital setae.

Setae : The setae are ectodermal structures, composed of chitin and a protein, implanted in and protruding from body wall of each segment, except the peristomium and some posterior segments. They are in two dorso-lateral and two ventro-lateral bundles. Setae are of two types: hair setae occurring in dorsal and ventral bundles of Aeolosomatidae and in dorsal bundles of Opistocystidae, Phreodrilidae, most Naididae and many tubificids, and sigmoid setae or crotchets found in both dorsal and ventral bundles of all Microdrili. In *Chaetogasater* dorsal setae are completely absent. Hair setae and penial setae are absent in Lumbriculidae and Dorydrilidae.

Tubificidae has a wide diversity of setal form. Smooth or serrate hair setae in all or some of the dorsal bundles are found in many species. These may be in association with bifid sigmoid setae similar to those found in ventral bundles in the same species. These sigmoid dorsal setae may have a series of fine intermediate teeth, the pectinate setae, and when primary teeth are indistinguishable from intermediate teeth, the palmate setae. In genera where the hair setae are absent, the setae may be bifid with

rudimentary distal tooth. Penial setae and spermathecal setae, may be modified, rarely both may be present in the same species. Genital setae may have elongate teeth with a hollow tipped distal end as in *Rhyacodrilus*, *Bothrioneurum*, or sickle-shaped an in *Rhyacodrilus falciparum*, or spoon-shaped as in *Aulodrilus and Siolidrilus*.

Hair setae : In Naididae hair setae are present in all genera except in *Chaetogaster*, *Amphichaeta*, *Paranais*, *Homochaeta*, *Uncinais* and *Ophidonais*. Generally they are slender, elongated more or less flexible and without nodulus. They are either smooth or may possess fine serrations or lateral hair-like barbs on one or both sides of shaft in Naididae and Tubificidae. Generally they are of equal length all over the body but in *Ripistes parasitica, Pristina longiseta* they are very long in certain segments. In most members of the genera *Pristina*, *Stylaria*, *Ripistes* and *Vejdovskyella* the hair setae are provided with one or two rows of saw-teeth or serrations, and in *Vejdovskyella* hair setae are also very thick and rigid. In *Dero pectinata* and *D. plumosa* hair setae appear plumose due to the presence of long and close serrations provided with hair like barbs. In *Slavina appendiculata* hair setae of VI are extremely elongated and in *Pristina longiseta* hair setae of III segment, and all except those of the hindmost segments in *Branchiodrilus hortensis* are very long.

Needle setae : These occur in all genera of *Naididae* except in *Chaetogaster*, where all dorsal setae are absent. They are double-pronged or bifid resembling the ventral setae. In *Amphichaeta*, *Paranais*, *Homochaeta*, *Uncinais* and *Piguetella*, the needle setae are single-pointed, where the ventral setae are also single-pointed.

The needle setae are needle-like. Simple, straight or faintly curved setae with or without an inconspicuous nodulus are found in *Stylaria*, *Stephensoniana*, *Branchiodrilus, Slavina*. In *Pristina* needle setae are fairly straight, and show a series from double-pronged with very slight, short or very long teeth, and a nodulus, to quite simple, hair-like forms. In the remaining genera, the needle setae are characteristically sickle- or bayonet-shaped, the part proximal to nodulus being straight with distal curve. Dorsal setae of many Naididae and Phreodrilidae are straighter than ventral setae. In *Nais* there is a series from double-pronged through simple-pointed, obtuse to very sharp-pointed needle setae. In *Dero* and *Aulophorus* there are two series from common double-pronged needle setae through types with a "webbing" or intermediate teeth to "palmate" types. In *Allonais* there occur, besides the common type, forms with very long, stout teeth, straight or curved in odd manner as in *A. chelata*.

Ventral setae : These are sigmoid and S-shaped with a thickening, the nodulus and distal ends pointed, rounded or bifid. They are diverse in Naididae and Opistocystidae. The double pronged or bifid "crotchets" are present from II segment onwards in all segments (rarely distal prong is absent) except in *Chaetogaster* where they are absent from III to V segments. They are often all similar to each other

throughout body. They are more or less distinct, though often minute differences among the setae of a bundle and between those of anterior part of the body and those towards posterior end. The nodulus is situated more distally in outer-most setae and more proximally in the inner-most setae of a bundle in all or most genera, so that tips are all on a level when setae are extended. The outer-most seta is also often the longest and thickest of bundle, inner-most being thinnest and shortest. There is often a gradual change in length and differences in length of teeth, though the difference is sometimes very small. The setae usually become shorter and thinner towards hind end of the body, and difference in length between teeth often diminishes. Sometimes there is marked difference between setae of II-V segments, which are formed in budding zone, and those of remaining segments, former are longer, straighter and slenderer than latter, with longer teeth, and a more proximal nodulus. This difference is perceptible in most species of *Nais*, many species of *Dero*, *Aulophorus* and also in *Pristina aequiseta*, but only faintly so in *Allonais* and *Pristina foreli*, *P. synclites*, *Pristinella rosea*. In some species, *Nais pardalis*, *N. barbata*, *N. bretscheri* and *N. pseudobtusa* this difference is striking, especially so in *N. behningi*, where the anterior setae are 1½ times as long, but only half as thick as the rest, with distal tooth enormously long and strongly curved, the proximal one being reduced. In *Haemonais* and *Branchiodrilus* transition between two types, when present, is less abrupt and takes place further. In *Vejdovskyella*, *Ripistes* and several species of *Pristina*, only the setae of II segment differ distinctly in shape from the rest, where setae to rear are usually straight, with an abrupt proximal bend. In *Pristina*, one group of species has setae of II segment and often also of III segment differ from rest, but most often also those of III segment differing from the rest, most often all the setae in *Pristina* are approximately equal, except that those of II segment may be shorter, their lengths increasing gradually posteriorly.

In *Chaetogaster* all setae have a peculiar form, being fairly straight with an abrupt proximal bend, which is especially accentuated in *C. limnaei* group, where teeth are also strongly curved. Here the number of setae is usually high, upto more than 20. This may probably be an adaptation to special mode of life. In *Chaetogaster setosus* all the setae are simple-pointed, and in *C. krasnopolskiae* one prong is reduced. In *Homochaeta naidina* and *Paranais heteroseta*, all or some of the setae may be simple-pointed. In *Stylaria lacustris* all ventral setae have an unique shape with two sharp bends and in *Stylaria fossularis* all ventral setae have one abrupt sharp bend proximally.

Nais bretscheri, *N. pardalis* and *Vejdovskyella intermedia* are provided with specially enlarged setae "giant setae" in varying number of segments posterior to V segment, their extention varies with the age of the animal. In *Pristina aequiseta* and *P. evelinae*, the ventral setal bundles of IV and V segments or both may have enlarged setae of normal form, either alone or along with smaller setae, these enlarged setae are giant setae. Throughout the year individuals may be found with giant setae. Temperature

has no influence on the appearance of giant setae, but they are not found in the youngest individuals, and attainment of a certain age seems to be a factor in their production. They may possibly represent genital setae. In *Pristina longiseta* setae of VI segment are more strongly enlarged than usual.

INTERNAL ANATOMY

Coelom : The spacious body cavity extending throughout the body length, in which internal organs are suspended by septa and mesenteries is the coelom. It is filled with coelomic fluid and divided into a number of chambers by the septa. Mostly the septa are located beneath the external intersegmental furrows. The coelomic cavity is lined by unspecialised parietal peritoneum and a visceral peritoneum, some of whose cells are modified as chloragogen cells, which are found surrounding the gut and blood vessels beginning from V-X segments (Rosa (1898), Liebmann (1931) Avel (1959) and Cook (1971). The chloragogen cells have role in the metabolism of glycogen and protein and excretion as they contain a high concentration of ammonia and urea Rosa (1898), Liebermann (1932), Avel (1959) and Cook, 1971).

Coelomic fluid : The coelomic fluid acts as a hydrostatic skeleton upon which the muscular system may act to induce movement, and acts as a vehicle for free cells, many of which are phagocytic and helps in the defence system (Avel, 1959). It is also an intermediate reservoir of excretory products, from which the nephridia collect and excrete to the exterior.

Septa : The septa are composed of three internal layers of muscle fibres and two external layers of peritoneal epithelium (Nomura, 1913). The musculature of septa is often rather complex, consists mainly of fibres running dorso-ventrally laterally and, from ventral surface, circum-intestinally (Nomura, 1913, Pointner, 1911). Haffner (1927) found in *Lumbriculus variegatus* a band of muscle fibres from dorsal body wall pass beneath the dorsal blood vessel dorsal to the gut, and that the fibres having a similar origin in the dorsal part of the septa, run obliquely to the dorsal blood vessel.In a typical condition the septa are penetrated by the gut, the ventral nerve cord, the dorsal and ventral blood vessels, and a pair of nephridial tubes. In all families of Microdrli the first two to five segments they are incomplete or absent (Stephenson, 1930). Normally the septa are thin, delicate structures but a number of pre-genital septa are thickened by development of muscle layer in Tubificidae (Dahl, 1960).

In most microdriles the septa are modified in some regions of body, in the development of elongate pouches, the sperm-sacs, seminal vesicles, ovi-sacs in the septa of the genital segments. Most Microdrili have groups of chromophile cells in a few anterior segments, which are closely attached to the septa and have been named septal glands. These are associated with digestive system.

ALIMENTARY CANAL

The alimentary canal in *Aeolosomatidae*, *Naididae*, *Tubificidae*, *Enchytraeidae*, *Phreodrilidae* and *Haplotaxidae* is simple, conisting of ventral opening, the mouth, buccal cavity, pharynx, oesophagus, stomach and intestine teminating in posterior ventral anus. A number of these have appendages of various kinds. The structure of the microdrile gut is provided by Stephenson (1930) and detailed accounts of certain groups or species of Naididae by Sperber (1948), Naidu (1962b, 1963 a, b) of Tubificidae by Smith (1900a), Nomura (1913, 1915), Dixon (1915), Mehra (1922), Naidu (1965a); of Phreodrilidae by Goddard (!909a)

Mouth cavity : It is an introductory, short part of the alimentary canal beginning at mouth which is situated at anterior end of I segment (peristomium) overhung by the prostomium. It has a low non-ciliated epithelium.

Pharynx : It is generally confined to II and III segments, or sometimes to more segments. It is a thicker portion of alimentary canal, not very definitely separated from the mouth cavity in front, but more distinctly defined behind into a narrow oesophagus. The greater bulk of the pharynx is due in part to its musculature, in part to the often thick investment of the glandular cells and sometimes as in *Enchytraeidae*, in part to a localised thickening of the pharyngeal epithelium.

The most characteristic feature of the pharynx in the *Naididae* (except in *Chaetogastrinae*) and *Enchytraeidae* is the presence of a dorsal dilatation or diverticulum, covered by the gland cells. The diverticulum is highest at its front end in II segment and flattening out backwards stretching through III segment as in *Nais*, *Specaria* and *Pristina,* but it may occupy a major part in IV segment as in *Stylaria*, *Vejdovskyella*, *Ophidonais*, *Dero* and *Haemonais*. In *Slavina*, *Ripistes*, *Piguetella* and probably *Allonais* it occupies III-V segments and in *Paranais* and *Uncinais* only III segment. Its size and location varies considerably. Its depth and width vary with the state of protrusion and contraction. In worms not swallowing food or water, it has a very narrow, vertical or horizontal lumen almost closed off from the rest of the pharynx. In some Naididae (Marcus, 1943) and Lumbriculidae (Cook, 1967), two sets of muscles, anterior protractor muscles and posterior retractor muscles attach pharynx to dorsal body wall.

The diverticular wall consists of high columnar epithelium of narrow cells with basal nuclei. The cell borders are visible without any fibrils. The cell contents are finely granular and vacuolated in the more basal part. The cells bear a fairly low but very dense layer of mobile cilia, covered with mucus. These cilia move vigorously during ingestion of food. Species of *Aulophorus* which form their tubes by cementing together with mucus, foreign particles collected with the everted pharynx, have a pharynx roof of the shape of a circumscribed plate of high cells, like the *Enchytraeidae* and *Phreodrilidae*. In *Aulophorus tonkinensis* the protrusible pharynx is used as a

sucker for crawling forward without letting go its hold or it may pull itself forward by a series of jerks, extending itself and regaining a fresh hold between the jerks.

In most naids only the dorsal wall of the pharynx is shaped as described above, but in *Stylaria* and *Dero*, a strip of the ventral wall from the III segment to the beginning of the oesophagus has quite the same structure. The lateral walls, and the ventral wall in most naids, show a similar structure to that of the buccal cavity, with a low epithelium devoid of cilia. Towards the oesophagus they change a little before the dorsal wall so that there is a small part of the gut built mainly as the oesophagus but with the pharyngeal epithelium mid-dorsally. The muscular investment of the diverticulum is fairly strong mid-dorsally and it is connected with the dorsal body-wall by numerous muscular strands. There is a thickened wall in the border between the mouth and pharynx, immediately in front of the dorsal diverticulum, where the cells are high and columnar, and similar to those of the pharynx with short cilia.

In *Chaetogaster* and *Amphichaeta* the pharynx is in II-III segments, devoid of the dorsal diverticulum and ciliation, and with strong muscles radiating from it towards the body wall.

Pharyngeal glands : These glands occur between the muscle strands of dorsal diverticulum of the pharynx as cell aggregates with granular contents and large nuclei with evenly scattered chromatin and a small nucleolus. These cell-aggregates are pear-shaped, rounded in small species such as *Nais*, less rounded in *Stylaria* and very high and narrow in *Dero*. In the dorsal surface of the diverticulum, they are high and narrow than on the sides, and are weaker posteriorly. They are upto 40 μm high and cells themselves are about 5-7 μm in diameter in *Stylaria* and smaller in *Nais*. These cell aggregates communicate with the pharyngeal epithelium breaking the muscle layers and the ends of some cells pierce between the epithelial cells. There are no mucin ducts, but that the cells themselves reach the surface and pour out their secretions into the lumen of the pharynx (Sperber, 1948).

Oesophagus : It begins in the posterior part of the last pharyngeal segment and posteriorly widens into stomach. It occupies 2 to 5 segments depending on the difference in length of the pharynx and beginning of the stomach. It occupies one segment only in Chaetagastrinae. It has low epithelium which is non-cubical but its cells are fairly high, irregular and deep staining. It is lined with long, active cilia, more closely set than those in the pharynx ..The muscular coat is thinner than that of the pharynx. After septum 5/6 in most forms, 4/5 in *Stephensoniana* and 7/8 in *Pristina*, the chloragogen cells and intestinal plexus appear, in relation to the number of segments found anterior to the budding zone.

Oesophageal glands : These glands occur in III segment in *Nais* as aggregates of larger cells of different appearance. The largest diameter of the cells is 11-20 μm. In *Nais communis*, the amount of this type of cells varies much and they are sparsely

scattered in III segment, but on oesophagus they form a dense layer breaking up in V segment. In the VI segment, where chlorogogen cells begin, they cluster into two groups on the lower sides of the oesophagus with which there is only a weak connection. In *Nais elinguis* these groups are large, filling the whole lower part of segment and fitting tightly upto septum 6/7 thus closely resembling septal glands. In *Nais variabilis* and *N. simplex* also, these cells are found in VI, but in all other species of *Nais*, *Stylaria*, *Slavina appendiculata*, they stop in V In *Stylaria* cells group in large heaps around the last of the mucin gland cells; they then form a coat of two layers high around the last part of the pharynx.

Septal glands : In Naididae these glands are known to occur in *Pristina*, in most *Dero* and in *Paranais*, where the oesophageal gland cells are absent. Their shape varies considerably among different genera. These cells look similar to oesophageal gland cells. The septal glands are situated further away than the oesophageal glands from the alimentary canal. They are connected with the oesophagus by very thin strands running forwards from their lower ends though it could not determine any secretion in them (Sperber, 1948). Marcus (1943) saw each septal gland connected with the pharynx by a strand, forming a canal for emptying the secretion.

In *Dero*, the septal glands are in much closer contact with the gut. The first pair resemble in frontal section the usual oesophageal glands, grouped around the pharynx outside the pharyngeal glands cells. The lower ends of the glands are in close connection with the lower parts of the pharyngeal wall. The second and third pairs in *Dero digitata* are closely packed around oesophagus. There is every possibility of a connection with lumen of the oesophagus (Sperber, 1948).

Septal glands occur only in forms lacking oesophageal glands. Sometimes it is not easy to decide to which type the glands of a species are to be classified. There are three featuers which generally separate the septal and oesophageal glands, namely the connection of the septal glands with the septa, their character of being paired and the fact that they are usually closely interwoven with the blood vessels.

Stomach : It occurs in all species of Naididae, though it may not be marked off by a dilatation in some. It is of four different types. First is the *Nais* type, in which it begins in VII or VIII segment and occupies 2 segments. Second is the *Dero* and *Aulophorus* type, where it begins in VIII, IX or occasionally in X segment and occupies 2 or 3 segments. Third is the *Pristina* type located in VIII segment. Fourth is the *Chaetogaste*r type restricted to V-VI or V-VII segments.

Histologically, the stomach is well defined from the other parts of the alimentary canal with its distinguishing characteristic of a strong brush border, which is always present in addition to the ordinary investment of cilia.

Stomach walls are usually thicker than those of the oesophagus and intestine, and the ventral cells are larger. The cells of the stomach have granular cytoplasm, which

often appears striated basally. When stained with iron haemotoxylin, the cells of oesophagus appear homogeneous and densely blue, whereas the cells of stomach stain more conspicuously, only in the part that lies between the nucleus and the lumen of the stomach. More basally the cytoplasm stains more faintly. In the cells of intestine only a very narrow layer immediately below the surface is stained.

The stomach of *Paranais litoralis* differs from *Nais* type in the absence of brush border and presence of only ordinary cilia, and the cells, at least a number of them, contain short, and straight, ciliated canals. The surface layer of the epithelial cells stains more strongly than the rest. The nuclei here are basal.

The stomachal wall in *Pristina* consists of very high granular cells, each containing a canal, the wall of which is provided with a brush border, like the whole inner surface of the stomach and last part of the oesophagus. In *Pristina longiseta*, the canals are very long and curved at their basal ends, in other species, they are shorter. The free surfaces of the stomach cells and outer parts of the canals also possess an investment of ordinary cilia.

The stomach dilatation in *Chaetogaster* is distinct from the stomach dilatation of the other naids, as it is much more conspicuous, being very wide, with narrow inlet and outlet and restricted to V-VII in *C. diaphanus*, to V-VI in small species. The food remains for considerable period. The epithelium of the stomach consists of low, hexagonal cells provided with long cilia, which are immobile except in the last part of stomach. They are easily confused with the chloragogen cells, which are very similar in appearance, but as they are situated outside the stomach, the two types can be distinguished by focussing up and down with the microscope. The epithelium of the stomach of *Amphichaeta* agrees with that of *Chaetogaster*.

Intestine : The intestine succeeds the stomach and forms the longest part of the alimentary canal. It has a brush border, similar to that seen in the stomach, though much lower, beside the long cilia. In the hinder most part, before the anus, these are absent.

Generally the cells of the intestine are shorter and more vacuolated than those of the stomach, and they become more and more so posteriorly. In the foremost part, the cytoplasm is distinctly granular, a narrow zone below the free cell surface staining rather heavily with eosin and iron haemotoxylin. The basal part is slightly vacuolated. Between these cells, there are other more darkly staining, narrow and irregular cells. Sometimes in this part are found a few yellow granules looking like chloragosomes, though not distributed under the surface, but contained within the vacuoles. Further back the cells became strongly vacuolated and in the vacuoles are seen dark-blue staining, irregular cells, though the chloragogen is often very scanty. In the newly formed part immediately preceding the budding zone, the epithelium is homogeneous and non-vacuolated.

In sexually mature worms the cells of the intestine are very different. In *Stylaria lacustris*, the cells of narrow type are seen to be crammed with granules which are larger than usual, some of them refractive. In fully mature worms of *Dero*, on the contrary, the intestine degenerates. In *Piguetella* the case is similar as in *Stylaria*; the granules are partly smaller, filling the cytoplasm, and partly larger, very much resembling chloragosomes, lying in sometimes very large vacuoles, surrounded by a thin layer of cytoplasm, are discharged into the lumen of the intestine, where they round themselves off. Later the cytoplasm is evidently dissolved, for scattered heaps of the chloragosome-like granules are also seen in the lumen. This phenomenon is suggestive of excretion; in fact it is strongly reminiscent of the formation of excretion in the intestine of Myzostomids described by Jägersten (1940); but in this case the excrement-filled vesicles left the intestine still intact. It is seen that the amount of chloragogen surrounding the intestine increasing during maturity.

In *Chaetogaster*, at the transition of the stomach into intestine, there is usually a short constriction. The intestine itself is dilated in two or three segments. Then, in budding worms, the budding zone follows, but in fully sexualy mature specimens, in which the budding has ceased, there are a number of segments with very narrow intestine.

Histologically intestine has two types of cells. Most of the cells are cubical or columnar, ciliated, but without a brush-border, containing large amounts of yellowish granules of different sizes, staining like chloragosomes, in the cytoplasm or in the vacuoles of *C. diaphanus*. Among these are the second type consisting of a small number of cells with more strongly basophil plasm, containing something resembling a faintly stained secretion. The narrow end part of the intestine in mature worms consists of shorter cells with a smaller amount of small, refractive granules. The intestinal cells of *Amphichaeta* are similar to those of *Chaetogaster* but the cells are relatively smaller.

In the intestine of the naids (except *Chaetogaster, Amphichaeta*) there is an upward flow of water from the anus, caused by the ascending action of the cilia and carry oxygen to the intestinal plexus, which thus has also a respiratory function.

The structure of oesophagus is different from that of the stomach, the former having a columnar epithelium of narrow, basophil cells with cilia, the latter (except *Chaetogaster*) an epithelium of larger, less basephil cells with a brush-border beside the cilia. (But in *Pristina* the posterior part of the oesophagus has also larger cells and a brush-border. This part may perhaps be regarded histologically as a part of the stomach, though it lies in front of the dilatation, and the cells contain no canals). The intestinal epithelium, on the other hand, consists of cells, partly very similar to those of the stomach, and provided with a brush-border. Therefore the stomach cannot be regarded as a part of the oesophagus, but possibly as belonging to the intestine.

As to the stomach in *Chaetogaster* though it is very similiar to that of the other naids, it is probably homologous to it. It can safely be concluded that the intestine of *Chaetogaster* is homologous to that of *Nais* etc., in spite of its strongly deviating appearance and histology. The last part of the intestine representing a rectum is hardly recognizable.

Chloragogen : Generally the chloragogen cells have the same extension as the alimentary plexus. They begin in VI segment in most naids, in *Chaetogaster* and *Amphichaeta,* they begin in V, while in *Pristina*, they occur from IV or V, though there seems to be no vascular plexus on the oesophagus. In the foremost segments they are very scanty, and they are present not only on the gut and the dorsal vessel, but also in the anteriorly budded segments. They are also found fixed to the septa, setal sacs and the body wall. In these cells, the chloragosomes seem to be of a different composition from those on the gut and dorsal vessel, being considerably larger, 3.2-5 μm, against 1-1.5 μm and green instead of yellowish. In *Haemonais* the chloragogen is also present in the segments formed anteriorly on budding. It surrounds the gut as far forwards as IV segment, and is present in large aggregates in the prostomium and I-II segments. Here also, the chloragogen of the gut and dorsal vessel seem to differ from the rest, containing less brown pigment. In *Branchiodrilus*, there is a stripe of brown pigment in each gill-bearing segment and aggregates in the anterior segments, the pigment being of the same nature as the chloragogen and enclosed in cells attached to the parietes. The chloragogen is also seen on the transverse vessels in this genus. On the dorsal vessel it occurred only as far as between the first and second gills (VI and VII segments), so it does not here exceed the limits of the alimentary plexus. In *Chaetogaster* the chloragogen is scanty.

Ingestion of food : In Naididae the general mode of ingestion of food is by protruding the dorsal diverticulum of the pharynx through the mouth and retracting it with the matter that sticks to it. In *Nais variabilis* and *Dero digitata*, if food particles lie scattered in the water, the movement of the pharynx are very brisk, but if the animals are made to graze on a small twig with affixed algae or among very densely massed and cohering detritus, the pharynx is often extruded for several seconds at a time, thus allowing a thorough inspection. Only the dorsal diverticulum is protruded to tear off bits of detritus. When the animals had difficulties in tearing off anything loose, they are seen tugging at the matter and wrestling with it for several seconds. The protruded part of the pharynx formed an oval trumpet, the lateral parts functioning as lips, keeping hold of the food. Thus the food does not only merely adhere to the surface by the mucus but is also actively held.

In *Chaetogaster* and *Amphichaeta* the food particles are sucked in together with a quantity of water, the pharynx functioning as a pipette. The food of smaller species of *Chaetogaster* and all *Amphichaeta* consists of diatoms, detritus, etc., with occasional Rotifers and Protozoa, but larger *C. diaphanus*, *C. cristallinus* and *C. limnaei* feed regularly on prey.

VASCULAR SYSTEM

The blood in most genera of Microdili is red, the colour often becomes pale and yellowish. In *Aeolosoma* and *Chaetogaster* and in a number of Enchytraeidae the blood is colourless.

In Microdrili, the basic plan of vascular system is uniform, comprising of a large contractile dorsal blood vessel lying attached to surface of gut. It runs entire body length, dividing anteriorly in the region of brain into two and descend down unite to form the non-contactile ventral vessels, which runs the entire body length dorsal to nerve cord. Excepting the first, in each segment the dorsal and ventral vessels are connected by circum-intestinal connectives, or indirectly in posterior to genital segments, through a plexus of blood vessels around the gut, consisting of fine capillary network closely attached to gut surface. In genital segments dorso-ventral connectives may be long and run through the sperm- and ovi- sacs. Blood flows anteriorly in the dorsal vessel and posteriorly in the ventral vessel and dorsally through alimentary plexus and ventrally through the connectives (Haffner, 1927).

In Aeolosomatidae circulatory system consists of an intestinal plexus, a sinus, a dorsal vessel arising from the sinus in anterior part of body and is absent in intestinal region, and a ventral vessel which extends throughout the body and is connected to dorsal vessel anteriorly around the pharynx. Vascular commissures are absent. (Stephenson, 1930).

In Naididae the alimentary plexus is confined to the posterior part of the oesophagus, the stomach and the intestine, i.e., behind the segments formed through budding at the anterior end of the worm. They are parts behind septum 5/6 in most species, behind septum 4/5 in *Stephensoniana* and 7/8 in *Pristina*. In *Pristinella rosea* and *P. menoni* it is present also on the part of the stomach lying in VII which is formed in the budding zone. In *Chaetogaster* and *Amphichaeta* also, the plexus is present on the whole of the stomach, though the first part of the stomach, lies within the V segment formed by the budding zone.

The extension and appearance of the alimentary plexus are difficult to observe, as it is obscured by the chloragogen cells. But it can be easily observed when stained intra vitam with neutral red. The branches of the plexus are fairly free of chloragogen. There are 7-8 longitudinal ducts laterally on the intestine on each side, and crossing these regularly are about 5-7 transverse ducts in each segment. The broadest of the transverse ducts is situated in the constriction of the segment border. Thus, a very regular network is formed, with parallel meshes, and with only occasional irregularities. As a rule, the plexus appears to be more irregular.

In *Chaetogaster* the regular arrangement of ducts on the stomach wall, has a systematic value. Here, a distinctly larger, longitudinal duct is formed on the ventral side, which is termed the sub-intestinal vessel by Stephenson. The plexus is always much swollen, filled with blood in mature worms.

The dorsal vessel is free only in the oesophageal and pharyngeal segments and internally connected with the alimentary plexus on the stomach and intestine. It is generally observed by the waves of contractions from behind forward, the blood flowing through a pair of branches of the dorsal vessel, which form the ventral vessel anteriorly. In many members of Naididae, the dorsal vessel for most part of its course runs ventrally on the gut, along the left side of the ventral vessel as in *Dero*, *Piguetella*, *Specaria* and *Allonais*.

In *Aulophorus*, *Haemonais*, *Branchiodrilus*, *Stephensoniana*, *Nais* (except *N. elinguis*), *Slavina* and *Allonais* the dorsal vessel also runs along the left side of the gut, though more laterally. It is exactly mid-dorsal or only slightly to the left, in *Nais elinguis*, *Stylaria*, *Ripistes*, *Vejdovskyella comata*, *Ophidonais*, *Pristina* and *Arctonais lomandi*, *Homochaeta lactea*. The displacement of the dorsal vessel from mid-dorsal position in many species may have connection with the swimming habits of those species.

The commissural vessels in most Naididae unite with the longitudinal vessels, in a number of anterior segments, often only in those formed by the budding zone, i.e., 5 or 7 (*Pristina* and *Pristinella*). Often the loop in I segment is reduced. The loops may show all degrees of complexity, from the simple stage, with all loops simple and free, as in *Stylaria*, *Arctonais*, *Ripistes*, *Piguetella*, *Allonais*, many species of *Pristina*, some *Nais* and *Homochaeta lactea* with only occasional branching or anastomoses, to a complicated network, where it is impossible to find any main vessels. Slightly more frequent anastomoses are found in most species of *Nais,* especially in. *N. communis*, *Vejdovskyella comata*, *Ophidonais serpentina*. When a real network of capillaries is formed, it may show various conditions. Thus, in *Pristinella rosea* the transverse loops in I-II form a plexus, while those of IV-VII are free and simple; and in *Pristina americana* there is a plexus in II-V, with free loops in VI-VII. In *Uncinais unciniata*, *Homochaeta naidina*, *Slavina appendiculata*, *Allonais paraguayensis* and *Pristinella amphibiotica* all the loops are dissolved into plexus. This is also the case with the anterior loops in *Dero*, *Aulophorus*, *Allonais inaequalis*, *Allonais chelata*, *Specaria josinae*, and *Paranais* (I-IV), but here an additional free loop is found in some of the next following segments: 1 loop in *Specaria* (branching once), 2-3 in *Paranais* and from 3 to about 10 in the rest. In *Allonais inaequalis*, *Dero* and *Aulophorus* these free loops are attached to the anterior face of the septa. In *Uncinais* the capillaries are concentrated on the inner surface of the body wall; in *Specaria* they are found on the wall as well as in the whole space between the wall and the alimentary canal; and in *Paranais*, *Dero*, *Aulophorus* they are concentrated around the latter, and interwoven with the septal glands.

In *Chaetogaster* and *Amphichaeta* the number of transverse vessels is reduced, to one pair in IV in *Chaetogaster*, and one unpaired vessel in *C. krasnopolskiae*, and none in *Amphichaeta*. The transverse vessels in anterior segments are always more

or less contractile, though the contractility is hardly perceptible, when they form a plexus. In some forms some vessels are especially contractile, and wider than the rest, and are then often called hearts as in *Dero*, *Aulophorus* and *Pristina*. In mature worms, loops are formed in genital segments, following the inner side of the ovi-sac and sperm-sac.

In Tubificidae vascular system consists of intestinal plexus, dorsal and ventral vessels, with sometimes supra- and infra-intestinal vessels in addition, and a number of transverse vascular commissures throughout the body, one or more of which are contractile in VIII, IX, X or some of these. In many species hinder part of the body is covered with vascular commissures with winding course on body wall and branching to form plexus. Such arrangements in body wall are for respiratory purposes especially when combined with waving about of the hinder part of body in water. In *Branchiura sowerbyi* alone are developed fingerlike processes of body wall in mid-dorsal and mid-ventral lines of posterior region of the body, each enclosing a vascular loop.

In Enchytraeidae the circulatory system is at a relatively low level of differentiation. The alimentary sinus is well developed; the dorsal vessel, as in *Aeolosoma,* is present only in anterior part of the body. In some cases as in *Henlea,* it takes its origin from the sinus as far forwards as segment VIII, so that its whole length is very short. A ventral vessel is present, and there are a few pairs of transverse commissural vessels in anterior segments.

Accounts of vascular system of Naididae are provided by Stephenson (1913a, 1930), Sperber (1948), Naidu (1962 a, b, 1963 a, b), of Tubificidae by d'Udekem (1853), Claparéde (1862), Eisen (1886), Beddard (1892, 1895, 1896), Goodrich (1895), Benham (1903, 1907, 1915), Moore (1905), Southern (1909), Stephenson (1912b), Nomura (1913, 1915, 1926, 1929), Dixon (1915), Meyer (1916), Mehra (1922), Cernosvitov (1939), Chen (1940), Yamamoto & Okado (1940), Marcus (1942), Dahl (1960) and Naidu (1965a), Palmer (1966), and of Enchytraeidae (Bell, 1958, Stephenson, 1930); of Phreodrlidae by Beddaed (1891), Goddard (1909a), Stout (1958); of Lumbriculidae by Haffner (1927), Cook (1967).

RESPIRATION AND RESPIRATORTY ORGANS

In Microdrili, as in other oligochaetes, cutaneous respiration by the body wall is common, in which dissolved oxygen of water is absorbed and carbon-di-oxide is released into water. In addition to this, respiration through gills takes place in some genera, *Dero, Aulophorus, Branchiodrilus* of Naididae, *Branchiura sowerbyi* of Tubificidae and *Phreodrilus branchiatus* of Phreodrilidae.

In *Dero* and *Aulophorus* posterior end of body has a shallow cup like branchial fossa, its opening directed upwards and backwards, with centrally located anus. Around the anus are 2-4 or 5 (rarely more) pairs of ciliated hollow digitiform or foliate gills

on inner wall of the fossa. The coelom extends into the gills. Both gills and branchial fossa are extremely contractile. Gills are supplied with a vascular loop connected to both dorsal and ventral blood vessels.

In *Branchiodrilus* dorso-lateral segmental, paired cylindrical gills start from VI or in one or more anterior segments and extend backwards, decreasing in length and finally becoming mere tubercles towards posterior end. General body surface and gills are ciliated. Maximum length of gills is 3 or 4 times the body width. Coelom extends into the gills and each gill bears a vascular loop connected to dorsal and ventral blood vessels.

In *Branchiura sowerbyi*, the gills are cylindrical projections of body wall, arranged segmentally in two series, along mid-dorsal and mid-ventral lines respectively, in hinder sixth to two-fifth of animal length. In all, they may be 50-140 pairs, their length about equal to body diameter, diminishing in size towards anterior and less marked towards their posterior limit. Each gill contains a vascular loop connected to dorsal and ventral blood vessels. In life they are constantly waved about from side to side.

INTESTINAL RESPIRATION

Among Microdrili, the phenomenon of intestinal respiration is found in Aeolosomatidae, naidid genera except *Chaetogaster* and several tubificids. This type of respiration takes place both by reverse ciliary action of intestine and anti-peristalsis of posterior part of intestine. Due to reverse ciliary motion of cilia of the gut wall water enters through open anus and flow forward. Anti-peristalsis of intestine enhances the driving force of water current. Intestinal wall absorbs dissolved oxygen releasing carbon-di-oxide into water. (Vasisht & Angrish, 1981b).

NEPHRIDIAL SYSTEM

In Microdrili as in all oligochaetes, the nephridia are the organs for excretion and osmo-rgulation. Each nephridium basically consists of a ciliated funnel with nephrostome, a short duct that pierces through a septum, and a long coiled or looped nephridial duct, which opens to the exterior by a small pore, the nephropore, near the ventral setae of the segment behind that bears the nephrostome. This type of a nephridium is known as open exonephric holonephridum (Fig. 14 E, 18 E, 25 D, 29 G, 30 G, 31 H, 32 E, 37 G, 39 G, 40 H, 43 F, 45 F, 49 F, 50 E, 54 F, 60 E, 63 D, 64 D) found in all microdrili except *Chaetogaster* of Naididae, in which the funnel is absent and it is called closed exonephric holonephridium (Fig. 8 C). Generally the nephridia are paired and occur in each segment except a few anterior and genital segments.

In Aeolosomatidae, the nephridia (Fig. 2 F, 3 F, 6 F, 7 C) are of small size, much simpler than in larger Microdrili. They begin in a funnel shaped opening, with a ciliated margin and a body consisting of a loop containing a ciliary flame beating down the canal. The loop is closely attached to side of the gut, on which it ascends and descends with a few windings. The loop begins in a glandular swelling, its lumen is intracellular and in living worms ciliary action is seen in the interior. The nephridium penetrates the epithelium, but has no ectodermal lining of its own. As there are no septa in these worms, the usual relationship of a single nephridium to two segments is not applicable here. First nephridium is located behind the second setal bundle. The nephridia of the anterior segments are larger, gradually diminishing in size posteriorly. Accounts of the nephridia of the Aeolosomatidae are provided by Vejdovsky (1905), Boveri-Boner (1920), and Dehorne, A. (1923, 1925).

In Naididide the nephridia have an inverted U-shape and start in pairs in segments behind the genital segments. In *Stylaria* the upper lip of the funnel projects more than the lower and on the edge of the funnel are numerous small, delicate protoplasmic processes ending in knobs or hooks, as well as very fine and long cilia which beat down actively in life, and a ciliary flame also beats down the lumen. Behind the septum is a swollen ampulla with a wide lumen, its walls have alveolar protoplasm often with numerous inclusions probably excretory substances taken up by phagocytosis in the process of digestion and about to be passed into lumen, the last remains of the process are apparently represented by numerous small deep coloured granules in the protoplasm. There is a small terminal dilatation of lumen, which is often filled with excretory granules. Accounts of nephridia of Naididae are given Boveri-Boner (1920), A. Dehorne (1923, 1925) and Naidu (1962 a, b; 1963 a, b).

In Tubificidae generally nephridia (Fig. 69 E) start about the VI to VIII segment in pairs, but are absent in genital segments, X and XI, and are often absent or poorly developed on one side of the body. The funnel is a narrow tube with 3 or 4 nuclei, drawn out to a point on its dorsal aspect; cilia of the margin wave in the coelomic cavity, while the ciliary flame beats down the tube. The loops which constitute the body of the nephridium, are not confined to one segment, but extend into the segment in front of that to which the body proper belongs, some of the loops usually follow in their course the ventral vessel, running between the elongated peritoneal cells, which invest the vessel. The cell limits are not seen in the loops. The first part of the tube is succeeded by the ampulla, a roundish bladder like dialatation of varying size, containing a brownish granular mass, probably excretory. The ampulla (Fig. 69 E-am) is situated in the part of the nephridium which lies on the ventral vessel, and towards its hinder end it is not ciliated, but particularly long cilia project into it from the first part of the tube. The second part of the tube which succeeds the ampulla, has thick walls of coarsely granular protoplasm, which stains deeply; it is this part of the tube which is surrounded by the large vesicular peritoneal cells. Just before the termination the lumen expands to form a small pear shaped contractile vesicle (Fig. 69 E-cc). The

nephropore (Fig. 69 E-np) is situated a short distance in front of the ventral setae on either side. Descriptions of the nephridia of Tubificidae are provided by Claparéde (1862), Eisen (1886), Goodrich (1895), Beddard (1896), Hatai (1898, 1899), Rybka (1899), Southern (1909), Pointer (1911), Nomura (1913, 1926, 1929), Dixon (1915), Boveri-Boner (1920), Mehra (1922), Mrazek (1926), Naidu (1965a) and Jamieson (1968).

The nephridia in Enchytaeidae (Fig. 86 F, 87 B, 88 F, 90 C, 91 C, 93 C) have characteristic form. The ciliated funnel is as usual pre-septal and coils of the post-septal part are not free but are completely fused to form an ovoid or elongated solid, cellular or syncytial mass, through which the lumen tunnels its winding course. Accounts of the nephridia of Enchytaeidae are provided by Bolsius (1893), Ude (1895) and Schenider (1896).

NERVOUS SYSTEM

In Microdrili the nervous system consists of a bilobed brain formed of two pairs of cerebral ganglion placed one above the other, located dorsal to the buccal cavity in I segment. It gives off a number of nerves anteriorly to prostomium and a pair of circum-pharyngeal connectives laterally to connect the sub-pharyngeal ganglia of ventral nerve cord below the pharynx in II segment. The ventral nerve cord is formed of two closely and parallely placed nerve trunks running the entire body length mid-ventrally, which are swollen into segmental ganglia in each segment except the first two. Four pairs of lateral nerves unite dorsally, forming a complex nerve ring.

In Aeolosomatidae the nervous system is fused to the surface epithelium throughout life. The brain, (Fig. 3 C-b, 4 B-b, 5 B-b) though partly embedded in the epidermis, projects below into the prostomial cavity. It gives off two cirum-pharyngeal connectives on either side of pharynx, which join the sub-pharyngeal ganglia of the ventral nerve cord. From each sub-pharyngeal ganglion a nerve is supplied to the prostomium. From an angle between the posterior lobe of cerebral ganglion and pharyngeal connectives, a pair of nerves, one on each side run backwards. The ventral nerve cord has the form of a step ladder, with a pair of ganglia in each segment, united by a transverse commissure. The ganglion cells of cord are distinct from the epidermal cells. Four pairs of nerves are given off from each ganglion in each segment.

In Naididae, the brain (Fig. 8 B, E-b, 14D, 18 D, 25 C, 29 F, 30 F, 31 G, 37 F, 40 I, 50 D, 54 E, 60 E, gives off 4 pairs of nerves, 3 pairs of which are supplied to the first segment, and the fourth pair to the second segment. The ventral nerve cord is connected to the epidermis at hind end and at the fission zones; and this connection indicating that the cord is derived from the epidermis. Each segmental ganglion has four swellings, of which the hindmost swelling lies in the segment behind that occupied by the other three swellings. Four pairs of lateral nerves are given off by the segmental ganglion, of which the first pair is supplied to muscle layers of the body wall and

viscera; the second pair passes through the setal bundle to the chief band of sense organs of the segment; the third pair innervates the septum; and the fourth pair supplies to the smaller band of sense organs in the next segment. Certain species of *Chaetogaster* have a curious, bright refractile body called statocyst (Fig. 8 B-stc, E-stc) located medially in posterior part of the brain, which may function as statocyst or balancing organ (Sperber, 1948)). Also in *Chaetogaster* the two halves of the nerve cord are not completely fused to each other, but run parallel to each other a little apart, united by transverse commissures between the segmental ganglia of each pair. This step ladder type of the cord is also noticed in Aeolosomatidae. In *Aulophorus vagus* Brode (1898) describes a nerve trunk given off to the pharynx from the sub-pharyngeal connective on each side, which on reaching the pharynx branches into two, the larger of the two lying in a longitudinal groove caused by the infolding of the pharyngeal wall, passes to a pharyngeal ganglia situated at the junction of the anterior and posterior parts, into which pharynx is divided, the smaller branch lies more dorsally, and unites behind with the larger branch at the ganglion. The commissures pass transversely over the pharynx from one larger branch to the other, anastomosing with the smaller branches in their course. In *Stylaria lacustris* Dehorne, L. (1916) found three canals in the usual position of the giant fibres, but considers them to be spaces between cord and connective tissue covering. Vejdovsky (1884 a) describes a single giant fibre in the middle and hind parts of the body in the species and two in front.

In Tubificidae the morphology of the nervous system is more or less similar. Stephenson (1912b) and Keyl (1913) showed large giant fibres occurring in *Branchiura sowerbyi*. One is generally larger than the other two, in posterior part of the body much larger, and in diameter may be almost equal to the rest of the cord. The fibres are larger towards the hind end of the body. Morphological accounts of the nervous system of Nadidae are provided by Vejdovsky (1884), Brode (1898), Stephenson (1907 a, b), Southern (1909), Dehorne, L. (1916); of Tubificidae by Eisen (1879, 1886), Goodrich (1895), Stephenson (1912a), Keyl (1913), Nomura (1913, 1915, 1926), Dixon (1915), Chen (1940) and of Lumbriculidae (Isossimoff 1926).

SENSE ORGANS

Pigmented eye-spots are present laterally on I segment, Hesse (1902) described the eyes in *Stylaria lacustris,* each consists of five or six large unpigmented cells located beneath and medial to the row of sense cells. Each cell contains a number of vacuoles filled with clear fluid, and a transparent hyaline ovoid body. Dehorne (1916) found that a mass of nerve cells located anterior to the eyes, connected each nerve cell to a short nerve leading to circum-pharyngeal connective. In most species of *Chaetogaster*, a peculiar refractile body, statocyst, (Fig. 8 B-stc; C-stc) located medianally in posterior part of brain, may function as a balancing organ (Sperber,

1948). It is a lens-shaped vesicle with refractile brownish aggregations. Atheston (1899) found in *Tubifex,* loose and isolated groups of flask-shaped sensory cells in the epidermis. They are enervated by nerve fibres entering the cells a little distance from their bases. They are found abundantly in the prostomial and posterior regions of the body. Some of these cells have one or more thin hair-like processes externally. These sense cells are similar to those found in *Slavina appendiculata* (Marcus, 1944). In tubificid, *Bothrioneurum* a peculiar sensory ciliated pit situated asymmetrically on the dorsal surface of the prostomium. Its cells are taller than surrounding epidermal cells and muscle layers of body wall immediately beneath the pit are absent. Prostomial sense organs consist of ciliated pits (Fig. 2 B-cp, 3 C-cp, 4 B-cp, 5 B-cp) on the prostomium of *Aeolosoma*, which are paired depressions, one on each side of prostomium, their cilia longer than those of neighbouring regions, and move slowly with wave-like motion. These pits are connected to cerebral ganglion by a very slender nerve.(Vejdovsky, 1884, Aiyer 1926, Bunke, 1967).

REPRODUCTIVE ORGANS

The oligochaetes are hermaphrodites with their genital system composed of male, female organs, male efferent apparatus and spermathecae. Generally the male genitalia consist of one to four pairs of testes, associated with vasa deferentia and storage organ, the atria. The testes are situated ventrally on the anterior septa of their segments. The posterior septa of these possess elongate pouches, sperm-sacs, in which spermatogenesis occur and also serve as sperm reservoirs. A pair of male funnels are located on the posterior septum of each testicular segment and open into a pair of narrow, ciliated vasa deferentia, which enter into paired or rarely single, atria. The atria are present in the segment immediately posterior to testicular segment in Naididae, Tubificidae, Phreodrilidae, or in same segment in Lumbriculidae. The atrium is a muscular sac, (Hrabe, 1939a, Cook, 1967). often associated with prostate glands, which either terminates in a penis or opens to the exterior in a simple pore. The ventral setae near atrial segment are modified in some species as penial setae. These are embedded in, or associated with, glandular tissue or copulatory glands. In some species accessory glands in the form of pads of tissue are situated ventrally near atria. The female genitalia consists of paired ovaries which are attached to anterior septa of their segments, and paired, small ciliated funnels which are situated ventrally on the posterior septa of the ovarian segments. The ovi-sacs are back-pouchings of posterior septa of ovarian segments situated posterior to sperm-sacs. The spermathecae are pedunculate pouches of ectodermal origin, which store sperm after copulation. They are paired structures opening ventro-laterally in the region of gonads.

Clitellum : The clitellum is usually thicker dorsally and it is most often absent around and between the male pores in *Nais* and *Stylaria*. In *Piguetella* it is present on the whole ventral surface posterior to spermathecal pores, but in the part anterior

to and around the male pores, it has not of the same appearance as usual. It is apparently also present between male pores in *Branchiodrulus*, *Stephensoniana* and some *Allonais*, and in *Pristina* the conditions vary.

In Naididae, the clitellum has two types of gland cells besides the common epithelial supporting cells. The two types of gland cells are finely granular gland cells secreting the albuminous fluid of the cocoons and large cells with large granules which form the cocoon itself. As to the origin of the gland cells, they seem to be formed from ordinary epidermal cells. Between the gland cells are the ordinary epidermal cells, which are closely pressed together, when the gland cells grow, they constitute the "supporting cells" At last there is nothing to be seen of them except the outermost part below the cuticle, where a little cytoplasm with the nucleus is left.

During the development of the clitellum, large secretory globules appear in the cytoplasm of the gland cells, and grow more and more numerous, while the cells grow higher and higher, and the cytoplasm is pushed to the walls, and the nucleus is located basally. At the fullest development, the clitellum in *Stylaria* becomes as much as 50 μm thick on the dorsal surface, about 10 times as thick as the ordinary epidermis in this region, when the whole of the cell is taken up by a vacuole crammed with the secretion, while the nucleus is pushed to the bottom of the cell and may even hardly be conspicuous, especially in *Piguetella*, where the gland cells are not so high and narrow as in *Stylaria*. The borders of the cells are not lost. The secretory globules differ very much in size. In *Stylaria* they attain about 5 μm in diameter, being irregularly round and flattened against each other.

Sperm-ovisacs : The sperm-sacs (or seminal vesicles) are pouches within which the male cells develop and metamorphose into spermatozoa. In Microdrili they are simple out-pouchings of the posterior septum of the testicular segment. In Naididae (except in *Chaetogaster*, where sperm sacs are absent) there is single such sac, the posterior out-pouching of the posterior septum of segment V, which extends backwards for some segments dorsal to the alimentary canal, its posterior part lying within the ovi-sac, which is a similar posterior outpouching of the posterior septum of ovarian segment, i.e., segment VI.

Male efferent apparatus : The male funnels (Fig. 8 E-mf, 10 E-mf, 11 D-mf, 15 F-mf, 16 D-mf, 18 I-m, 19 D-mf, 20 F-mf, 22 D-mf, 23 D-mf, 24 F-m, 25 E-mf, 26 D-mf, 27 E-mf, 30 H-mf, 34 H-m, 41 F-e, 43 G-m, 51 F-sf, 52 F-d, 55 F-m, 57 E-d, 58 G-d, 60 H-d) are usually cup-shaped in Microdrili. In the Naididae they are cup-shaped, though often more or less deformed due to the pressure in the sperm-sac. In *Stylaria* and *Slavina*, they are strongly enlarged, the outer and lower (original dorsal) wall extending very far along the wall of the sperm-sac. The funnels consist of ciliated cubical or columnar cells, usually thick at the base of the funnels.

The male funnels continue into vasa deferentia (sperm-ducts), which are straight or coiled tubes of different lengths, usually have cubical ciliated epithelium with well

defined cell boundaries. In *Nais*, *Dero and Uncinais unciniata* the epithelium is very thin. In some cases this epithelium is slightly or strongly glandular. In *Nais elinguis*, *Specaria, Stylaria lacustris*, *Pristina biserrata*, the epithelium is strongly glandular; whereas in *Nais*, *Ophidonais*, *Uncinais* the epithelium is slightly glandular. In *Stylaria* the cytoplasm of the epithelial cells is granular. Sometimes it is difficult to judge, whether the cytoplasm of epithelial cells is slightly granular or not.

In many cases the vas deferens is covered for a shorter or longer part of its length with prostate gland cells, which may be scattered or densely grouped. These cells are spherical or pear-shaped, with vacuolated or granular cytoplasm. They occur in *Nais, Ophidonais*, *Uncinais*, *Specaria*, *Pristina biserrata*, *P. plumaseta*, *P. breviseta*, *P. americana* and *Stylaria lacustris*, but not in *S. fossularis*. The prostate cells are found in combination with faintly glandular wall of vas deferens in most species of *Nais*, *Ophidonais*, *Uncinais* and *Pristina* and with strongly glandular wall in *Nais elinguis*, *Specaria*, *Stylaria lacustris*, and probably *Pristina biserrata*; while the wall is glandular without prostate in *Pristina longiseta* and *P. evelinae* and not or only slightly glandular without prostate in rest of the Naididae whose sex organs are known.

The vasa deferentia join the atria at the top in *Pristina*, *Piguetella*, *Homochaeta*, *Chaetogaster* and *Stephensoniana*, and at various heights in the anterior wall, often immediately above the ejaculatory duct, and in the rest mid-ventrally.

The atria are ectodermal in origin and their ampulla or sac are spherical, sub-spherical, ovoid, pear-shaped, elongate-ovoid and elongated and reflected. Its epithelium is covered by strong muscular layer outside formed by the muscular layers of the body wall. The atria are poorly developed in most *Pristina* and are also large enough to fill the entire segment in *Piguetella* and *Stylaria*. The inner side of the body wall around the atrial opening is often covered with gland cells.

The atrial epithelium is formed of non-ciliated cuboid cells with homogeneous cytoplasm. In many cases it is more or less thick, and the cytoplasm granular or vacuolated, thus giving a glandular appearance. This condition is often combined with the presence of a prostate covering of varying density and extension. The prostate cells have reticulate, basophil cytoplasm containing non-staining vacuoles, similar to those found in vasa deferentia. In very advanced stage a large vacuole, similar to those found in vasa deferentia, is found outside of the nucleus, but only in one specimen, where oviposition had already taken place, was the secretion granular. The epithelium of the atrium and spermduct contains a strongly granular and basophil secretions resembling the secretion found in the atrial lumen. The cells always retain their individuality even at mature stages. The epithelial cells and prostate cells are glandular. There are no direct connection between the prostate cells and the atrial lumen, but their inner ends penetrate the muscular wall, and so it is likely that their secretions escape between the epithelial cells. In *Stylaria*, *Ripistes*, *Arctonais*, *Slavina*, *Vejdovskyella*, *Piguetella* and *Stephensoniana*, where the atrium is covered with

prostate cells, its epithelium is glandular. In *Branchiodrilus*, *Haemonais*, *Dero* (at least in *D. digitata)*, *Aulophorus*, *Chaetogaster*, *Amphichaeta* and probably in some *Allonais*, the atrium is glandular without prostate cells. In *Chaetogaster*, *Amphichaeta* and *Dero*, the epithelium is strongly vacuolated, though not granular.

Thus some part or other of the male efferent apparatus, either with the vas deferens, its prostate, or the atrium, with or without prostate, or a combination of several of these is glandular in all naids, except in *Paranais* and in some *Allonais*, and probably in *Pristinella amphibiotica* and *P. idrensis* which have only vestigial apparatus.

The ejaculatory ducts are normally present at the distal end of atrial ampulla and they are formed of non-glandular epithelium surrounded by the muscle layer and peritoneum. Its epithelium is thicker than that of the atrium and is distinct from it, and also from the epithelium of the body wall where they open to outside. They are well developed and long in *Chaetogaster*, *Amphichaeta*, *Paranais*, *Dero*, some *Aulophorus*, *Branchiodrilus* and *Pristina evelinae*, short and well marked in *Nais*, *Uncinais*, *Ophidonais*, *Haenonais* and most *Allonais*. In most *Pristina*, *Specaria*, *Vejdovskyella*, *Slavina* and *Ripistes* they are conspicuous, but their epithelium does not differ from that of the atrium. In *Haemonais*, *Piguetella*, *Stylaria*, *Arctonais*, *Stephensoniana*, there is hardly any ejaculatory duct, the atrium opening directly outwards. In partially mature *Piguetella* and *Stylaria* the atrium narrows at the bottom, suggesting a duct, and the clitellum-free part of the body round the pore in *Stylaria* (as well as in other species) is slightly pushed inwards, forming a pit. This is also the case in the specimens after oviposition. In mature specimens which have copulated, both the atrial narrowing and the pit disappear and the atrium opens directly outwards at the level of the body-wall. In *Pristinella idrensis* and *Pristina breviseta* the two ducts open together, in the latter into a groove in the body wall. In *Slavina evelinae* they open into a common eversible 'ejaculatory chamber', and in *Specaria* each duct opens into an eversible pocket (Sperber, 1948).

Spermathecae : The spermathecae are ectodermal structures formed by the invagination of the epithelium of the body wall, composed of a proximal voluminous ampulla and a distal narrow duct, where the sperms from the atria of another worm are stored after copulation. In Naididae they are present in all except in *Aulophorus tonkinensis*, *Pristinella amphibiotica* and *P. idrensis*. There is no distinct difference between the ampulla and the duct in *Pristina* (except in *P. americana*; and in *Homochaeta setosa*) the ampulla opens directly outwards. In the rest, the duct is more or less well defined usually with a columnar epithelium. It has a thick muscular coat and investment of scattered peritoneal cells. In *Nais*, the shape of the duct is of taxonomic significance. In *Piguetella, Slavina* and *Vejdovskyella* the duct is usually long. The epithelium of the ampulla is usually flattened. In *Piguetella* and *Haemonais* it is thick and irregular with the inner end of the cells projecting into the lumen. The

ampullae are very long when filled with sperm, extending back into the sperm sac in *Ophidonais*, *Piguetella*, *Stylaria* and some species of *Aulophorus* and *Vejdovskyella*.

In Tubificidae spermathecae are paired in most cases, but single and median in *Monopylephorus* and *Phallodrilus monospemathecsatus,* opening ventrally in the former and dorsally in the latter (Knollner, 1935b). They are absent in *Bothrioneurum* and *Jolydrilus*. In *Tubifex* spermathecal wall is formed of cuboidal cells, a layer of scattered muscle fibres and an outer peritoneal layer (Dixon, 1915). In many species of Tubificidae spermathecal setae are present. In a number of species of Tubificidae the sperms are contained in the atria prior to copulation and within spermatheca after copulation are bundled into spermatophores, which are of characteristic shape and thus of systematic importance (Brinkhurst and Jamieson, 1971). In *Tubifex* the spermatophores are elongate, and in cross section, with an inner central circular lumen or axis around which the sperm heads are arranged with outer coat of sperm tails radiate from the axis in spiral form (Dixon, 1915). The structures attached to body wall containing sperm in *Bothrioneurum* are not homologous to these spermatophores but are sperm bearers or spermatozeugma (Brinkhurst and Jamieson, 1971).

The spermathecal setae are specially shaped setae occurring near the spermathecal pores in genera *Piguetella* and *Pristina*. In the former they are straight, with a nodulus about the middle, and a broader, pointed, slightly bent distal end, where the tip represents the distal tooth, while the proximal tooth is completely reduced or weak. These are situated behind the spermathecae, projecting through the openings of a pair of pockets, surrounded by gland cells. *In Pristina,* in addition to penial setae, the spermathecal setae are also present. The spermathecal setae of *P. longiseta* (Fig. 60 H-s) and *P. breviseta* (Fig. 57 E-s) have very long teeth, meeting at the ends and united by a thin webbing, with the proximal end strongly curved, resembling the penial setae of *P. breviseta* and *Pristinella amphibiotica*. The spermathecal setae of *Pristina plumaseta* are with a simple distal end and a thickening below, resembling the penial setae of *P. americana*. The spermathecal setae are usually situated in front of the spermathecae in VI, but in *P. breviseta* the unpaired seta is situated in VII, to the left of the common spermathecal aperture, from which it projects. The posterior spermathecal setae of *P. evelinae* are also exceptional being in VII, behind the spermathecae. The spermathecal setae of *P. leidyi*, P. *evelinae* occur either in VII or VIII and are very stout, curved with a very thick proximal tooth.

Genital setae : In several species of Microdrili certain setae are specially modified in connection with the reproductive function and these are called genital setae. Those setae close to the male aperture are called penial setae, if elsewhere they are called copulatory setae. They are elongated and often otherwise modified in shape.

In Naididae the ventral setae of the atrial segment disappear during the formation of the clitellum. In most cases new setae called penial setae develop very close to the atrial duct. Rarely special setae are formed in or immediately in front of the

spermathecal segment also, when the common ventral setae of the segment fall out. The penial setae (Fig. 9 D, E, 11 C, 15 D, 18 F, G, H, 24 E, 25 F, 26 E, 27 F, 50 F, 52 E, 53 G, H, 54 D, 55 G, H) are often found on atrial segment. In some species of *Pristina* they may be located one or two segments behind atrial segment. The penial setae, where they occur, the spermathecal setae, are associated with glandular tissue. Genital setae are absent in *Aulophorus* most *Dero*, *Amphichaeta.*

The setal sacs of the penial setae are usually situated medianally to the atrium, and the setae penetrate the body wall immediately behind, or sometimes in front of the pocket into which the latter opens. The muscles of the setal sacs are numerous and strong. The setae usually point more or less forwards, with the hook pointed upwards. In *Vejdovskyella comata*, it is probable that they function as penes during copulation, being inserted into the openings of the spermathecal ducts, uniting the animals so that the sperms can flow along them, with their hooks. When spermathecae open laterally, as in *Specaria*, this is rendered impossible, so presumably the setae anchor in the body wall at a convenient level (Sperber, 1948).

The type of penial setae vary considerably. In *Paranais simplex*, *P. frici* and *Homochaeta setosa* they wholly resemble ordinary ventral setae. In these they apparently represent the initial stage in the transformation from the ordinary setae. Mostly, they are considerably larger, thicker and straighter than ordinary setae, often with an inconspicuous, markedly distal nodulus, with reduced distal prong. Transitional forms occur in *Haemonais waldvogeli* and *Paranais botniensis*, where the penial setae are larger and straighter, but not thicker than the ordinary setae, with a conspicuous, though strongly distal nodulus and two teeth about equally strong. In *Dero dorsalis* (Chen, 1940) and *Stephensoniana trivandrana* (Aiyer, 1929a) (Fig, 55 G, H), the distal tooth is much reduced. In both these, setae are also thicker than the common setae with inconspicuous nodulus, and in the latter both teeth are usually blunt. The most common type, where the distal prong is wholly reduced, occurs in *Chaetogaster* (Fig. 9 D, E, 11 C), *Nais* (Fig. 15 D, 18, F-H), *Ophidonais*, *Uncinais*, *Allonais* (Fig. 50 F, 52 E, 53 G, H, 54 D), *Stylaria* (Fig. 25 F), *Arctonais*, *Ripistes*, *Slavina* (Fig. 24 E), *Vejdovskyella*, *Specaria*, *Branchiodrilus* (Fig. 27 F) and *Paranais littoralis*. However, in some *Nais*, a small distal tooth may occur. It is thus obvious, that these penial setae have developed from normal ventral setae, as is evident from the developmental series from normal ventral setae of *Paranais.*

In addition to the more normal and widely occurring penial setae, there are three other types which are strictly exclusive. *Dero asiatica* (Cernosvitov, 1930b) has the penial setae which is quite straight, without nodulus, and of the simplest possible type. The other types occur in *Pristina* and *Pristinella.* The penial setae of *Pristinella amphibiotica* and *Pristina breviseta* (Fig. 57 D) have very long teeth, meeting at the ends and united by a thin webbing, the proximal end is strongly curved. The penial setae of *Pristina americana* and *Pristina plumaseta* are slightly bent with a simple

distal end and a thickening below it. The penial setae of *P. americana* and *P. plumaseta* are situated in VIII, behind the atria, while the only, unpaired seta of *P. breviseta* lies in front of the atria either posteriorly in VII, or anteriorly in VIII, a little to the right. The exact position of the penial setae in *Pristinella amphibiotica* is not known, but they lie in VIII.

In *Pristina breviseta* there are two glands, each surrounding a single penial seta, which emerges on the surface through the opening of the gland. Each gland is pear-shaped and is composed of elongated cells arranged so as to leave a small central cavity in the ectal part of the gland. The gland is partly covered by a muscular coat from the muscles attached to the base of the penial seta, which projects into the body cavity beyond the base of the gland (Sperber, 1948).

The genital setae in *Pristina* usually occur in connection with special glands, which either surround them, lie immediately behind them, or surround on independent pocket, from which the setae project; mixed forms are also found. The result of this is that the setae always project more or less perpendicularly from the wall.

Naididae : The male genital organs consist of a pair of testes of irregular shape attached to the posterior face of the septum 4/5 on either side, and male funnels on anterior face of 5/6 in V, with a pair of atria in VI. The male funnels are cup-shaped, often deformed by the pressure of sperm-sacs, and in some cases extend into them. A pair of vasa deferentia of varying length open into a pair of atria at different positions from the apical to the proximal end. The atria are spherical or elongated sacs communicating with the exterior by narrow ejaculatory ducts. True penes appear to be absent, but in *Slavina evelinae*, the ejaculatory ducts open into a common eversible chamber (Marcus, 1944), which is considered as pseudo-penis by Brinkhurst (1965b). Generally prostate cells are pear-shaped, cover either whole or part of vasa deferentia, or the atrial wall. In Naididae two morphologically distinct types of prostate cells may be present; atrial prostate derived from the atrial lining, and prostate associated with the vasa differentia with mesodermal structure. Associated with reproduction but of uncertain function, some naidids possess ventrally situated glandular tissue in some pre-genital segments. Marcus (1943) described these ventral glands, termed as accessory copulatory glands, as containing ten to twenty pear-shaped to elongate cells containing secretory material, their ends formed part of body wall in the mid-ventral line.

In most species the testes break up and disappear completely at a very early stage, before any of the other reproductive organs except the ovaries and the first rudiments of the spermatogonia are formed. But in some specimens of *Stylaria*, they persist for a long time even after the copulation although large, spermatogonia are not seen. In *Pristina logiseta* and *P. evelinae*, testes are active till copulation takes place.

All Naididae except *Pristinella amphibiotica, P. idrensis* and *Aulophorus tonkinensis,* possess spermathecae. They have proximal spherical ampulla and distal narrow ducts. True spermatophores are not reported in this family (Sperber, 1948), but some degree of bundling of sperms occur in *Stylaria*, *Ophidonais* and *Piguetella*.

In Naididae a pair of ovaries are pear-shaped with definite outline, attached to the posterior face of the vestiges of septum 5/6 on either side and attached to the ventral nerve cord and surrounded by connective tissue and stretch back through the whole segment. They always persist much longer than the testes and they are often found in fully mature worms, which have already copulated. The ovaries are easier to find than the testes, as they develop more slowly and persist longer.

In *Chaetogaster*, genital organs are formed while fission is going on, and sperms and ova are found in the posterior zooid also.

Tubificidae : A pair of testes on posterior face of 9/10. Ciliated male funnels are on anterior face of septum 10/11, from each of which vasa deferentia continues backwards in XI and enter atria. Ciliated male funnels on 10/11, vas deferens, sometimes short as in *Ilyodrilus*, often long, coiled and enter into wider atrium. Atrium continues into short or long ejaculatory duct opening by male pores on XI. Sperm-sacs (seminal vesicles) are outpouchings of septum 10/11 which extend posteriorly for several segments. In many cases a forward bulging of septum 9/10 produces an anterior sperm-sac which occupies IX. In species with prostate glands, the atrial lining from which the prostate tissue is derived is usually thin, (Hrabe, 1939a), but in *Clitellio arenarius,* which has no prostate glands, the atrial lining is thick and may itself perform the function of prostate glands. The prostate glands are composed of pear-shaped cells, their ends penetrate the wall of atria and cover the atria diffusely, as in *Rhyacodrilus*, or, commonly localised to one part of atrial surface as an organ. In *Tubifex* the prostate gland is a sub-spherical connected to the atrium close to vas deferens by a narrow stalk. In *Telmatodrilus* a number of prostate glands are arranged along the tubular atrium (Eisen, 1879, Brinkhurst, 1965b). Generally the atria are of variable form, tubular communicating to exterior by a simple pore or in a modified penis. The penis is formed of the folds of body wall together with the cuticle. In some species the penial cuticle is thickened, to form penis sheath, reaching its maximum development in some species of *Limnodrilus*, where the penis is a very thick cuticular tube. In some tubificids another type of organ, pseudo-penis formed of a simple invagination of the body wall, is capable of eversion (Brinkhurst, 1965b). In *Bothrioneurum* a bulbous paratrium opens into a common chamber with tubular atrium. In *Branchiura* an atrial diverticulum, different in structure to the paratrium of *Bothrioneurum* is present. Ejaculatory ducts may end simply on the surface of body, or a penis may be present. Penis is protrusible as a whole. Penis may be of two types, in one type true penis, which is a permanent structure, tubular or conical projection of terminal part of the ejaculatory duct formed by the invagination of the

surface of body. The other type is pseudo-penis, which is a temporary structure produced by the evagination of the ectal part of atrium and disappearing altogether after functioning. The outer epithelium derived from the surface of body, of the true penis, secretes a layer of thin or thick and firm chitinous penis sheath in *Limnodrilus.* Male ducts unite to open by a single aperture in the middle in *Bothrioneurum* and *Monopylephorus.*

Ovaries are a pair situated on posterior face of septum 10/11. An ovi-sac is formed by backward bulging of septum 11/12, as in Naididae, its anterior part containing sperm-sac, so that ova are confined to hinder part of ovi-sac. Female funnels are situated on the anterior face of septum 11/12, continue as short and narrow oviducts, leading immediately downwards to reach surface furrow 11/12.

Spermathecae are ectodermal structures formed by the invagination of the epithelium of body wall, and consists of a voluminous ampulla and a distinct narrow duct. They are paired in most cases and lateral, but single and median in *Monopylephorus parvus* and *Phallodrlus monospermathecatus,* opening ventrally in the former, their place taken functionally by the characteristic spermatophores (Moore, 1905) and dorsally in the latter. They are simple sacs, where sperms from the atria of another worm are stored. They are absent in *Bothrioneurum* and *Jolydrilus.* Spermathecal setae, modified ventral setae of spermathecal segment occur in many tubificid species (Brinkhurst and Jamieson, 1971). They are located in testes segment, and may, as sometimes as in the Naididae, extend backwards for some segments, more often they are confined to one segment. Their apertures are united in the median line in some species.of *Rhizodrilus*. Penial setae, modified ventral setae of XI, are often found.

The genital organs do not always occupy the above position. In *Aulodrilus,* they are shifted, according to the species, and in *Ilyodrilus bedoti,* two segments forwards, while in *Limnodrilodes pectinatus* some specimens have the sexual organs two segments further forwards than normal. Pair of ovaries and female funnels in atrial segment, and a pair of spermathecae in the testicular segment. Sperm- and ovi-sacs are developed as posterior, and often anterior pouchings of the septa of gonadial segments. Penial setae are found in many species in *Tubificidae*, which are associated with glandular tissue (Smith, 1900b, Mehra, 1922) and located on the atrial segment.

Lumbriculidae : In this family the genital organs are diverse and vary in number, position and arrangement. The atria are located in VII to XIV segments. This family exhibits two types of male systems, both of which are unique in Oligochaeta in that one pair of testes and their associated atria occur in the same segment (Cook, 1968). In *Lumbriculus variegatus*, one to four pairs of testes and one to two pairs associated with each pair of atria are present. Male funnels occur on posterior septum of last testicular segment. Vasa deferentia are ciliated elongated tubes opening apically into atria. The atria are paired into which prostate cells empty their secretions. The atria

end in narrow ducts opening to exterior either by simple pores or through penes. Penial and spermathecal setae are absent, but at full maturity ventral setae of genital segments are lost. Usually one pair of ovaries is present, but some species of *Lumbriculus* and *Styloscolex* have two pairs. Spermathecae number one to five pairs, composed of large ampullae and narrow ducts, located in front of, behind, or within, the atrial segment. Spermatophores are absent in this family. (Brinkhurst and Jamieson, 1971).

Phreodrilidae : In this family paired testes and ovaries occur in XI and XII segments respectively. A pair of vasa deferentia are located in the ovarian segment. Paired ovaries and female funnels are located in the atrial segment. Spermathecae variable in number, but normally 2 to 5 pairs occur, usually beginning two segments behind last atrial segment, opening by simple pores ventro-laterally.

The accounts of genital organs of Aelosomatidae are provided by Bunka (1967), Ax & Bunke (1967); of Naididae are provided by Vejdovsky (1884a), Stephenson (1915c, 1926a), Mehra (1924, 1925), Mayhew (1922), Stolte (1933), Turner (1935), Marcus (1943), Sperber (1948), Naidu (1962a, b, 1963a, b); and detailed accounts of genitalia of Tubificidae are presented by Beddard (1892), Goodrich (1895), Benham (1903), Nomura (1913, 1915), Dixon (1915), Gatenby (1916), Hrabe (1935, 1939a,b), Cernosvitov (1939a), Naidu (1965a), Jamieson (1968) and Brinkhurst and Jamieson (1971), Qi Sang (1992); of Lumbriculidae by Cook (1968), Brinkhurst and Jamieson (1971), Hrabe (1927, 1939a,b), Altman (1936), and Isossomoff (1962); of Phreodrilidae by Beddard (1891, 1894), Michaelsen, (1913 a, b), Benham (1904), Goddard, 1909a, b)), Goddard and Malan (1913a, b), Stephenson (1930), Jackson (1931) Stout (1958), Brinkhurst (1965b) and Brinkhurst and Jamieson (1971).

ASEXUAL REPRODUCTION

Majority of the Microdrili that reproduce asexually divide by paratomy (by formation of budding or fission zones) as in Aeolosomatidae, most Naididae, *Opistocysta flagellum*. Architomy or fragmentation occurs in some Naididae (3 species of *Slavina, all species of Allonais*); in Tubificidae (3 species of *Aulodrilus*, 2 species of *Bothrineurum*) in Lumbriculidae (*Lumbriculus variegatus*).

The paratomy is the most common mode of reproduction in Aeolosomatidae and Naididae. Sexual individuals in these two famlies are comparatively rare and in some genera, they have not been described. In most of the Naididae and Aeolosomatidae when individuals are fully grown in the ordinary process of growth by the addition of segments at the hind end 'a budding zone' or 'fission zone' is formed about the middle of the animals. The separation of the individuals ultimately takes place through this zone, and the newly formed segments in front of the line of division form the hind segments of anterior worm, while those behind the line of division form the head

segments of the posterior worm. The position of the fission zone, is definite for each species and the number of segments in front of the fission zone is denoted by 'n' Also the number of segments the fission zone buds off to the head of the posterior zooid is always constant for each species, it is commonly five in the Naididae, but the number of segments which are budded off to the tail of anterior zooid is indefinite. Often a new fission zone begins to form in one or both the components of the chain of two zooids before they separate, thus forming chains of three or four. Sometimes formation of more new fission zones may take place further and produce chains of six or even eight zooids. The whole chain is coordinated with regard to movement, circulation, peristaltic and anti-peristaltic contractions of the intestine, but the hinder zooid begins to show independent muscular contractions before separation, while the anterior zooid remains motionless. The above process of asexual reproduction is also called budding, an advanced mode of fission called paratomy, and the individuals so produced are called 'buds' or zooids.

When individuals divide without previous production of new segments into two is called fragmentation, a primitive mode of fission called architomy and the two fragments produce the new segments at the tail end of anterior fragment and head segments of the posterior fragment.

Types of fission : The fission can be divided into slow and rapid types. The slow type of fission occurs in *Dero* and *Aulophorus*, the individuals when separated do not show signs of another fission zone, as a period of growth follows, and when sufficient length is attained another fission zone develops. In all other Naididae (except in *Allonais*) a new fission zone appears in front of the segment produced in the earlier fission zone, even before these are still in embryonic stage, and this method is the rapid type of fission.

The rapid type is further subdivided into two types : (a) *Pristina* type as seen in *Nais*, *Chaetogaster*, *Aeolosoma* in which new fission zone develops at the anterior limit of earlier produced fission zone, behind exactly the same number of segment from the front end of the worm as the first zone, 'n' being same in both cases. Thus the second individual contains no segments of the original worm and is composed of entirely new segments. (b) *Stylaria* type in which the new budding zone develops behind segment n-1 of the original worm, containing one segment only of the original worm to form the second individual. This is repeated, the next budding zone forming behind segment n-2 of the original worm, and the next budding zone behind n-3, each new individual containing one segment of the original worm, and the diminution of the n cannot go on indefinitely as there is a lower limit to n in *Stylaria*, which is 14-17. When this limit is reached the anterior individual elongates by growth of the hinder end in the usual way till the total number of segments is more than 40; then a new fission zone is intercalated in the middle. This form is also found in *Pristina* in which the lower limit is 12, and when it is reached the position of the zone jumps

backwards, three, two or one segment. Rarely a worm with the *Pristina* type of fission shows the *Stylaria* type, and one of the *Stylarian* shows the *Pristinian* type.

In *Pristina* type, when chains of considerable lengths are formed the two primary components of the chain are called A and B, A being the anterior and B the posterior. The hinder part of A grows by production of new segments, and a second fission appears at the anterior end of newly formed part, thus limiting an individual C between A and B, and if the division of the chain is further delayed, a fission zone may be formed in the hinder part of B, marking off a posterior component of the chain, D. If the growth proceed further in the region in front of C (i.e., in the hindermost end of A), an individual E is marked off, composed entirely like C of new segments (not including any of the original segment of A); a sixth individual F, may be produced between C and B by the formation of a fission zone in C. The group B + D is the first to detach itself, growth continues on the same lines, and groups of two zooids continued to be liberated.

In *Chaetogaster*, after formation of the components A, B, C, D, formation of further individuals is different. In *Chaetogaster diaphanus*, the fourth and fifth fission zones, delimiting the components E and F occur in D and C components respectively. The fourth fission zone, marking off F, is the hinder part of B, in front of D, the fifth marking off F, is in the hinder part of A, in front of E, the sixth marking off G, is again in the hinder part of A in front of the last.

In *Aeolosoma viride* the series of fission zones appear in regular sequence from behind forwards; the second fission zone forming some distance in front of the first, the third a short distance in front of the second, etc., so that in a chain of six individuals, the most anterior and the most posterior, A and B are the oldest, C is immediately in front of B, D is in front of C, etc., F is the youngest being behind the oldest A.

Occasionally, reabsorption of fission zones occurs after the formation of fission zone. In sexual individuals of *Chaetogaster* Semper (1877) found the fission zones become indefinite in contour, and the rudiment of the oesophageal ring disappears; the newly produced setae remain, so that the sexual *Chaetogasters* were found with as many as 22-24 seta-bearing segments, many more than usual. He found that no such re-absorption occurring in *Nais.* In unfavourable conditions, in *Pristina*, if the development of fission zone has not gone too far, it may be re-absorbed; and it may reappear again at the same or another level in favourable conditions.

CLASSIFICATION

Brinkhurst and Jamieson (1971) recognised 3 orders based on reproductive system and ancillary somatic characters: Haplotaxida, Lumbriculida and Moniligastrida, excluding Aeolosomatidae from oligochaetes for various anatomical reasons.

Timm (1981) proposed the following classification :

Class	CLITELLATA
Subclass	APHANONEURA
Order	AEOLOSOMATIDA
Family	AEOLOSOMATIDAE
Family	POTAMODRILIDAE
Subclass	OLIGOCHAETA
Superorder	NAIDIMORPHA
Order	TUBIFICIDA
Family	TUBIFICIDAE
Family	NAIDIDAE
Family	PHREODRILLIDAE
Family	LYCODRILLIDAE
Family	OPISTOCYSTIDAE
Family	ENCHYTRAEIDAE
Superorder	LUMBRICOMORPHA
Order	LUMBRICULIDA
Family	LUMBRICULIDAE
Family	DORYDRILIDAE
Order	HAPLOTAXIDA
Family	HAPLOTAXIDAE
Family	ALLUROIDIDAE and many mainly terrestrial families of earthworms.
Order	MONILIGASTRIDA
Family	MONILIGASTRIDAE
Order	BRANCHIOBDRILLIDA
Family	BRANCHIOBDELLIDAE
Subclass	HIRUDINA

Of these two classifications, Timm's (1981) classification is more comprehensive, hence it is followed in this work.

SYSTEMATIC SECTION

Aquatic oligochaetes are divisible into two subclasses: Subclass Aphanoneura and Subclass Oligochaeta (Timm, 1981).

Subclass APHANONEURA

Diagnosis : Minute worms of 1-2 mm long, chains of individuals formed by budding zone much longer. Both dorsal and ventral bundles with hair setae. Locomotion by gliding motion using ventral ciliation of prostomium. Body wall with refractile or coloured epidermal glands. Septa absent. Pharynx without eversible roof. Nervous system ladder type attached to epidermis. Asexual reproduction by budding or fragmentation and regeneration. Hermaphrodites, testes one to several pairs. Ovaries single or a pair. Clitellum absent.

Subclass Aphanoneura comprises of two familes Aeolosomatidae and Potamodrlidae. Aeolosomatidae with three genera: *Aeolosoma* Ehrenberg, 1828, *Hystricosoma* Michaelsen, 1926 and *Rheomorpha* Ruttner-Kolisko, 1955, and Potamodrlidae with single genus *Potamodrilus* Lastockin, 1935.

Order AEOLOSOMATIDA

Family AEOLOSOMATIDAE Beddard, 1895.

Aeolosomatidae Beddard, 1895 : 176; Stephenson, 1923 : 40; 1930 : 722; Naidu, 1961b : 645; Chekanovskaya, 1962 : 142; Brinkhurst & Cook, 1966 : 20; Brinkhurst & Jamieson, 1971 : 665; Mukhopadhyay, 1998 : 98.

Diagnosis : Small mostly asexually reproducing worms; upto 10 mm long, but generally much smaller. Small number of segments (upto 17 in the first zooid). Prostomium cilitated ventrally. Eyes absent. Epidermis with numerous glands, part of which generally have vacuoles with refractile and most often with coloured contents. Inter-segmental furrows present in some species only. Setae in four bundles per segment or absent in *Rheomorpha*; each bundle with an indefinite number of hair and needle setae (the latter occur only in part of the species and they may be restricted to the ventral or posterior bundles). A muscular ciliated pharynx in I, a simple oesophagus from II-III, IV or V Anterior part of intestine dilated. Septa absent in most species. Commissural vessels mostly absent. Two nephridia may occur in each segment, but usually several absent. Cerebral ganglion, pharyngeal commissures and ventral nerve cord attached to body wall. Copulatory gland ventrally in middle or posterior part of body. Two to five pairs of spermathecae in anterior half of body. Functional testes in 2 to several segments may be both anterior and posterior to ovaries, spermatogenesis free in body cavity, two to several nephridia which are not at all or nearly or only slightly differentiated, act as male ducts. One or two functional ovaries in mid-body; one median female pore in the middle of copulatory gland. In fresh water and brackish water, rarely terrestrial. Cosmopolitan.

Type genus : *Aeolosoma* Ehrenberg, 1831.

This family has three genera: *Aeolosoma* Ehrenberg, 1831; *Hystricosoma* Michaelsen, 1926 and *Rheomorpha* Ruttner-Kolisko, 1955. Of these *Aeolosoma* alone occurs in the subcontinent.

Genus ***Aeolosoma*** Ehrenberg, 1828.

Aeolosoma Beddard, 1895: 176; Stephenson, 1923: 40; 1930: 725; Marcus, 1944: 8; Bunke, 1967: 190; Naidu, 1961b: 647; Chekanovskaya, 1962: 143; Brinkhurst & Jamieson, 1971: 666; Mukhopadhyay, 1998: 99.

Type species : *Aeolosoma hemprichi* Ehrenberg, 1828.

Diagnosis : Very small to relatively vary large species (chains of about 1-10 mm). Eyes absent. Prostomium not separated from the body by well defined groove, semi-circular, flat with or without lateral sensory ciliated pits. Refractive or coloured epidermal glands generally present. Inter-segmental furrows mostly absent. Setae present including needle setae in several species. Septa mostly absent. Pharynx funnel-shaped, oesophagus narrow, stomach conspicuous, intestine wide, blood colourless, commissural vessels present in some species only. Two nephridia per segment in large species. Two to five pairs of spermathecae, each consisting of one cell, in anterior half of the body, functional testes in several segments. Normal nephridia of posterior half of body act as male ducts. One functional ovary in mid-body. Free living in fresh and brackish water, rarely terrestrial. Cosmopolitan.

Key to Indian species of Genus *Aeolosoma*

1. Setal bundles with long, thin, flexible hair setae in all segments and short, stiff sigmoid setae in posterior bundles 2

– Sigmoid setae absent 3

2. Sigmoid setae 30-35 μm long with very thin distal point with 2 rows of 10 minute teeth on concave border of distal end, epidermal glands colourless ..... *Aeolosoma travancorense*

– Sigmoid setae smooth, distal end sharply bent; epidermal glands colourless or absent ..... *Aeolosoma beddardi*

3. Body 200-300 μm wide, hair setae upto 250 μm long..... *Aeolosoma viride*

– Body less than 200 μm wide 4

4. Epidermal glands colourless 5

– Epidermal glands coloured 6

5. Fission zones after VI or VII, rarely after VIII; body width about 80 μm ..... *Aeolosoma niveum*

– Fission zone after IX or X, rarely after VIII, body width about 80-130 μm .... *Aeolosoma hyalinum.*

6. Small body, 40-100 μm wide; epidermal glands orange red or dark red without satellite cell; fission zone after VII or VIII, mostly after VII ....*Aeolosoma hemprichi*

– Medium size body, 150-200 μm wide; epidermal glands green, yellowish green or bluish-green with satellite cell; fission zone after IX-XI, mostly after X..... .....*Aeolosoma headleyi*

Aeolosoma beddardi Michaelsen, 1900
(Fig. 1)

Aeolosoma beddardi Michaelsen, 1900 : 14; Naidu, 1961b : 648.

l(p.) = 0.5-1.0 mm; d(p.) = 0.05-0.07 mm; s = 10-12; n = $\dot{6}$ (rarely 5).

Description : Worms minute, slender, delicate and transparent. Prostomium semicircular, flat, slightly wider than peristomium, with tactile cilia of about 8 μm long around margin. Ciliated pits round, connected with ventral ciliated field.

Fig. 1 : *Aeolosoma beddardi.* Needle Seta.

Epidermal refractile glands scanty, more on prostomium and anal segment, mostly colourless and a few light orange or greenish yellow, some times refractile glands absent. Dorsal and ventral bundles with bayonet-shaped hair setae of two lengths and sigmoid needle setae (Fig. 1). Longer hair setae 1-2, 100-130 μm long, shorter hair setae 2-3, 50-70 μm long and needle setae 1-3 per bundle, 30-48 μm long.

Buccal cavity in I, wide. Pharynx in II, wide. Oesophagus in III, narrow. Stomach in IV-VI wide. Intestine from VII, narrow. Brain nearly twice as broad as long, deeply incised behind and nearly straight in front. Blood colourless. Dorsal and ventral vessels mid-dorsal and mid-ventral respectively. Lateral commissural vessels absent. First nephridium in II or III behind setal bundle.

Asexual reproduction by paratomy. Sexual worms not known.

Habits : Fresh water. Worms glide with the help of ventral cilia of the prostomium. Swimming absent.

Distribution : India : Palghat, Malapuza Dam area (Kerala). Chittoor, Horsley hills, Vizianagaram (Andhra Pradesh).

World distribution : China (Asia); England (Europe); Lousiana (North America); Surinam, Argentina (South America);

Aeolosoma headleyi Beddard 1888.
(Fig. 2)

Aelosoma headleyi Beddard 1888 : 213.

Aeolosoma bengalense Stephenson, 1911: 204; 1923: 41; Aiyer, 1926 : 131; 1929a : 18; Naidu, 1961b: 648; 1966 : 209; Costa, 1967 : 39; Naidu & Srivastava, 1980 : 261; Naidu & Naidu, 1981a : 526; Singh, 1989 : 274; Mukhopadhyay, 1998 : 99.

Aeolosoma sp. Aiyer, 1926 : 131.

Aeolosoma headleyi, Vasisht, 1981 : 74; Vasisht. & Jhingran, 1982 : 51; Vasisht. 1984 : 23.

Type locality : England.

l(p.) = 1.0-1.5 mm; d(p.) = 0.2-0.3 mm; s = 12-14 + undifferentiated region; n = 11-13.

Description : Worms (Fig. 2 A) of medium size, slender, delicate, transparent and whitish. Prostomium (Fig. 2 B, C) thin. flat, semi-circular, wider than succeeding segments, about equal to widest diameter of body, mobile, with stiff sensory cilia around margin and with ventral ciliation and two small dorso-lateral ciliated sensory pits (Fig. 2 B-cp). Body-wall transparent, colourless, with epidermal glands (Fig. 2 B-eg, D) of usually yellowish-green, frequently yellow, bluish green, rarely brownish yellow, usually spherical but frequently irregular in shape, being specially numerous on dorsal surface, and on ventral surface they are confined to margin. Dorsal and ventral bundles of setae (Fig. 2 A-sb, E) begin in II composed of bayonet-shaped hair setae of two lengths, long and short, non-serrate, 1-3 long hair setae 250-350 μm long and 2-4 short hair setae 100-140 μm long dorsally; and 2-3 long hair setae 200-220 μm long and 2-5 short hair setae of 100-130 μm long ventrally.

Mouth (Fig. 2 C-m) ventral U-shaped. Pharynx in II funnel-shaped. Oesophagus in III, narrow and wavy. Stomach in IV-VIII, barrel-shaped, wide, and deep orange

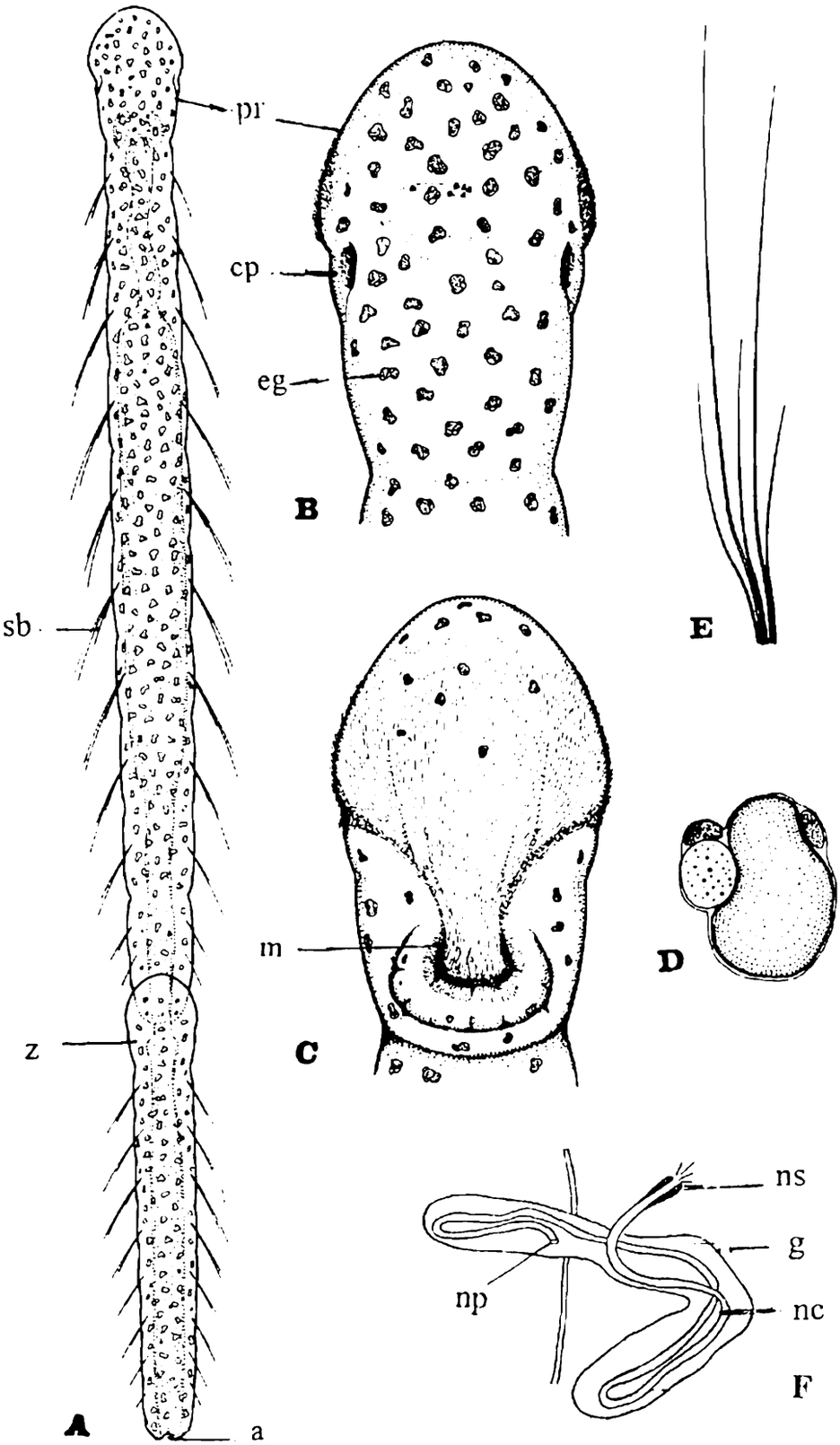

Fig. 2 : *Aeolosoma headleyi.* A : General view of worm; B, C : Dorsal and ventral view of prostomium; D : Epidermal gland; E : Bundle of setae; F : Nephridium. (A-E from Bunke, 1967). a : anus; cp : ciliary pit; eg : epidermal gland; g : glandular part; m : mouth; nc : nephridial canal; np : nephropore; ns : nephrostome. pr : prostomium; sb : setal bundle; z : zooid.

in life. Intestine begins in IX, narrow and straight ending in anus (Fig. 2 A-a) in last segment. Septum between I and II complete, other septa incomplete. Brain transversely elongated, rounded on either side, with a slight concavity in front and behind. Blood colourless. Dorsal vessel mid-dorsal contractile, blood flowing behind forward, divides into two, over buccal funnel behind brain, descends on either side of oesophagus, and unite to form ventral vessel in II, in which blood flows from anterior to posterior. Ventral vessel gives off in each segment a pair of small branches to nephridia. First pair of exonephric meganephridia in II, and last pair in IX or X. Each nephridium (Fig. 2F) has a minute funnel with ciliated nephrostome (Fig. 2 F-ns), followed by a long coiled ciliated canal (Fig. 2 F-nc) passing through glandular mass (Fig. 2 F-g) and opening to exterior by a nephropore (Fig. 2 F-np) ventro-laterally. Cilia in nephrostome and nephridial duct beat down the lumen.

Sex organs not known. Asexual reproduction by paratomy. Worms with 1-4 budding zones common. Some hind segments to anterior individual, and a prostomium and some anterior segments to posterior individual budded off by fission zone before separation. As first budding zone proliferates segments to both the individuals, second, third and fourth budding zones develop, second zone in front of first, third zone behind first and fourth zone anterior to second zone.

Habits : Worms are found among roots of *Eichhornia crassipes*. Swimming absent. Worms glide along on substratum like a Turbellarian with help of ventral ciliation of prostomium.

Parasites : Astomatous ciliate (Protozoa) *Radiophryoides aelosomatis* de Puytorac, 1957 is parasitic in the gut of this species (de Puytorac, 1959).

Remarks : As stated by Land (1971) *Aeolosoma bengalense* described by Stephenson, (1911) does not show any essential differences with the description of *Aeolosoma headleyi* Beddard, 1888 and so the Indian species is treated here as *A. headleyi*.

Distribution : India : Trivandrum, Palghat, Malapuza dam area (Kerala); Chittoor, Horsley Hills, Tirupati, Tirumala, Cuddapah, Gudur, Warangal, Hyderabad (Andhra Pradesh); Bangalore, Mysore (Karnataka); Mumbai, Vehar Lake, Nagpur (Maharashtra); Delhi; Chandigarh; Kolkata (West Bengal). Maha Oya near Peradeniya (Sri Lanka).

World distribution : Asia, England, Germany, Rumania, Poland (Europe); Canada (North America); South America.

Aeolosoma hemprichi Ehrenberg, 1828.
(Fig. 3)

Aeolosoma hemprichi Ehrenberg, 1828 : 121; Stewart, 1908 : 363; Stephenson, 1909a : 106; 1909b : 277; 1909c : 53; Michaelsen, 1910 : 7; Stewart, 1911 : 69; Stephenson, 1913a : 743.

Aeolosoma kashyapi, Stephenson, 1923 : 41; Aiyer, 1926 : 138; 1929a : 18; Cernosvitov, 1942b : 281.

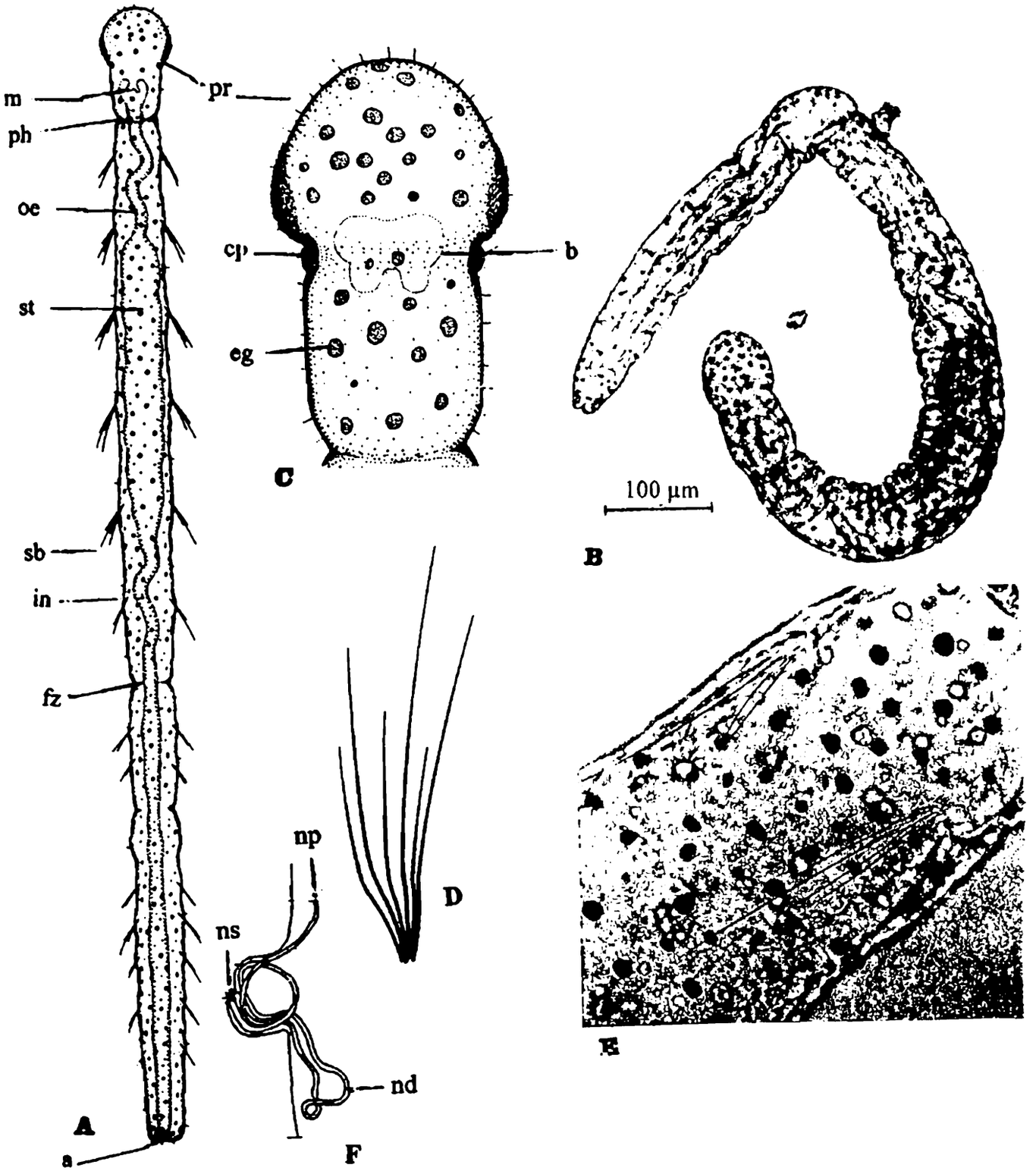

Fig. 3 : *Aeolosoma hemprichi.* A, B : General view of worm; C : Prostomium; D : Setal bundle; E : Dorsal setal bundle; F : Nephridium. (A-E from Bunke, 1967). a : anus; b : brain; cp : ciliary pit; eg : epidermal gland; fz : fission zone; in : intestine; m : mouth; nd : nephridial duct; np : nephropore; ns : nephrostome; oe : oesophagus; ph : pharynx; pr : prostomium; sb : setal bundle; st : stomach.

Aeolosoma hemprichi, Naidu, 1961b : 650; 1966 : 209; Costa, 1967 : 38; Vasisht & Gandhi, 1972 : 99; Sharma, Handa & Sahi, 1976: 104; Naidu & Naidu, 1979b: 411; 1981a : 527; Battish & Sharma, 1997 : 81.

Type locality : Unassigned, in Germany.

l = 0.6-2.0 mm; d = 0.05-0.10 mm; s =12-13 + undifferentiated region; n = 7, rarely 6 or 8.

Description : Worms (Fig. 3 A, B) minute, colourless, transparent. Prostomium (Fig. 3 C) flat, rounded or slightly triangular, wider than following segments with stiff cilia, upto 10 μm long, ciliated fields restricted to ventral surface or with small dorso-lateral continuations, ciliated sensory pits (Fig. 3 C-cp) round, about 10-15 μm in diameter. Its margin highly mobile, constantly curling up and down as worm glides on substratum. Epidermal glands (Fig. 3 C-eg) globular, orange to dark red without satellite cell, upto 10 μm in diameter, present all over body evenly distributed except on ventral surface of prostomium and portions near hind end of body. Dorsal and ventral bundles (Fig. 3 A-sb, D, E) with bayonet-shaped hair setae, unequal in small specimens, sometimes sub-equal, 2-6 (8) per bundle; short setae 1-3 per bundle, 35-80 μm long, long setae 0-3 (4) per bundle, 70-120 μm long.

Mouth semi-circular, with a thick ciliated rim. Pharynx (Fig. 3 A-ph) short, funnel-shaped in II; osesophagus (Fig. 3 A-oe) narrow in III, stomach (Fig. 3 A-st) barrel-shaped, wide, brownish in IV-VI; intestine (Fig. 3 A-in) narrow and sinuous from VII. Food particles rotate in gut. Brain (Fig. 3 C-b) dumb-bell shaped. Dorsal vessel contractile, mid-dorsally attached to gut, dividing anteriorly into 2, branches uniting into a non-contractile ventral vessel below pharynx. Nephridia (Fig. 3 F) 2 per segment from II or III to IX, each nephridium a long coiled duct (Fig. 3 F-nd) with a ciliated funnel-shaped nephrostome (Fig. 3 F-ns) anteriorly opening into coelom, duct attached to gut and ending in nephropore (Fig. 3 F-np) opening to outside ventrally. Copulatory glands in IV/V or V/VI; spermathecae upto 3 pairs in II-IV.

Worms with 2-4 fission zones (Fig. 3 A-fz) common.

Habits : Moves about by swimming and creep about with help of ventral ciliation of prostomium.

Chromosomes : 2n = 56 (Sharma, Handa & Sahi, 1976).

Parasites : Astomatous ciliate (Protozoa) *Radiophryoides komareki* Lom, 1956 (Lom, 1956) and *Radiophryoides maupasi* (Cepede, 1910) are parasitic in gut of this species (Heidenreich, 1955).

Distribution : India : Trivandum, Chirayinkil, Nagarkoil (Kerala); Chittoor, Tirupati, Tirumala, Srikalahasti, Cuddapah, Nayudupeta, Gudur, Vijayawada, Kakinada, Warangal, Hyderabad (Andhra Pradesh); Bellary (Karnataka); Mumbai, Vehar Lake (Maharashtra); Chandigarh; Punjab; Haryana; Srinagar (Jammu & Kashmir). Gyant-se (Tibet); Lahore (Pakistan). Kandy, Galle, Peradeniya (Sri Lanka).

World distribution : Cosmopolitan

Aeolosoma hyalinum Bunke, 1967
(Fig. 4)

Aeolosoma hyalinum Bunke, 1967 : 260; Joseph & Hanumantharao, 1980 : 31; Naidu, Kalpana & Sureshkumar, 1981 : 104.

Type locality : Bremon, Germany.

l(p.) = 0.5-1.0 mm (single), 2 mm (chain of 4 zooids); d(p.) = 0.1-0.2 mm; s = 13-15; n = 8-10.

Description : Worms (Fig. 4 A) minute, delicate, slender, transparent. Prostomium (Fig. 4 A-pr, B) bluntly triangular to semicircular, wider than succeeding segments; stiff, tactile cilia on margin upto 9 μm long, with several ciliated fields on ventral surface; sensary ciliary pits (Fig. 4 B-cp) circular, upto 12 μm in diameter, separated from ventral fields. Refractile epidermal glands (Fig. 4 C), colourless, upto 14 μm in diameter with satallite cells, sometimes these glands absent. Dorsal and ventral setal bundles (Fig. 4 A-sb, D) begin in II with bayonet-shaped hair satae of two lengths, 2-3 long unequal setae of 200-240 μm long, and 1-5 short unequal setae of 100-120 μm long per bundle.

Pharynx (Fig. 4 A-ph) in I, wide. Oesophagus (Fig. 4 A-oe) in II-IV, narrow. Stomach (Fig. 4 A-st) in ½IV-VII, wide. Intestine (Fig. 4 A-in) narrow from VIII to end of worm. Septa incomplete. Brain (Fig. 4 B-b) broader than long, deeply incised behind and gently incised in front. Dorsal and ventral vessels mid-dorsal and mid-ventral respectively. Lateral commissural vessels absent. Nephridia (Fig. 4 A-ne) irregularly distributed, first pair of nephridia in II/III or III/IV

Copulatory glands in V/VI. First fission zone (Fig. 4 A-fz) develops behind VIII or IX or X. Worms with 3 or 4 zooids common.

Habits : Worms live in fresh and brackish water in tubes, they produce mucous with which they stick to the substratum. Movements of the worm awkward with contracted and bent hind part of body. Swimming absent, glides with help of ventral ciliation.

Parasites : Astomatous ciliate (Protozoa), *Radiophyroides visakapatnamensis* Joseph and Hanumantharao, 1980 reported from gut of this species from brackish water of Visakapatnam. It is colourless, transparent, 80-105 μm long, 30-35 μm wide with a rod-shaped macronucleus placed longitudinally extending entire length and a small micronucleus about mid-body (Joseph and Hanumantharao, 1980).

Distribution : India : Chandragiri, Tirupati, Vijayawada, Hyderabad, Visakhapatnam, Vizianagaram (Andhra Pradesh).

World distribution : India (Asia); Germany, the Netherlands (Europe).

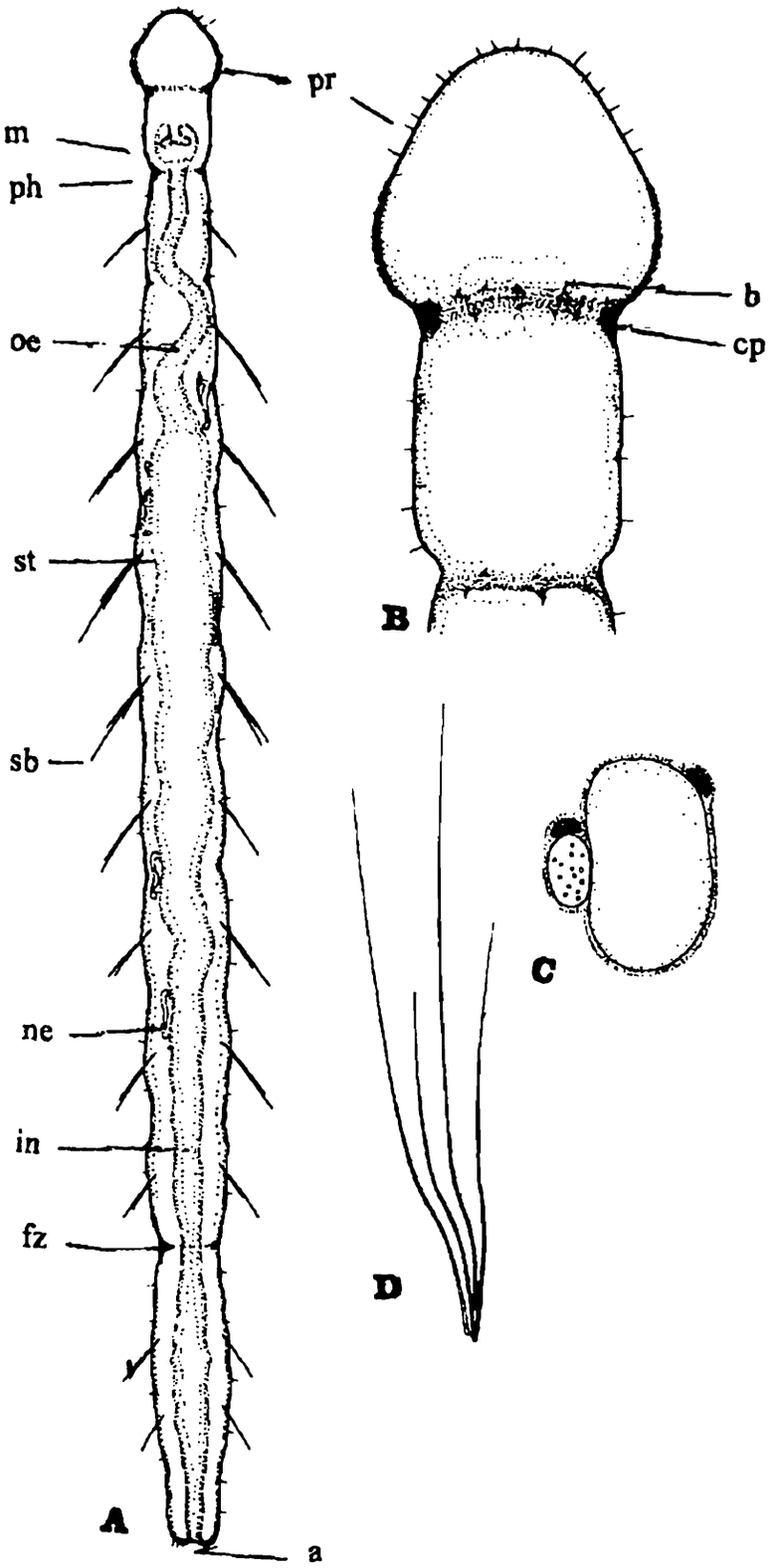

Fig. 4 : *Aeolosoma hyalinum.* A : General view of worm; B : Prostomium; C : Epidermal gland; D : Setal bundle. (all from Bunke, 1967). a : anus; b : brain; cp : ciliary pit; fz : fission zone; in : intestine; m : mouth; ne : nephridium; oe : oesophagus; ph : pharynx; pr : prostomium; sb : setal bundle; st : stomach.

Aeolosoma niveum Leydig, 1865
(Fig. 5)

Aeolosoma niveum Leydig, 1865 : 636; Michaelsen, 1909b : 6; Stephenson, 1930 : 722; Naidu, 1961b : 648.

l(p.) = 0.5-0.8 mm (single), 1.5 mm (chain of 4 zooids); d(p.) = 0.08 mm; s = 12-18; n = 6-8.

Description : Worms (Fig. 5 A, D) minute, delicate, slender, transparent and colourless. Prostomium (Fig. 5 A-pr, B) bluntly triangular, rounded in front, slightly wider than following segments, with stiff, cilia of about 7 μm long on its margin; ciliated field restricted to ventral surface; sensory ciliated pits (Fig. 5 B-cp) relatively large, round, upto 10 μm in diameter, separated from ventral field. Refractile epidermal glands (Fig. 5 B-eg) upto 8 μm in diamter, colourless or with very faint greenish tinge, without satellite cell, sometimes glands absent. Dorsal and ventral setal bundles (Fig. 5 A-sb, C) with sub-equal simple hair setae 1-3(4) per bundle, 50-80 μm long.

Mouth (Fig. 5 A-m) U-shaped. Pharynx (Fig. 5 A-ph) in I, wide and muscular. Oesophagus (Fig. 5 A-oe) in II-III, narrow and wavy. Stomach (Fig. 5 A-st) broad in III-V. Intestine (Fig. 5 A-in) from VI, narrow and sinuous. Brain (Fig. 5 B-b) broader than long, deeply incised behind and less deeply in front. Brain, pharyngeal commissures and ventral nerve-cord attached to body wall. First nephridial pair in II/III or III/IV Nephridia irregularly distributed. Blood colourless. Dorsal and ventral vessels mid-dorsal and mid-ventral. Blood flows from behind forward in dorsal vessel and from anterior to posterior in ventral vessels. Lateral commissural vessels absent.

Sex organs not known. Asexual reproduction by development of budding zones. Some posterior segments to anterior zooid, and prostomium and anterior segments to posterior zooid budded off before they separate. Upto 3 budding zones common.

Habits : Liva in fresh water. Swimming absent. Worms glide on substratum with help of ventral cilia of prostomium.

Distribution : India : Palghat, Trivandrum (Kerala); Chittoor, Horsley Hills, Chandragiri, Hyderabad (Andhra Pradesh).

World distribution : Japan, (Asia); Somalia (Africa); Europe; U.S.A. (North America); Uruguay (South America); Costa Rica, (Central America); New Zealand.

Aeolosoma travancorense Aiyer, 1926
(Fig. 6)

Aeolosoma travancorense Aiyer, 1926 : 136; Aiyer, 1929a : 16; Stephenson, 1930 : 723; Naidu, 1961b : 651; 1966 : 210.

Type locality : Chirayinkil, Travancore, Kerala, India.

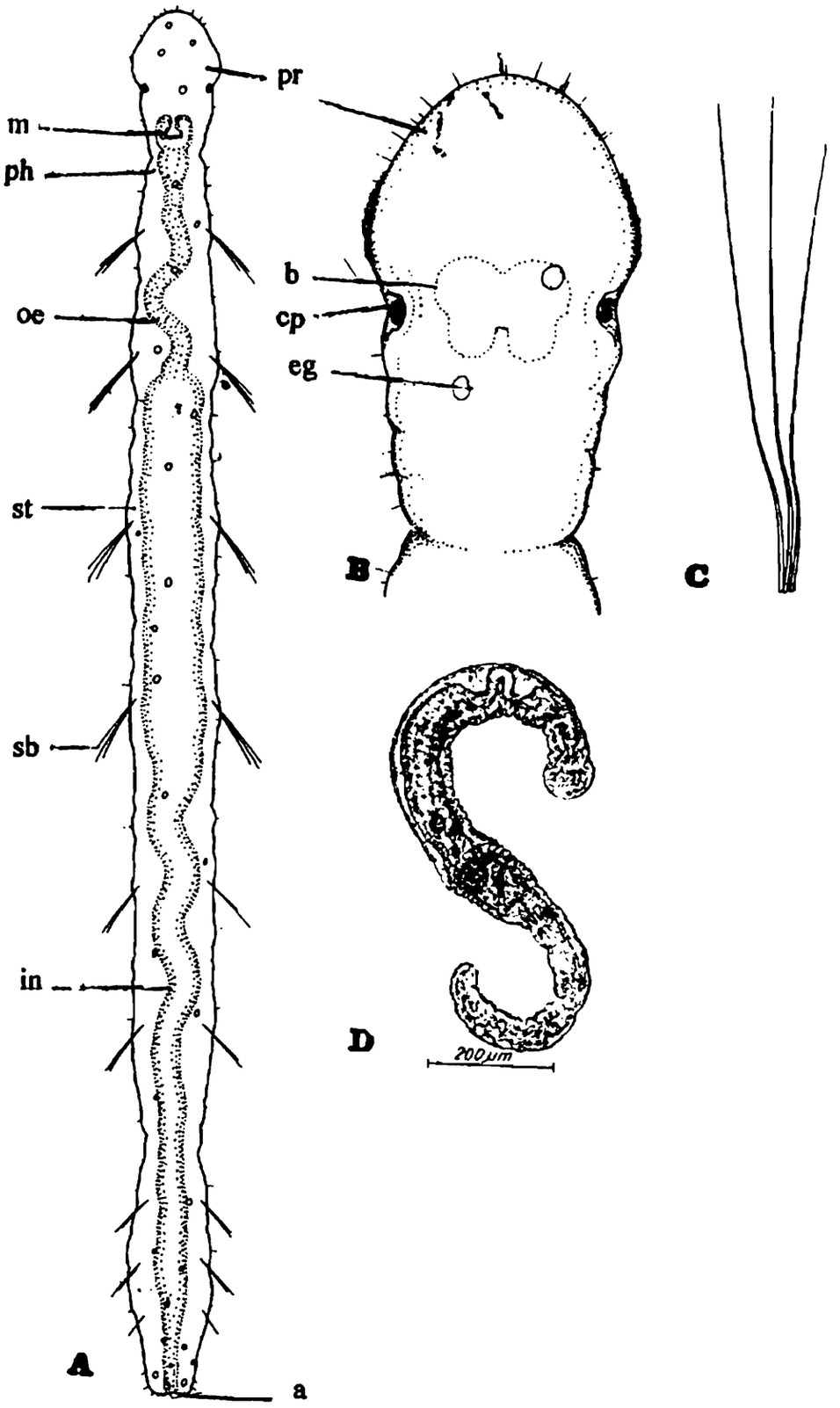

Fig. 5 : *Aeolosoma niveum.* A, D : General view of worm; B : Prostomium; C : Setal bundle. (all from Bunke, 1967). a : anus; b : brain; cp : ciliary pit; eg : epidermal gland; in : intestine; m : mouth; oe : oesophagus; ph : pharynx; pr : prostomium; sb : setal bundle; st : stomach.

l = 0.8-1.5 mm; d = 0.07 mm; s = 12-13 + undifferentiated region; n = 7-8.

Description : Worms (Fig. 6 A) minute, whitish, living in tubes longer than themselves, made of mucus, sand and mud particles. Body wall colourless, transparent, with globular or ovoid, colourless epidermal glands (Fig. 6 D, E). Prostomium (Fig. 6 A-pr) flat, slightly wider than body diameter, highly flexible, ciliated fields restricted to ventral surface, sensory pits round, widely separated from ventral fields. Ventral surface of prostomium with gland cells. Prostomium and anal segment beset with stiff, cilia 14-20 μm long. Dorsal and ventral bundles (Fig. 6 A-sb, B) composed of hair setae and needle setae, in II all hair setae from III needle setae appear. Hair setae unequal or subequal, simple bayonet-shaped (Fig. 6 B), 49-82 μm long, 0-6 per bundle; most abundant in II-IV, less in V-VII; needle setae sigmoid (Fig. 6 C), slightly sickle-shaped, 30-45 μm long, 0-4 per bundle with 2 rows of 10 each of very minute curved teeth 0.5-1.0 μm long on concave border distally and ending in a single claw like tooth upto 7 μm long distally.

Mouth (Fig. 6 A-m) ventral, four cornered, ciliated in I. Pharynx (Fig. A-ph) U-shaped in II, funnel-shaped; oesophagus (Fig. 6 A-oe) in III, narrow and wavy; stomach (Fig. 6 A-st) in IV-VII, wide, yellowish or orange coloured in life; intestine (Fig. 6 A-in) narrow and ciliated from VIII. Coelomocytes and septa absent. Brain dumb-bell shaped. Dorsal blood vessel mid-dorsal and contractile. Ventral vessel mid-ventral and non-contractile. Contractile vascular loops absent. Nephridia (Fig. 6 F) irregularly distributed, first pair in II, each with a long coiled duct (Fig. 6 F-nd) with ciliated nephrostome (Fig. 6 F-ns) opening in coelom, a minute nephropore (Fig. 6 F-np) opening to exterior ventro-laterally, proximal half of duct compactly coiled and enclosed in glandular tissue (Fig. 6 F-gl).

Clitellum not developed. Testes absent, male cells are produced from wall of dorsal blood vessel. Sperm-sac absent. Marulae develop in coelom and spermatozoa freely float about in coelom. Special genital duct absent for escape of spermatozoa. Ova 1-2 produced from ventral body wall of V Oviduct and spermathecae absent. Budding by development of fission zones (Fig. 6 A-fz).

Habits : Live in fresh-water in fixed tubes abandoned by *Aulodrilus* No evidence of tube building in this species (Bunke, 1967, Marcus, 1944, Naidu, 1961a, Land 1977, Smith & Hendry, 1991).

Parasites : In the gut of several worms, astomatous ciliate *Radiophryoides puytoraci* Naidu (1961a) are harboured. They are light green in colour in life, with a flat elongate ovoid bodies, 160-180 μm long, 70-78 μm wide, and 35-40 μm thick (Aiyer, 1929a, reported them to be 200-220 μm long); with longitudinal rows of cilia. They move slowly rotating on their axes. Several specimens have 2-4 buds attached posteriorly.

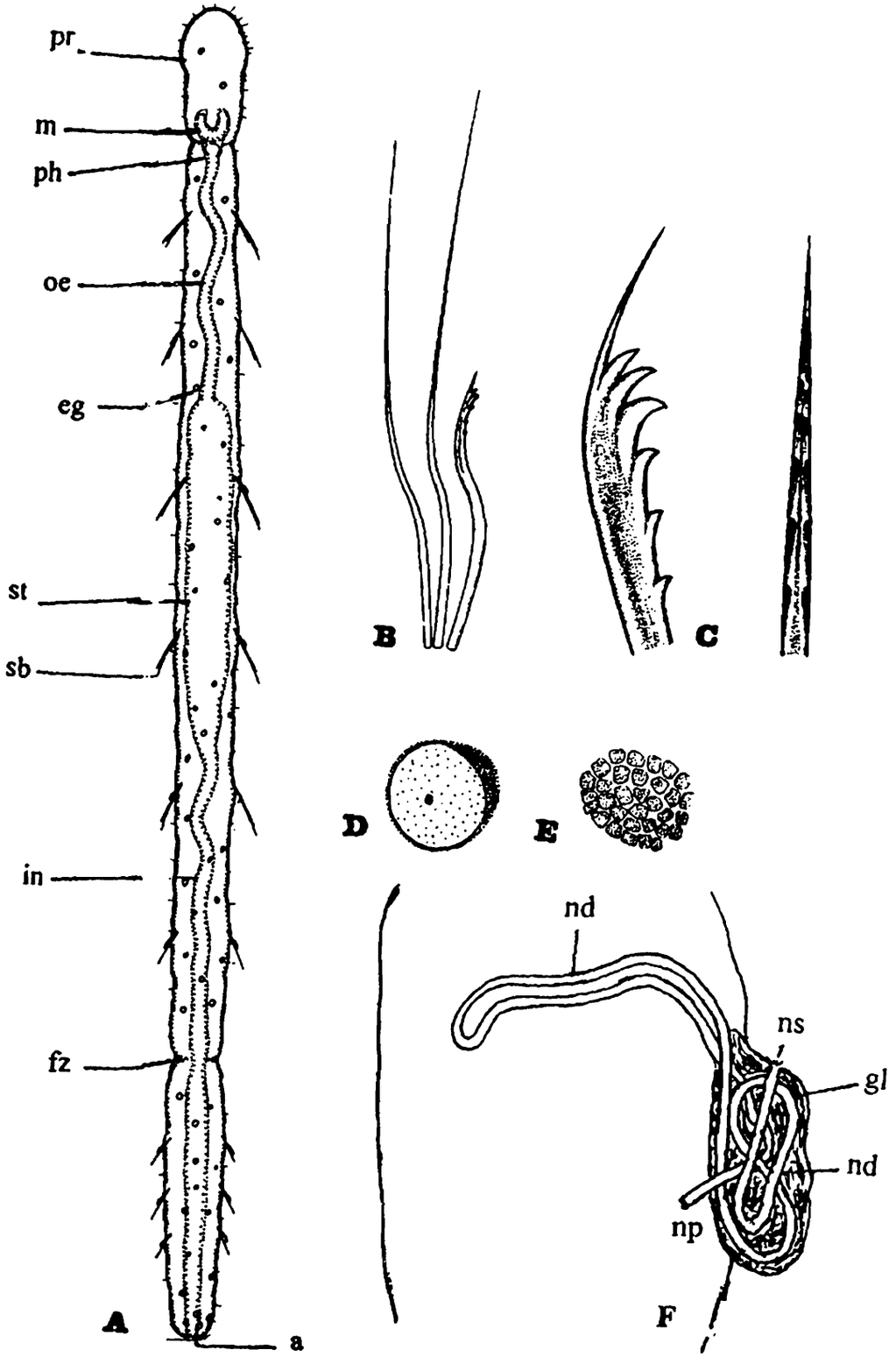

Fig. 6 : *Aeolosoma travancorense.* A : General view of worm; B : Setal bundle; C : Lateral and front view of distal end of needle seta; D, E : Epidermal glands; F : Nephridium. (A-E from Bunke, 1967). a : anus; eg : epidermal gland; fz : fission zone; gl : glandular part; in : intestine; m : mouth; nd : nephridial duct; np : nephropore; ns : nephrostome; oe : oesophagus; ph : pharynx; pr : prostomium; sb : setal bundle; st : stomach.

Distribution : India : Chirayinkil, Trivandrum, Nagarkoil (Kerala); Chandragiri, Horsley Hills, Cuddapah, Gudur, Hyderabad, Vizianagaram (Andhra Pradesh); Mysore (Karnataka). Lahore (Pakistan).

World distribution : Asia; Somalia, Tunisia (Africa); Europe; Georgia in U. S..A (North America); Uruguay, Surinam, Brazil (South America); Australia.

Aeolosoma viride Stephenson, 1911.
(Fig. 7)

Aeolosoma sp. Stephenson, 1907b: 233;

Aeolosoma viride Stephenson, 1911 : 205; 1913a : 742; 1923 : 42; 1930; 525; Naidu, 1961b : 643; 1966 : 210; Vasisht & Gandhi, 1972 : 99.

Type locality : Lahore, Pakistan.

l = 2 mm (undividing), 8 mm (chain of 5-8 individuals); d = 0.2-0.3 mm; s = upto 10 + undifferentiated region; n = 7-9.

Description : Worms (Fig. 7 A) large, transparent. Prostomium (Fig. 7 A-pr, B) rounded, wider than following segments, ciliated at its rim and on ventral surface, with stiff, tactile cilia around its margin, upto 25 μm long. Ciliated fields with large dorso-lateral continuations; sensory pits large, ovoid, situated posterior to level of brain, not connected with ventral fields. Epidermal glands globular or of irregular form, green or brownish green with satellite cells. Dorsal and ventral bundles (Fig. 7 A-sb) from II, all of one type, composed of longer and shorter hair setae. Dorsal bundles with 2-6 hair setae, ventral bundles with 4-6 per bundle. Each bundle with 1-5 short hair setae of 80-100 μm long and 1-4 long setae of 190-250 μm long. Posterior end bilabed.

Buccal cavity and pharynx in I; oesophagus (Fig. 7 A-oe) in II-III, narrow; stomach (Fig. 7 A-st) in IV-VIII, wide, and intestine (Fig. 7 A-in) narrow from IX. Blood colourless; dorsal vessel contractile and mid-dorsal, bifurcating in prostomium in front of mouth and uniting into a non-contractile ventral vessel beneath pharynx, running backwards mid-ventrally. Transverse commissural vessels absent. Nephridia (Fig. 7 C) 4-7 pairs starting in II or III, each consisting of a long coiled tube (Fig. 7 C-nc) with a small ciliated funnel (Fig. 7 C-nf) lying unattached in body cavity. Brain (Fig. 7 A-b) transversely placed oval mass, broader than long in I with posteriorly directed lateral cornua.

Sex organs not reported. Asexual reproduction by budding.

Habits : Worms live in fresh water and glide with help of ventral ciliation.

Distribution : India : Chandigarh; Punjab; Haryana. Lahore (Pakistan).

World distribution : Asia; Europe; Brazil (South America); New Zealand.

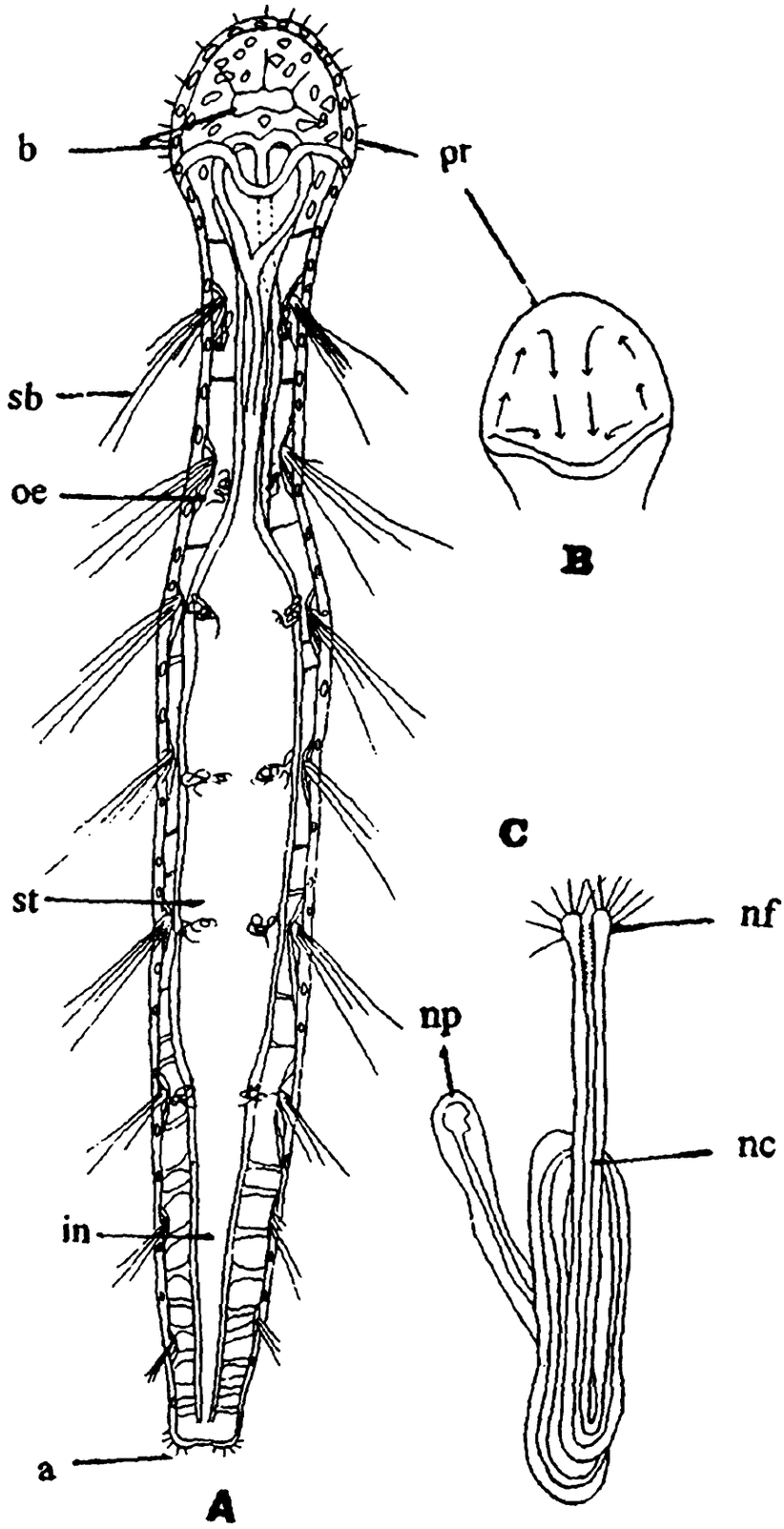

Fig. 7 : *Aeolosoma viride*. A : General view of worm; B : Prostomium indicating ciliary movement; C : Nephridium. (all from Ercolini, 1960). a : anus; b : brain; in : intestine; nc : nephridial canal; nf : nephridial funnel; np : nephropore; oe : oesophagus; pr : prostomium; sb : setal bundle; st : stomach.

SPECIES DUBIA

Aeolosoma ternarium Schmarda, 1861

Aeolosoma ternarium Schmarda, 1861 : 10; Beddard, 1895, 182;

Pleurophleps ternaria, Michaelsen, 1900 : 16; Michaelsen, 1903b : 41; 1909a : 104; 1910 : 7.

Aeolosoma ternarium, Stephenson, 1923 : 43; 1930 : 726; Naidu, 1961b : 643; Mendis & Fernando, 1962 : 45; Naidu, 1966 : 210.

Type locality : Galle, Sri Lanka.

l(p.) = 2.5 mm; d(p.) = 0.5 mm; s = 12.

Description : Worms of small size, slender, transparent, yellowish grey. Prostomium bluntly semicircular, flat, as broad as peristomium with 12 stiff, tactile cilia on margin. Epidermal glands absent. Dorsal and ventral setae begin in II, all hair setae, nearly straight, simple, 3 per bundle, shorter than diameter of body.

Pharynx in I-II, wide. Oesophagus in III, narrow. Stomach in IV-V dilated. Intestine from VI narrow. Septa incomplete. Coelomocytes absent.

Sex organs not known. Worms undergoing asexual reproduction not observed.

Habits : Fresh water form found in stagment water.

Distribution : Known only from type locality.

Subclass OLIGOCHAETA

Diagnosis : Worms of medium and large size. Setae relatively few or rarely absent. Locomotion effected by alternate contraction and relaxation of longitudinal and circular muscles. Coloured epidermal glands absent. Coelom reduced to sinuses. Septa usually present. Pharynx with eversible roof pad (except in aquatic earthworms). Ventral nerve cord and ganglia fused not sub-epidermal but within muscle layers. Hermaphrodites. Reproductive organs usually concentrated in a few segments with gonoducts. Clitellum glandular, saddle-shaped and incomplete ventrally or annular. Fertlized ova enclosed in cocoons. Development direct. Asexual reproduction by budding or fragmentation in one family Naididae.

Subclass Oligochaeta comprises of two superorders, Naidimorpha and Lumbricomorpha, former with one order Tubificida comprising of families Naididae, Tubificidae, Phreodrilidae, Enchytraeidae, Lycodrlidae and Opistocystidae and Superorder Lumbricomorpha with four orders : order Lumbriculida with families Lumbriculidae and Dorydrilidae, Haplotaxida with four families Haplotaxidae, Alluroidae and many mainly terrestrial families of earthworms, order Moniligastrida with single family Moniligastridae, order Branchiobdellida with single family Branchiobdelliodae. Of these, only Naididae, Tubificidae, Phreodrillidae, Enchytraeidae and Lumbriculidae and Microchaetidae are represented in the Indian subcontinent.

Family NAIDIDAE

Naidimorpha Beddard, 1895 : 273;

Naididae Stephenson, 1923 : 43; Stephensom, 1930: 727; Sperber, 1948 : 57; Chekanovskaya, 1962 : 153; Brinkhurst, 1964 : 198; Brinkhurst & Cook, 1966 : 12; Brinkhurst & Jamieson, 1971 : 305; Brinkhurt, 1981 : 106; Mukhopadhyay, 1998 : 99.

Diagnosis : Prostomium usually well developed, sometimes forming a proboscis. Eyes present or absent. Dorsal setae usually present, beginning in II, III, IV, V or VI or further back or totally absent, consisting of an indefinite number of hair setae accompanied by needle setae of various shapes, or of needle setae only. Ventral setae of indefinite number per bundle, beginning in II, bifid or simple-pointed crotchets. Alimentary canal with pharynx, oesophagus, stomach and intestine, pharygeal, and oesophageal or septal glands usually present. Pharynx generally with a dorsal diverticulum of ciliated cells. Vascular systems consisting of alimentary plexus, dorsal and ventral vessels, and a varying number of commissural vessels, from none to one or two pairs per segment, often forming a plexus in anterior end, seldom a plexus in body-wall; additional loops formed during maturity in sperm-sac and ovi-sac. Nephridia usually open, with a glandular part behind septum; its tube coiling, sometimes packed against ventral vessel, sometimes invested with a bladder-like peritoneal cells; beginning in segment behind ovarial segment, seldom wholly absent. Nervous system not connected with epidermis; connectives of nerve-cord usually fused. Clitellum in a few segments in region of gonads, testes and ovaries, one pair each, in IV-V, V-VI, or VII-VIII; male efferent apparatus paired; funnels in testis segment, atria in ovarial segment, usually opening apart; penis absent, penial setae often present; often diffuse prostate gland cells on vasa deferentia or atria; spermathecae in testis segment, usually opening apart sometimes accmopanied by special setae; usually with an unpaired sperm-sac and ovi-sac. Asexual reproduction by budding or fragmentation. Ontogeny deviating, with a periblast forming round embryo. Cosmopolitan.

Type genus : *Nais* Müller, 1773.

This family is divided into five subfamilies: 1. Chaetogastrinae Sperber, 1948; 2. Paranaidinae Sperber, 1948; 3. Naidinae Lastockin, 1924; 4. Stephensonianinae Naidu, 1963; 5. Pristininae Lastockin, 1924. Of these subfamily Paranaidinae does not occur in the subcontinent.

Key to Indian subfamilies of Family NAIDIDAE

1. Dorsal setae totally absent, prostomium weakly developed ..... CHAETOGASTRINAE.

– Dorsal setae present, prostomium well developed 2

2. Fission zone produces antereior five segments, sex organs in V and VI .... NAIDINAE.

– Fission zone produces anterior 4 or 7 segments, sex organs in IV and V or VII and VIII, dorsal setae begin in II or III 3

3. Fission zone produces 4 anterior segments, sex organs in IV and V .... STEPHENSONIANINAE.

– Fission zone produces 7 anterior segments, sex organs in VII and VIII .... PRISTININAE.

Subfamily CHAETOGASTRINAE Sperber, 1948

Chaetogastrinae Sperber, 1948 : 57; Naidu, 1962a : 132; Chekanovskaya, 1962 : 201; Brinkhurst, 1964 : 201; Brinkhurst & Jamieson, 1971 : 306; Brinkhurst, 1985 : 471 : Mukhopadhyay, 1990 : 99.

Diagnosis : Prostomium often reduced. Segment III elongated. Eyes absent. Dorsal setae absent. Pharynx in I-III, attached to body-wall by numerous radial muscular strands; dorsal diverticulum absent; pharyngeal, oesophageal and septal glands absent; stomach of special structure. Chloragogen cells beginning in V. Commissural vessels none to one pair. Nephridia closed type. Coelomocytes absent. Connectives of ventral nerve-cord sometimes not fused anteriorly; Cerebral ganglia often weak; without posterior lobes; most often a statocyst present in brain. Clitellum in ½V-VI. Testes in V and ovaries and atria VI. Spermathecae in V. Male funnels cup-shaped and lie freely in coelom due to weak development of septa 5/6. Vasa differentia entering atria at proximal end. Penial setae present. As a rule sperm-sac and ovi-sac absent. Spermathecal and atrial ducts well defined; prostate absent. Budding and fission continuing during earlier stages of sexual maturity. Five segments formed at anterior end by budding. Swimming absent. Cosmopolitan.

Type genus : *Chaetogaster* von Baer, 1827.

Subfamily Chaetogastrinae has two genera : (1) *Chaetogaster* von Baer, 1827 and (2) *Amphichaeta* Tauber, 1879; of which former occurs in Indian subcontinent.

Genus ***Chaetogaster*** von Baer, 1827

Chaetogaster von Baer, 1827 : 611; Beddard, 1895 : 304; Stephenson, 1923 : 47; 1930 : 731; Sperber, 1948 : 58; Naidu, 1962a : 132; Chekanovskaya, 1962 : 203; Brinkhurst, 1964 : 201; Brinkhurst & Jamieson, 1971 : 307: Mukhopadhyay, 1998 : 100.

Diagnosis : Worms transparent and whitish. Body wall of most segments and prostomium covered with cilia. Dorsal setae absent. Ventral setae double-pronged or simple setae, absent in III-V. Septa incomplete. Pharynx acts like a sucker. Oesophagus in IV. Stomach well defined. Intestinal plexus on stomach conspicuous, with a ventral

trunk; usually one pair of commissural vessels in IV; in some cases vascular system in pharyngeal region atrophied. Connectives of ventral nerve-cord not fused in anterior segments. Blood colourless. Brain usually weak, without posterior lobes; most often a statocyst present in brain. Clitellum in V-VI. Testes and ovaries in V and VI. Spermathecae in V. Male funnels cup-shaped and lie freely in coelom due to weak development of septum 5/6. Vasa deferentia entering atria at proximal end. Penial setae present. As a rule sperm-sac and ovi-sac absent. Budding and fission continuing during earlier stages of maturity. Some species predatory. Cosmopolitan.

Type species : *Chaetogaster limnaei* von Baer, 1827

Key to Indian species of Genus *Chaetogaster*

1. Free living worms, setae fewer of normal shape 2
– Parasites or commensals on snails, setae numerous with long, strongly curved teeth 5
2. Prostomium conspicuous ..... *Chaetogaster diastrophus*
– Prostomium inconspicuous 3
3. Prostomium with median incision ..... *Chaetogaster cristallinus*
– Prostomium without median incision 4
4. Setae small less than 100 μm long in II ..... *Chaetogaster langi*
– Setae large, more than 145 μm long in II ..... *Chaetogaster diaphanus*
5. Setae of II 130-140 μm long, with distal tooth longer and thinner than proximal ..... *Chaetogaster limnaei bengalensis*
– Setae of II 53-123 μm long, teeth equally thick, distal shorter than proximal ..... *Chaetogaster limnaei limnaei*

Chaetogaster cristallinus Vejdovsky, 1883.
(Fig. 8)

Chaetogaster cristallinus Vejdovsky, 1883 : 220;

Chaetogaster sp. Annandale, 1906 : 189; Stephenson, 1907b : 248; 1923 : 53;

Chaetogaster cristallinus, Naidu, 1962a : 135; 1966 : 210; Costa, 1967 : 40; Vasisht & Gandhi, 1972 : 99; Ali & Issaque, 1975 : 55; Naidu & Srivastava, 1980 : 263; Naidu & Naidu, 1981a : 528; 1981b : 113.

Type locality : Bohemia.

l = 2.5-7.0 mm (chain); d = 0.3-0.6 mm; s = 12-16 + undifferentiated region; n = 8-10.

Description : Worms larger than *C. langi* and *C. diastrophus,* colourless and transparent. Prostomium inconspicuous with a median incision and with stiff, sensory

cilia of two lengths, longer alternating with shorter on margin. Ventral setae (Fig. 8 A) in II 4-13 per bundle, longer than others, 140-168 μm long, 1.7 μm thick; in others 4-6 per bundle 118-140 μm long, 1.5 μm thick, with strong proximal nodulus (D : P :: 2 : 1) in II, in others, nodulus proximal (D : P :: 11 : 8) with straight shaft above nodulus and bent at an angle below nodulus near proximal end; teeth curved, distal longer than proximal. Length and position of nodulus vary from seta to seta in each bundle.

Mouth subterminal and circular. Pharynx thick-walled with spinose exterior. Oesophagus in IV, narrow, S-shaped, with longitudinal folds and closed when empty, distended during passage of food. Stomach in V-½VII, barrel-shaped, with 26-30 transverse ducts giving a striped appearance, narrow anteriorly and widening behind,

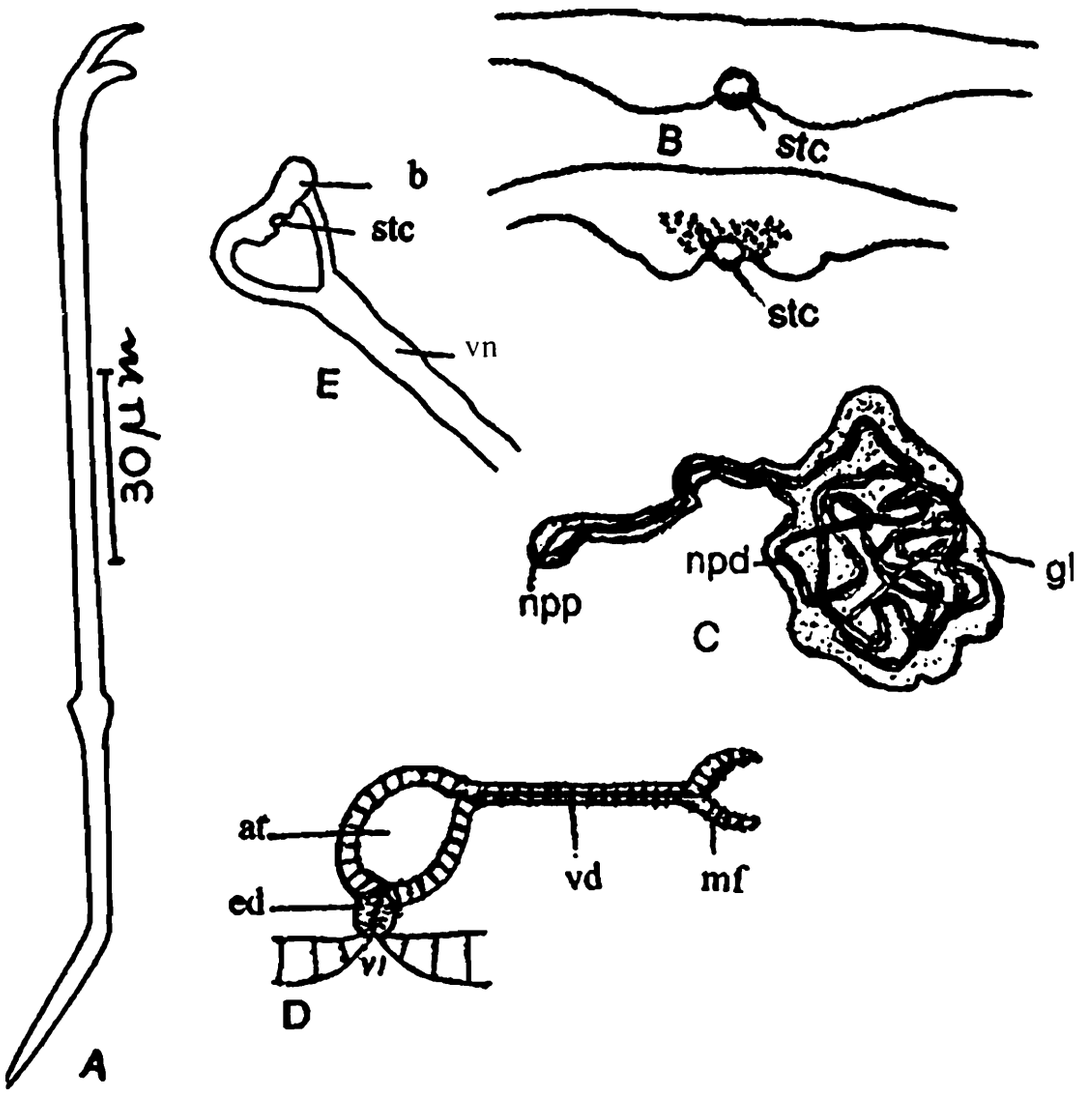

Fig. 8 : *Chaetogaster cristallinus.* A : Ventral seta of II; B : Brain; C : Nephridium; D : Genital organs; E : Nerve ring. (D from Sperber, 1948). at : atrium; b : brain; ed : ejaculatory duct; gl : glandular part; mf : male funnel; npd : nephridial duct; npp : nephropore; stc : statocyst; vd : vas deferens; vn : ventral nerve cord.

its wall contracting near septa forming 3 compartments in deflation, disappearing in inflation. Intestine yellowish, wide in ½VII-VIII and narrow behind. Brain (Fig. 8 B, E-b) with a median statocyst (Fig. 8 B-stc, E-stc), bluish in live worms, without granules in old worms. Nerve-ring thick (Fig. 8 E), ventral nerve-cord with well developed ganglia free from body-wall. Dorsal vessel mid-dorsal and contractile; one pair of contractile transverse vessels in IV. Nephridia (Fig. 8 C) from VII, attached to body-wall near setal bundles, composed of irregular glandular part (Fig. 8 C-gl), enclosing a highly coiled nephridial duct (Fig. 8 C-npd), opening by a nephropore (Fig. 8 C-npp) near setal bundles ventrally.

Clitellum extends from ½V-VI, absent between male pores. Testes irregular in shape, about 25 μm high, 20 μm wide, 35 μm long, found only at a very early stage of maturity attached to posterior face of septum 4/5 and ventral nerve-cord. Sperm-sac absent. Scattered spermatocyte aggregates found in V and VI. Ovaries pear-shaped, about 20 μm long and broad, 12 μ high, with oogonia and attached to posterior face of septum 5/6 and nerve-cord. Oocytes 4.5-17 μm in diameter. Ovaries persist longer than testes. Spermathecae when empty small and spherical and when filled with sperms may reach length of 160 μm and diameter of 40-50 μm with wall thickness of 2 μm. Spermathecal duct well defined, 30 μm long, 17 μm wide, with a wall thickness of 8.5 μm. Male funnels (Fig. 8 D-mf) cup-shaped and strongly ciliated with about 30 μm long and wide and wall thickness of 6-9 μm. Vasa deferentia (Fig. 8 D-vd) run directly backwards, very narrow, 7-8 μm in diameter and wall thickness of 2.5 μm, 125-130 μm long in live worms, and 65-85 μm long in preserved specimens. Atria (Fig. 8 D-at) 50 μm × 40 μm × 44 μm, with glandular wall, bent slightly forward, spherical or oblong in live worms and flattened by stomach in fixed worms. Ejaculatory ducts (Fig. 8 D-ed) short, about 20 μm long. Penial setae 2 per bundle, 53-69 μm long, with a simple hook, with ill defined nodulus about 1/4 of setal length from distal end. Sperm-sac absent. Smaller oocyte aggregates slip through partial septa, and when grown larger, they remain in VI, pressing against septum 6/7 which bulges backwards, so that a small ovi-sac is formed. Worms with 2-5 zooids common. In a chain of 5 zooids, I, II, III and IV budding zones are located between X and XI, VIII and IX, XV and XVI, and XIX and XX respectively.1 to 5 zooids each composed of 8, 2, 5, 4 and 6 segments respectively.

Habits : Worms live among filamentous algae in fresh and brackish water. Also found on the surface of polyzoan *Plumatella repens* var. *emarginata*. Gut generally contains bits of algal filament, protozoans, rotifers, small crustaceans and bits of oligochaetes. Those in captivity contained in their gut pieces of body and setae of their kin. Swimming absent.

Commensals : Vorticellid protozoans are attached to body wall of several worms.

Parasites : Several unidentified spherical ciliate parasites with blue-green inclusions were found in their gut.

Distribution : India : Malapuza, Palghat (Kerala); Udhakamandalam (Tamil Nadu); Chittoor, Horsley Hills, Cuddapah, Hyderabad (Andhra Pradesh); Bangalore (Karnataka); Mumbai, Vehar Lake, Nagpur (Maharastra); Ujjain (Madhya Pradesh); Varanasi (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Kolkata (West Bengal). Dhaka (Bangladesh); Inle Lake (Burma); Pilamatala near Peradeniya (Sri Lanka).

World distribution : Cosmopolitan.

Chaetogaster diaphanus (Gruithuisen, 1828)
(Fig. 9)

Nais diaphana Gruithuisen, 1828 : 409:

Chaetogaster pellucidus Stephenson, 1907b : 237;

Chaetogaster orientalis Stephenson. 1909a : 107; 1910a : 68; Michaelsen, 1910 : 7; Stewart, 1911 : 69; Stephenson, 1913a : 754; Mehra, 1920 : 457; Stephenson, 1922b : 109; 1923 : 51; Cernosvitov, 1942b : 282;

Chaetogaster diaphanus, Cernosvitov, 1942a : 197; Naidu, 1962a 132; 1966 : 211; Costa, 1967 : 39; Singh, 1989 : 274.

Type locality : Unassigned, Germany.

l(p.) = 2-7 mm; d(p.) = 0.2-0.35 mm; s = 14-15 + undifferentiated region; n = 9-12.

Description : Worms small, transparent and colourless. Prostomium incompicuous. Mouth terminal, obliquely placed, generally open. Ventral setae (Fig. 9 A, B) much longer and stronger than in any other species of genus. In II 6-13 per bundle, 145-350 μm long, with teeth 8 μm/4.5 μm long, 4.5 μm thich; in others 4-10 per bundle, 105-210 μm long, 2.5 μm thick, with teeth of 7/5.5 μm long. Teeth more curved than usual, and with abrupt and strong proximal flexion with proximal nodulus.

Pharynx in II-III, wide. Oesophagus in IV, narrow. Stomach in V-VII, wide, barrel-shaped, transverse vascular ducts restricted to anterior half. Intestine wide in VIII and narrow behind. Chloragocytes from V. Coelomocytes absent. Anus terminal. Brain with a statocyst. Commissural and ventral nerve-cord well developed with segmental ganglia. Dorsal vessel mid-dorsal and contractile. Ventral vessel mid-ventral and non-contractile. One pair of contractile lateral vessels in IV Nephridia exoneplinic type, without funnels attached to body-wall, start from VII.

Clitellum in ½V-½VII (2 segments). Testes and ovaries develop early, much before development of other sex organs and clitellum. Testes irregular in shape, 50-60 μm long, attached to septum 4/5 and ventral nerve-cord in V Ovaries pear-shaped with a definite outline, about 60 μm long, 30-50 μm wide attached to sides of nerve cord behind septum 5/6 and vestiges of septum 5/6 in VI. Sperm-sac and ovi-sac absent. Male funnels. large, cup-shaped on anterior face of septum 5/6 in V, ciliated, about 35 μm long, 85 μm wide with thick wall. Vasa deferentia about 160 μm long, 20 μm

wide, with wall thickness of 6-7 μm. They enter atria at top. Atria large, their ampullae roundish to ovoid, 185 μm long, 120 μm wide and 100 μm high, with glandular walls 3-11 μm thick. Ejaculatory ducts about 80-90 μm long, with their wall thickness of 35-45 μm. Male apertures at level of ventral setae of VI. Penial setae (Fig. 9 D, E) 3-5 per bundle, modified with strong nodulus at about 1/4 length from distal end, generally simple pointed, rarely with a short distal tooth. Female funnels laterally situated posteriorly in VI. Spermathecae when full, roundish and bag-like, narrowing towards their ducts, their ampullae (Fig. 9 C-sa) 145-235 μm long, 60-140 μm wide, ducts (Fig. 9 C-sd) about 80 μm long with an outer diameter of 30 μm, except about the opening, where they may be strongly dilated to a diameter of 55 μm. Asexual reproduction by formation of budding zones, which occurs at all times. Both asexual and sexual reproduction go on simultaneously except in advanced stage of sexual development.

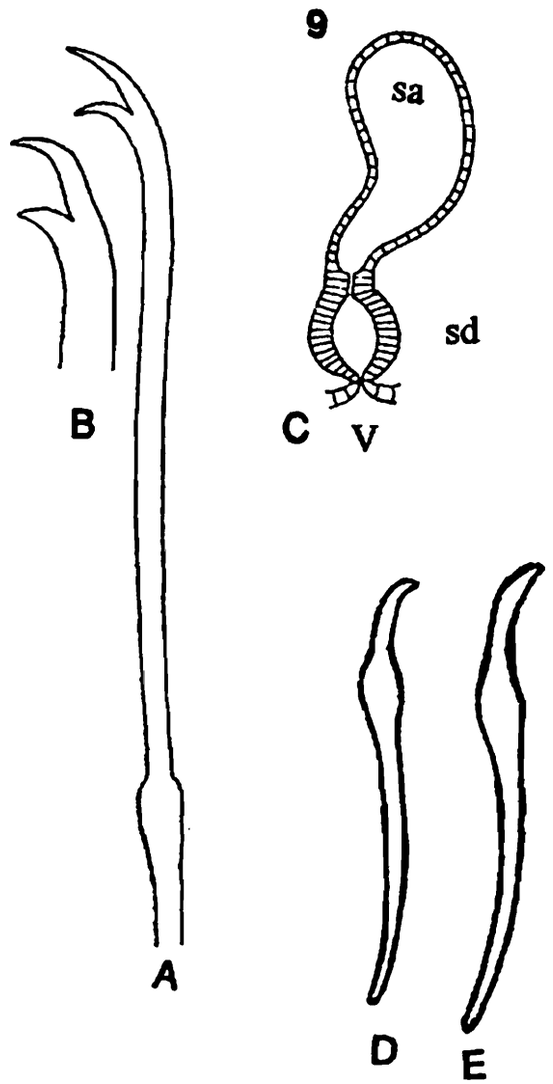

Fig. 9 : *Chaetogaster diaphanus.* A : Ventral seta of VI; B : Distal end of ventral seta of II; C : Spermatheca; D, E : Penial setae. (A-C from Sperber, 1948; D, E from Stephenson, 1923). sa : spermamathecal ampulla; sd : spermathecal duct.

Habits : Live in fresh and brackish-water. This species is carnvorous devouring small crustacaus. Rotifers, and minute Nematodes, Ciliates, etc, rarely they are found swallowing animals larger than themselves.

Distribution : India : Ujjain (Madhya Pradesh); Agra (Uttar Pradesh). Se-Chen, Gyantse (Tibet); Lahore (Pakistan); Inle Lake in Shan State (Burma); Sri Lanka.

World distribution : Cosmopolitan.

Chaetogaster diastrophus (Gruithuisen, 1828).
(Fig. 10)

Nais diastropha Gruithuisen, 1828: 416;

Chaetogaster punjabensis Stephenson, 1907a : 133; 1907b: 246; Michaelsen, 1910 : 7; Stephenson, 1913a : 753;

Chaetogaster annandalei Stephenson., 1918 : 9;

Chaetogaster punjabensis, Stephenson, 1920: 196; Mehra, 1920 : 457;

Chaetogsaster annandalai, Stephenson, 1923 : 49;

Chaetogaster langi Bretscher, Stephenson, 1923 : 50;

Chaetogaster diastrophus, Sperber, 1960: 155; Naidu, 1962a : 133; 1966 : 211; Costa, 1967 : 40; Gates, 1972 : 316; Naidu & Srivastava, 1980 : 263.

Type locality : Unassigned, Germany.

l(p.) = 1.0-2 mm (chain of 2); d(p.) = 0.1 mm; s = 10-16 + undifferentiated region; n = 8-9.

Description : Worms minute, transparent and colourless. Prostomium well developed, bluntly pointed with fine long stiff sensory cilia on margin. Ventral setae (Fig. 10 A, B, C, D) bifid, with strong proximal nodulus, shaft straight above and bent at an angle proximally, teeth equally thick with distal tooth longer than proximal. Setae of II, 4-8 per bundle, 90-100 μm long; in rest 3-7 per bundle; 50-74 μm long.

Mouth ovoid, always open, gape increasing and decreasing. Pharynx in II-III wide. Oesophagus in IV, $^1/_2$-$^2/_3$ as long as pharynx, narrow. Stomach in V-VI, barrel-shaped with 15-20 transverse vascular vessels. Intestine yellowish, wide in VII-VIII, narrow behind. Chloragogen cells from V onwards. Septa delicate, incomplete. Brain incised in front and behind, with large hind lobes and a statocyst. Ventral nerve-cord well developed and irregular in outline. Dorsal vessel contractile, mid-dorsal, and ventral vessel mid-ventral, non-contractile, a pair of lateral contractile vessels connecting them in IV Nephridia begin in VII, two per segment, with nephrostomes, compact with glandular tissue enclosing a long coiled nephridial duct, its ectal part thick, nephropores open ventro-laterally.

Clitellum in V-VI. Testes and ovaries about 25 μm long, 15 μm broad, attached to ventral nerve-cord. Spermatogonia and oogonia in V and VI respectively. Male funnels (Fig. 10 E-mf) small, widely open, ciliate, 8 μm long and 15 μm wide. Vasa deferentia

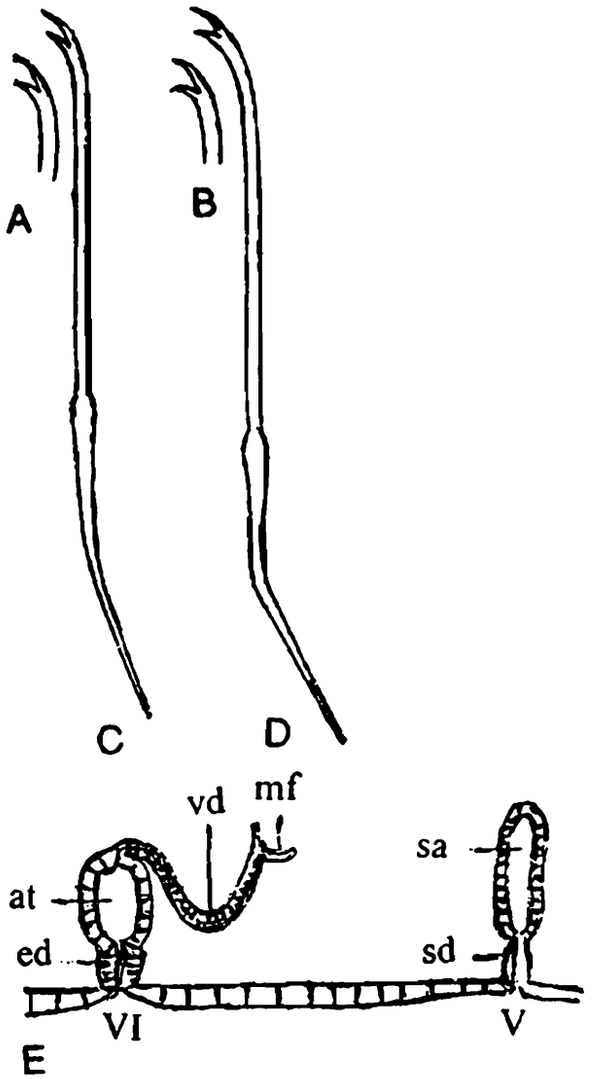

Fig. 10 : *Chaetogaster diastrophus.* A, B : Distal end of setae of II and VI; C, D : Ventral setae of III and VIII; E : Genital organs. (all from Sperber, 1948). at : atrium; ed : ejaculatory duct; mf : male funnel; sa : spermamathecal ampulla; sd : spermathecal duct; vd : vas deferens.

(Fig. 10 E-vd) 70 μm long, 4.5 μm thick, with thin walls and enter atria at top. Atrial ampulla (Fig. 10 E-at) sub-spherical 35 μm high and 25 μm wide. Ejaculatory ducts (Fig. 10 E-ed) 16 μm long, 16 μm thick. Sexual and asexual reproduction go on side by side, and in sexually mature worms, asexual reproduction suspended. Spermathecae (Fig. 10 E-sa) elongate with short ejaculatory duct (Fig. 10 E-sd) in V Worms without fission zones rare; chains of 2-5 individuals common. First fission zone always appears between VIII and IX, second zone a segment anterior to it. A chain of 8 individuals has following composition :

Zooid number	No. of segment in the zooid	Type of segments
I	4	All of parent
	VI fission zone	
II	3	1 old + 2 new
	II fission zone	

III	4 IV fission zone	1 old + 3 new
IV	3 I fission zone	All new
V	8 VII fission zone	3 old + 5 new
VI	1 III fission zone	Old
VII	4 V fission zone	All new
VIII	2 + undifferentiated region	All new

Habits : Worms live among sponge colonies of *Ephydatia fluviatalis* and among algae in fresh water.

Remarks : Grimm (1987) considers this species as synonym of *Chaetogaster langi.*

Distribution : India : Cuddapah (Andhra Pradesh); Bellary (Karnataka); Nagpur (Maharastra); Bhopal, Ujjain (Madhya Pradesh); Agra, Varanasi (Uttar Pradesh). Lahore (Pakistan); Inle Lake in Shan Plateau (Burma); Peradeniya (Sri Lanka); Paghman (Afghanistan).

World Distribution : Asia; Africa; Europe; North and South America.

Chaetogaster langi Bretscher, 1896.
(Fig. 11)

Chaetogaster langi Bretscher, 1896 : 512.

Chaetogaster sp. Annandale, 1906: 189.

Chaetogaster spongillae Annandale, 1906 : 188; Stephenson, 1907b : 248; Michaelsen, 1910 : 7; Stephenson, 1911 : 205; 1920 : 195; 1923 : 52.

Chaetogaster langi, Sperber, 1960 : 155; Naidu, 1962a : 134; 1966 : 211; Costa, 1967 : 40; Vasisht & Gandhi, 1972 : 99; Mukhopadhyay, 1998 : 100.

Type locality : Zurich, Switzerland.

l(p.) = 0.8-1.7 mm; d(p.) = 0.1-0.15 mm; s = 8-21 + undifferentiated region; n = 8-9.

Description : Worms minute, transparent. Prostomium inconspicuous with a round margin fringed with fine sensory cilia. Ventral setae (Fig. 11 A, B) 3-9 per bundle, with conspicuous nodulus, shaft bent at an angle near proximal end, teeth equally thick, distal longer than proximal, in II 62-101 μm long, and from VI, 39-75 μm long.

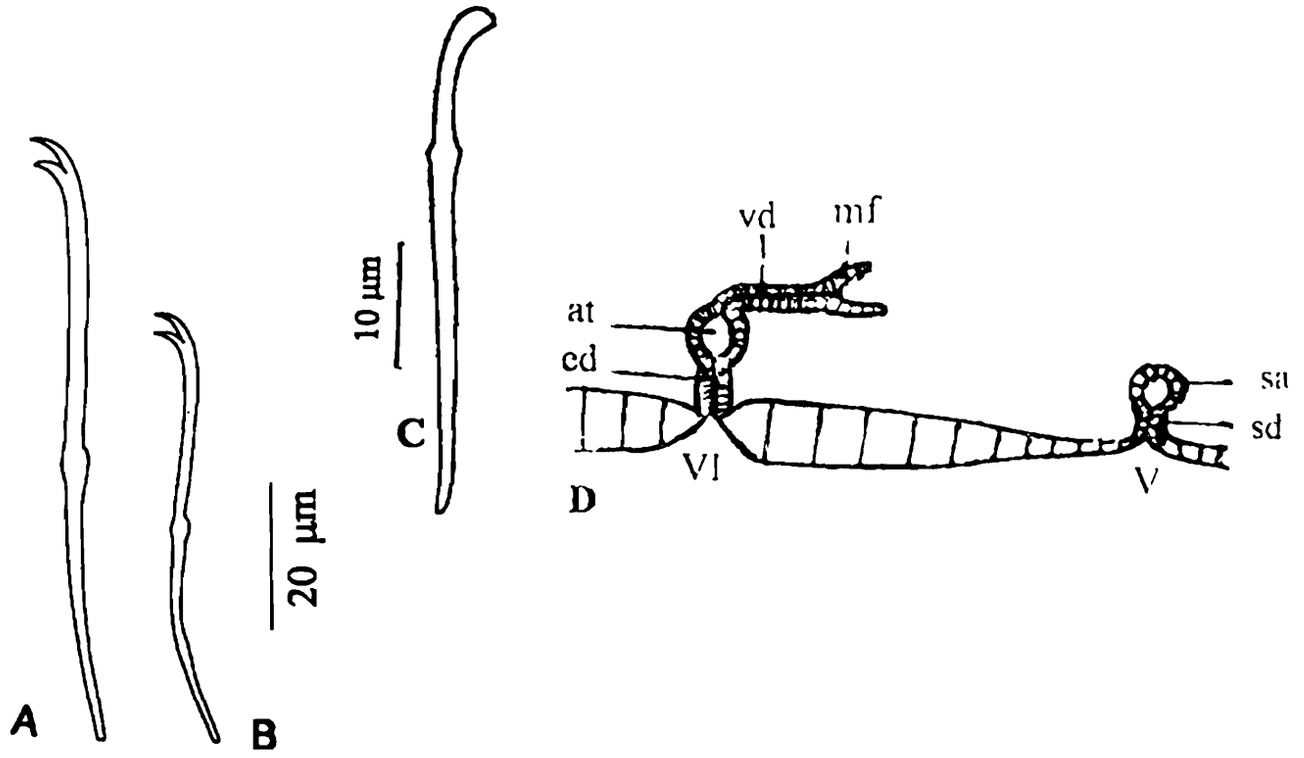

Fig. 11 : *Chaetogaster langi.* A, B : Ventral setae of II and VI; C : Penial seta; D : Genital organs. (A, B from Ercolini, 1969; D from Sperber, 1948). at : atrium; ed : ejaculatory duct; mf : male funnel; sa : spermamathecal ampulla; sd : spermathecal duct; vd : vas deferens.

Mouth sub-terminal, ovoid, always open, gape increasing and decreasing. Pharynx in II-III, wide. Oesophagus in IV, narrow, half as long as pharynx. Stomach in V-VI, yellowish, barrel-shaped, with 8-10 transverse vascular ducts. Pharynx and stomach push septa 3/4 and 4/5 into III and V. Intestine from VII, wide, yellowish. Septa perforated. Chloragocytess from V. Coelomocytes absent. Brain opaque with a statocyst in centre. Dorsal vessel mid-dorsal, contractile and ventral vessel mid-ventral, non-contractile, placed immediately above and below the alimentary canal, with 2 contractile, lateral vessels connecting them in IV Nephridia two per segment, exonephric, starting from VI or VII, consisting of a glandular mass and a coiled nephridial duct, opening by a nephropore ventro-laterally.

Clitellum in V-VII. Testes and ovaries attached to ventral nerve-cord, close to septa 4/5 and 5/6 respectively. Sperm-sac and ovi-sac small. Male funnels (Fig. 11 D-mf) cup-shaped, ciliated, 15 µm long, 11 µm wide. Vasa deferentia (Fig. 11 D-vd) about 30 µm long, 6.5 µm wide, opening into atria on top. Atrial ampullae (Fig. 11 D-at) spherical, 15 µm in diameter and ejaculatory ducts (Fig. 11 D-ed) about 15 µm long. Penial setae (Fig. 11 C) 2 per bundle in VI, distal end bluntly pointed and with a distal nodulus located about 1/4 distance from distal end. Spermathecae in V, their ampullae (Fig 11 D-sa) spherical, thin-walled, their ducts (Fig. 11 D-sd) half as long as ampullae, bulged before opening to exterior ventro-laterally.

Worms with 1-3 budding zones common.

Habits : Worms live among *Spongilla carteri, S. decipiens, S. crateriformis, Plumatella repens* var. *emarginata, Ephidatia crateriformis (*Potts*)* etc. in fresh water. Also found in brackish water.

Distribution : India : Chittoor, Chandragiri, Tirupati, Cuddapah, Hyderabad (Andhra Pradesh); Bellary, Mysore (Karnataka); Khandala, Satara (Maharastra); Ujjain (Madhya Pradesh); Gurdaspur district (Punjab); Chandigarh; Haryana; Kolkata (West Bengal). Lahore (Pakistan); Inle Lake in Shan Plateau (Burma); Peradeniya (Sri Lanka); Col-de-Sabzzak, Herat (Afghanistan); Seistan (Persia);

World distribution : Cosmopolitan.

Chaetogaster limnaei bengalensis Annandale, 1905.
(Fig. 12)

Chaetogaster bengalensis Annandale, 1905: 117; Stephenson, 1907b : 248; Michaelsen, 1910 : 7; Stephenson, 1918 : 10; Stephenson, 1920 : 195; 1923 : 49.

Chaetogaster limnaei bengalensis, Naidu, 1966 : 211; Gates, 1972 : 316; Mukhopadhyay, 1998 : 100.

Type locality : Kolkata, West Bengal, India.

l = 3-8 mm; d = 0.2 mm; s = 17-26 (chain) + undifferentiated region; n = 9-11.

Description : Worms small, colourless and transparent. Prostomium rudimentary. Eyes absent. Ventral setae (Fig. 12 A, B) strongly hooked, 11-20 in all bundles, in II 130-140 μm long, 2 μm thick with teeth 6.5 μm long, distal thinner and slightly longer than proximal; in others 60-88 μm long, 1.7 mm thick, with teeth equally long, distal thinner than proximal, Nodulus distal in all setae.

Mouth large, circular opening ventro-terminal, obliquely forward and downward. Pharynx in II-III wide. Oesophagus in IV narrow. Stomach in V-VII, thin-walled, wide with a ring of cells hanging into lumen of stomach around opening with oesophagus. Vascular plexus on stomach wall forming regular network of rectangular spaces by transverse and longitudinal vessels. Intestine from VIII, wide. Chloragogen cells from V. Brain with a statocyst. Chen (1940) reported sensory papillae of two types, larger ones about 7-11 μm in height, found around circumference of setal bundles, and smaller ones irregularly distributed on body wall. Each sensory papilla conical with a few stiff cilia. Dorsal vessel contractile and mid-dorsal. Ventral vessel non-contractile and mid-ventral. One pair of hearts connects them in IV Nephridia begin in IV, large and exonephric attached to body-wall.

Sex organs not known. Asexual reproduction by formation of budding zones, producing 5 anterior segments to posterior zooid and some hind segments to anterior zooid before separation.

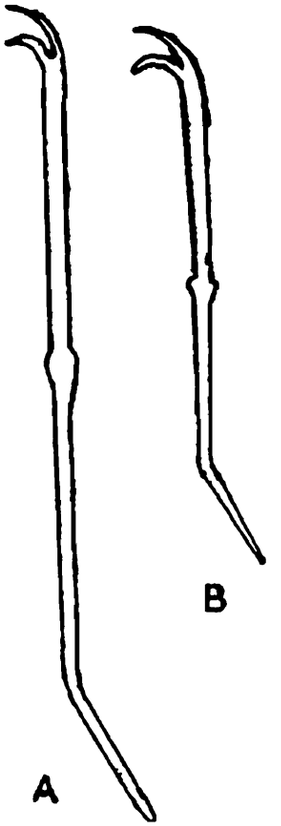

Fig. 12 : *Chaetogaster limnaei bangalensis*. A, B : Ventral setae of II and VI.

Habits : Worms live as commensals in mouth cavity of molluscs, *Limnaea gedrosiana* var. *rectilatrum*, *L. acuminata*, *L. chlamys* and among sponges *Ephydatia fluviatilis* and *Spongilla carteri*, etc., in fresh water.

Distribution : India : Satara Fort (Maharastra); Ujjain (Madhya Pradesh); Modhopur in Gurdaspur district (Punjab); Kolkata (West Bengal). Lahore (Pakistan); Inle Lake in Shan State (Burma); Nowshera (Peshawar).

World distribution : Persia; China; Asiatic Russia (Asia).

Chaetogaster limnaei limnaei von Baer, 1827.
(Fig. 13)

Chaetogaster limnaei von Baer, 1827 : 611; Michaelsen, 1909a : 131; 1910 : 7; Stephenson, 1918 : 9; 1920 : 195; 1923 : 50;

Chaetogaster limnaei limnaei, Sperber, 1960 : 155; Naidu, 1966 : 211; Vasisht & Gandhi, 1972 : 99.

Chaetogaster limnaei, Gates, 1972 : 316.

Type locality : Unassigned, in Germany.

l(p.) = 2-3 mm (chain of 2); d(p.) = 0.15-0.20 mm; s =14-28 (chain of 2) + undifferentiated region; n = 8-9.

Description : Worms minute, colourless and transparent, with annular wrinkles on body surface. Prostomium rudimentary hardly marked off from peristomium, with fine stiff cilia around margin. Ventral setae (Fig. 13 A, B) strongly hooked with teeth at right angles to shaft, in II 5-20 per bundle 53-123 μm long, 2 μm thick, teeth equally thick, and long, 6.5 μm long each. In others 4-20 per bundle, 50-60 μm long, 1.7 μm thick, teeth equally thick, distal 4.5 μm long and proximal 4.8 μm long. Nodulus distal in all setae, more distal than in other species of genus.

Mouth nearly at anterior end of body. Pharynx in II-III, wide and suctorial. Oesophagus very short in anterior half of IV, narrow. Stomach in ½IV-VI, wide, thin-walled, with a vascular plexus forming an irregular network. Intestine from VII, wide. Brain with a statocyst. Dorsal vessel mid-dorsal and contractile. Ventral vessel mid-ventral and non-contractile. A pair of lateral hearts connect dorsal and ventral vessels in IV. Nephridia large from VI or VII attached to body-wall.

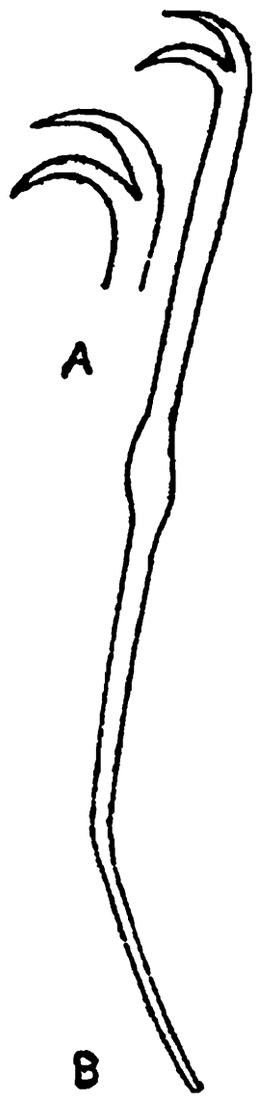

Fig. 13 : *Chaetogaster limnaei limnaei*. A, B : Ventral setae of II and VI. (all from Sperber, 1948.

Clitellum in V-VII. Spermathecae with long duct. Atria small and elongated. Penial setae 14 per bundle, with a double hook. Asexual reproduction by development of fission zones, 1-3 fission zones common, producing 5 anterior segments to posterior and several segments to anterior zooids.

Habits : Worms live as parasites or commensals in respiratory chamber of fresh water molluscs, belonging to several species of *Limnaea*, *Planorbis*, *Bithynia tentaculata, Ephydatia carinatus* in fresh and brackish waters. Live as commensal in *Lymnaea tomentosa* ingesting cercaria of *Fasicola hepatica* (Rajasekhariah, 1973).

Distribution : India : Naini Tal (Uttaranchal); Chandigarh; Punjab; Haryana. North-West Frontier Province (Pakistan); Inle Lake in Shan Plateau (Burma); Chindaud in Herat and Farah, Etang, Ali Cheng in Lagman district, north east of Djelalabad (Afghanistan).

World distribution : Asia; Afria; Europe; North & South America.

Subfamily NAIDINAE Lstockin, 1924

Naidinae Lastockin. Sperber, 1948: 92; Brinkhurst, 1964 : 204; 1966 : 72; Chekanovskaya, 1962 : 157; Brinkhurst & Jamieson, 1971 : 322; Brinkhurst, 1985 : 471; Mukhopadhyay, 1998 : 100.

Diagnosis : Eyes present or absent. Dorsal bundles with hair setae and bifid or sigle pointed needle setae. Pharynx with dorsal diverticulum, pharyngeal and oesophageal or septal glands present. Commissural vessels in I-V, simple or forming a plexes, additional free loops often present. Nephridia present or absent. Testes and speremathecae in IV or V, ovaries and atria in V and VI. Four or five segments formed anteriorly, by budding or fragmentation. Cosmopolitan.

Type genus : *Nais* Müller, 1773.

Subfamily Naidinae has twenty one genera (1) *Nais* Müller, 1773, (2) *Slavina* Vejdovsky, 1883, (3) *Stylaria* Lamarck, 1816, (4) *Heamonais* Brestcher, 1900, (5) *Branchidriolus* Michealsen, 1900, (6) *Dero* Oken, 1815, (7) *Aulophorus* Schmarda, 1861, (8) *Allonais* Sperber, 1948, (9) *Ripistes* Dujardin, 1842, (10), *Ophidonais* Gervais, (11) *Uncinais* Levinsen, 1894, (12) *Homocheata* Brestcher, 1896, (13) *Vejdovskyella* Michaelsen, 1903, (14) *Arctonais* Piguet, 1928, (15) *Specaria* Sperber, 1939, (16) *Piguetella* Sperber, 1948, (17) *Allodero* Sperber, 1948, (18) *Neonais* Sokoloskaya, 1962, (19) *Waspa* Marcus, 1963, (20) *Rhopalnais* Dzwillo and Grimm, 1974, (21) *Bratislavia* Kosel, 1976. Of these, first eight genera occur in the subcontinent.

Key to Indian genera of subfamily NAIDINAE

1. Prostomium with proboscis ..... ***Stylaria***

– Prostomium without proboscis 2

2. Branchial processes present 3

– Branchial processes absent 5

3. Gills finger like, dorso-lateral processes, two per segment in anterior segments ..... ***Branchiodrilus***

– Gill processes around anus in funnel-shaped fossa at hind end 4

4. Branchial fossa with palps ..... ***Aulophorus***.

– Branchial fossa without palps ..... ***Dero***

5. Dorsal bundles begin from XVIII, XIX or XX in adults ..... ***Haemonais***

– Dorsal bundles begin from IV,V or VI 6

6. Aseual reproduction by fragmentation, dorsal setae begin VI ..... ***Allonais***

– Asexual reproduction by formation of fission zones 7

7. Hair setae of VI very long, body with rows of sensory papillae covered with foreign matter ..... ***Slavina***

– Elongated hair setae absent, body not covered with papillae and foreign matter ..... ***Nais***

Genus ***Nais*** Müller, 1773

Nais Müller, 1773 : 23; Beddard, 1895 : 281; Stephenson, 1923 : 53 ; 1930 : 732; Sperber, 1948 : 102; Naidu, 1962a : 138; Chekanovskaya, 1962 : 178; Brinkhurst, 1964 : 206; Brinkhurst & Jamieson, 1971 : 328; Mukhopadhyay, 1998 : 107.

Diagnosis : Eyes normally present. Anterior segments usually pigmented. Ventral setae of II-V well differentiated from those of the following segments; dorsal setae beginning in VI, with hairs and bifid or simple-pointed needles. Pharynx II-III, pharyngeal and oesophageal glands present; stomach beginning in VII, occasionally in VIII or IX. Vascular system with simple or anastomosing transverse vessels in I-V. Coelomocytes present. Clitellum in ½V-VII, absent between the male pores; spermathecae with distinct ducts; vasa deferentia with prostate gland, joining atria immediately above atrial ducts; atria without prostate; penial setae present, with a simple or double hook. Cosmopolitan.

Type species : *Nais barbata* Müller, 1773.

Key to India species of genus *Nais*

1. Needle setae simple-pointed 2

– Needle setae bifid 5

2. Needle setae more or less hairlike with long sharp tip 3

– Needle setae with short blunt tip 4

3. Ventral setae from VI much shorter, stouter, more curved than anterior setae, with equally long teeth; hairs and needles upto 5 each per bundle ..... *Nais barbata*

– Ventral setae behind V thin, not strongly curved with distal tooth about 1.5 times as long as proximal; hairs and needles 1-3 each per bundle ..... *Nais pseudobtusa*

4. All ventral setae of about equal in length ..... *Nais andina*

– Ventral setae of II-V longer than rest ..... *Nais simplex*

5. Ventral setae of some segments behind V very thick with distal tooth several times longer than proximal 6

– Enlarged ventral setae absent 7

6. Thick ventral setae begin in VII, some segments (VIII-XIII) often have giant setae without proximal tooth; stomach dilates gradually ..... *Nais bretscheri*

– Thick ventral setae begin in VI, giant setae absent; stomach dilates abruptly ..... *Nais pardalis*

7. Needle teeth long, almost parallel; all ventral setae with distal tooth twice as long as proximal ..... *Nais elinguis*

– Needle teeth short, diverging; teeth of ventral setae about same length 8

8. Ventral setae of II-V slightly longer than the rest ..... *Nais variabilis*

– Ventral setae of all segments of equal length 9

9. Needle teeth minute, equal; swimming absent ..... *Nais communis*

– Needle teeth distinct, proximal thicker than distal; swims by spiral movements ..... *Nais andhrensis*

Nais andhrensis Naidu & Naidu, 1981
(Fig. 14)

Nais menoni Naidu, 1962a: 142; Naidu, 1966 : 212, Costa, 1967 : 41;

Nais andhrensis Naidu & Naidu, 1981b : 114.

Type locality : Cuddapah, Andhra Pradesh, India.

l(p.) = 2.5-3.0 mm; d(p.) = 0.2 mm; s = 20-35 + undifferentiated region; n = 22 (in one).

Description : Worms small, slender and brownish without any pigmentation. Eyes absent. Prostomium bluntly triangular with stiff sensory cilia on outer margin. Dorsal

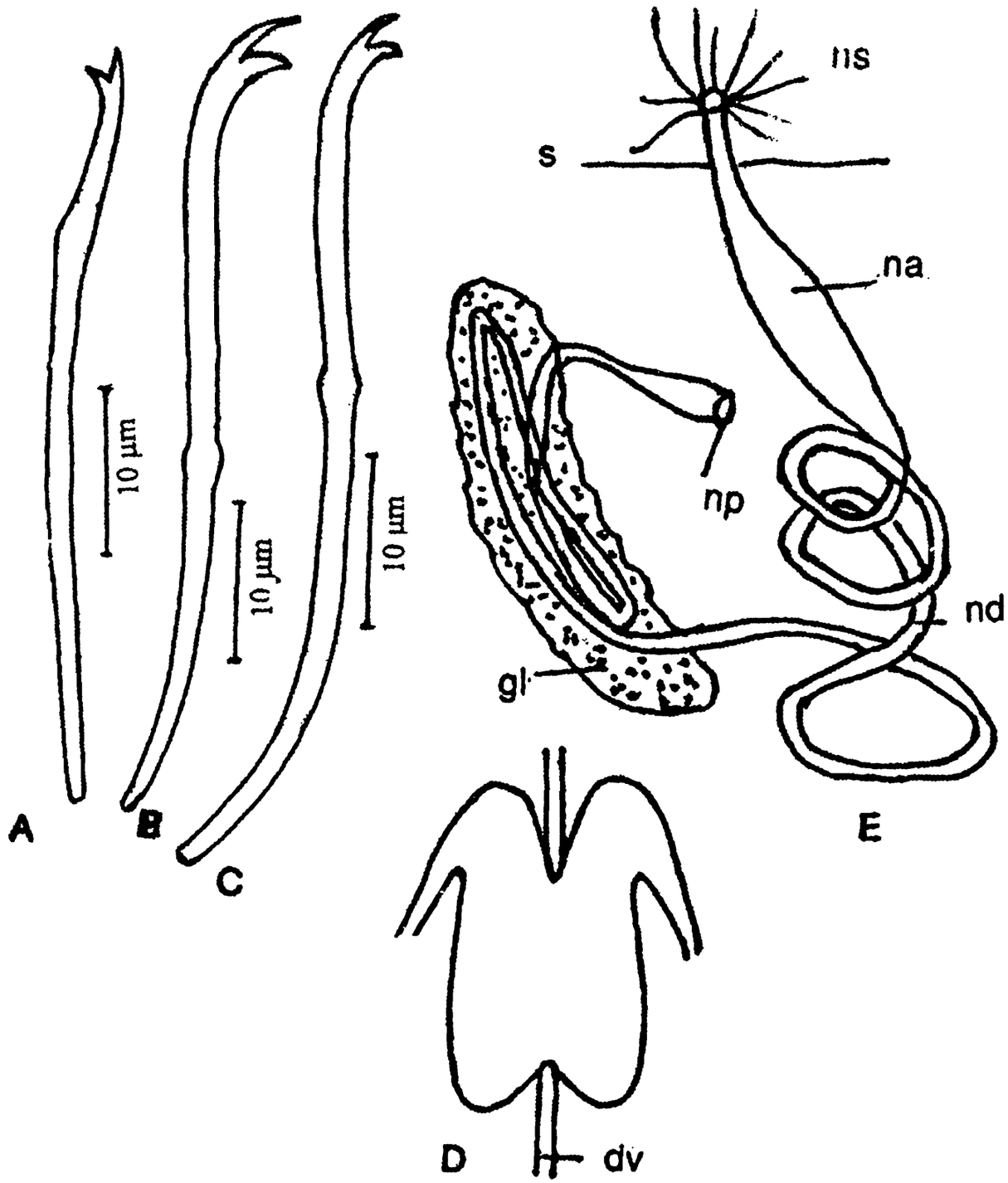

Fig. 14 : *Nais andhrensis.* A : Needle seta; B, C : Ventral seta of II and middle segment; D : Brain; E : Nephridium. dv : dorsal vessel; gl : gland; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

setae from V, 1 hair seta and 1 needle seta per bundle. Hair setae 140-175 μm long and needle setae bifid (Fig. 14 A) sickle-shaped, 40-45 μm long, with distal nodulus (D : P :: 1 : 3), teeth equally thick, distal straight and longer than proximal. Ventral setae (Fig. 14 B, C) in II-V 2-4 per bundle, less curved, 40-48 μm long, with proximal to middle nodulus (D : P :: 7 : 6; 1 : 1), distal tooth 1½ times as long as proximal; in rest 2-6 per bundle, 43-50 μm long, with distal nodulus (D : P :: 6 : 8) and teeth equally thick and distal longer than proximal.

Pharynx I-II, wide with a longitudinal slit in its roof and protrusible diverticulum. Oesophagus in IV-VIII narrow. Stomach in IX-X weak and gradual. Intestine from XI, sacculated with anti-peristalsis and ascending ciliary action occuring in it. Anus postero-dorsal. Chloragocytes brownish, start in VI. Coelomocytes numerous colourless, granular, spherical and morula-like. Septal glands absent. Brain (Fig. 14 D) incised deeply in front and less deeply behind. Blood yellowish. Dorsal vessel ventro-laterally attached to left of gut upto VI and mid-dorsal in head segments. Pharyngeal vascular plexus formed by loops from dorsal vessel. Lateral contractile vessels absent. First nephridium (Fig. 14 E) in VIII its pre-septale with fusiform brownish ampulla (Fig. 14 D-na) followed by a long ciliated duct (Fig. 14 D-nd), partly free and partly enclosed in gland tissue (Fig. 14 E-gl), opening by nephropore (Fig. 14 D-np) ventro-laterally in next segment.

Sex organs unknown. Worms develop one fission zone at a time and buds off prostomium and head segments to posterior zooid and some posterior segments to anterior zooid.

Habits : Worms live in fresh water and swim with brisk spiral movements.

Distribution : India : Udhakamandalam (Tamil Nadu); Cuddapah (Andhra Pradesh); Bangalore (Karnataka). Peradeniya (Sri Lanka).

World distribution : Known only in Indian subcontinent.

Remarks : Naidu (1962b) described a new species, *Nais menoni* distinguishing it form *N. communis* on basis of shape and position of nodulus of needle setae, position and shape of stomach, absence of lateral commissural blood vessels, size of setae and ability to swim. He however failed to compare new species with *N. variabilis*. Brinkhurst & Jamieson (1971) did not recognise this species and doubtfully placed it in *N. variabilis*. Naidu and Naidu (1981b) redescribed this species and named it as *Nais andhrensis* as name *menoni* was preoccupied having been used in *Pristina*, recorded as part of *Nais* by d'Udekem (1855).

Although needle setae of *N. andhrensis* resemble in shape and position of nodulus with those of *N. variabilis*, teeth are distinctive in that proximal tooth in former is slightly shorter and curved downwards, whereas in *N. variabilis* teeth are equal and proximal tooth is straight and not curved downwards. Also there are other differences,

in smaller size of setae and position and shape of stomach, hair setae are 140-175 μm (180-350 μm) long; ventral setae are 40-48 μm (86-107 μm) long; stomach is weak and gradual in IX-X (sudden and strong in VIII). Thus *N. andhrensis* is distinctive from *N. variabilis* and hence it is treated here as a distinct species.

Nais andina Cernosvitov, 1939
(Fig. 15)

Nais andina Cernosvitov, 1939 : 89; Naidu & Srivastava, 1980 : 263.

Type locality : Lake Titiaca; Peru.

l(p.) = 5-7 mm; d(p.) = 0.35-0.50 mm; s = 22-56 + undifferentiated region; n = 16-31.

Description : Worms of medium size, with pigment in head segments. Prostomium bluntly triangular. Eyes present or absent. Dorsal setae from VI, each bundle with 1-2 hair setate and 1-2 needle setae. Hair setae bayonet-shaped 100-180 μm long, smooth and simple. Needle setae (Fig. 15 A) sickle-shaped, simple pointed, 60-95 μm long, with nodulus about middle. Ventral setae (Fig. 15 B, C) 3-4 per bundle, in II-V thinner and straighter than rest, 90-112 μm long, with median nodulus, distal tooth thinner about twice as long as proximal. In rest, thicker, more curved, 90-107 μm long, with distal nodulus, distal tooth thinner and equal or slightly longer than proximal.

Pharynx in II-IV, wide. Oesophagusin V-VI, narrow. Stomach in VII-VIII, fusiform. Intestine narrow in IX-X and wide from XI. Coelomocytes spherical, 8-10 μm in diameter. Chloragocytes start from VI. Dorsal vessel contractile, laterally attached to gut on left side from hind end to VI, and mid-dorsal anteriorly.

Clitellum in V-½VII (2½ segments). Male funnels (Fig. 15 F-mf) cup-shaped and ciliated, laterally on anterior face of septum 5/6. Vasa deferentia (Fig. 15 F-vd) short, covered with prostate gland cells (Fig. 15 F-p) all their length and open into atrial ampulla on its anterior face about middle. Atrial ampulla (Fig. 15 F-a) ovoid about 77 μm long and 55 μm wide, thin-walled. Ejaculatory duct (Fig. 15 F-ed) short and bulging about middle of duct and opening to exterior in front of ventral bundles of VI. Penial setae (Fig. 15 D) 3 per bundle, 110 μm long, with distal nodulus and a simple blunt hook distally. Spermathecae (Fig. 15 E) a pair in V, club-shaped, 176 μm long; ampullae (Fig. 15 E-sa) 70 μm wide, thin-walled, their ducts (Fig. 15 E-sd) short, thin-walled 66 μm long and 30 μm wide, opening to exterior ventro-laterally in V. Asexual reproduction by paratomy. Asexual and sexual reproduction occur simultaneously upto some point, when fully mature sexually, asexual reproduction discontinued.

Commensals : Epizoic Vorticillids (Protozoa) were found attached to setae all over the worms from Nagpur (Naidu & Srivastava, 1980).

Habits : Live in fresh water.

Distribution : India : Nagpur (Maharastra).

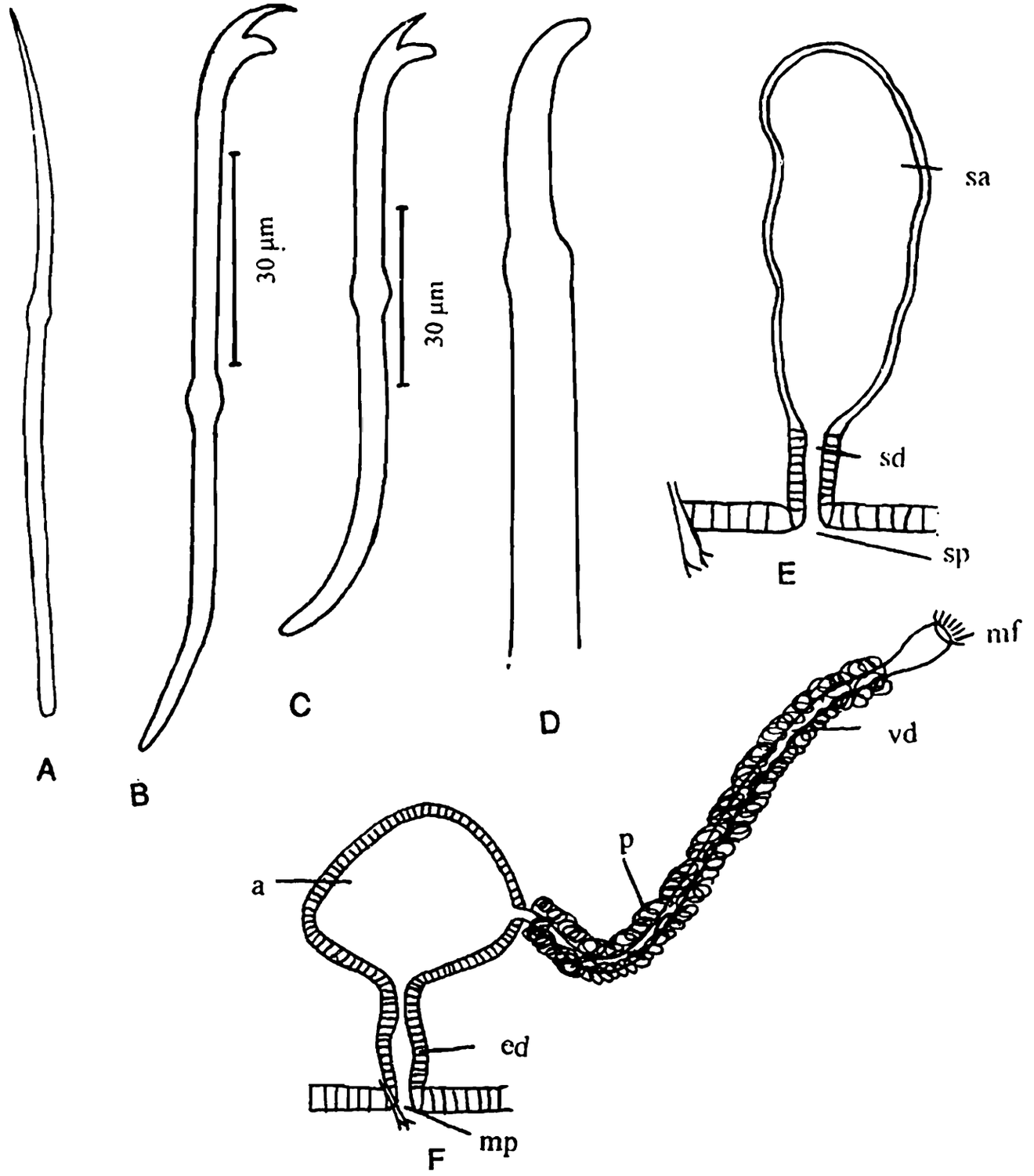

Fig. 15 : *Nais andina.* A : Needle seta; B, C : Ventral seta of II and middle segment; D : Penial seta; E : Spermatheca; F : Male efferent apparatus. a : atrium; ed : ejaculatory duct; mf : male funnel; mp : male pore; p : prostate; sa : spermamathecal ampulla; sd : spermathecal duct; sp : spermathecal pore; vd : vas deferens.

World distribution : India (Asia); Finland (Europe); Lake Titiaca in Peru, Bolivia (South America).

Nais barbata Müller, 1773
(Fig. 16)

Nais barbata Müller, 1773 : 23.

Nais obtusa (Gervais 1838), Michaelsen, 1909a : 131.

Nais sp. Stephenson, 1909 : 108.

Nais obtusa, Michaelsen, 1910 : 7; Stephenson, 1923 : 60.

Nais sp. (*obtusa*), Cernosvitov, 1942b : 282.

Nais barbata, Sperber, 1960 : 156.

Nais obtusa, Naidu, 1966 : 211.

Nais barbata, Vaisisht, Julka & Bala, 1987 : 141; Mukhopadhyay, 1998 : 108.

Type locality : Unassigned, Germany.

l(p.) = 3-5 mm; d(p.) = 0.20-0.25 mm; s = 21-33 undifferentiated region; n = 11-19.

Description : Worms of medium size, brownish in colour and with bright yellow pigmentation in anterior segments. Prostomium bluntly triangular, longer than broad. Eyes present. Dorsal setae from VI, 1-5 hair setae and 2-5 needle setae per bundle. Hairs stiff simple, 135-311 μm long and 3 μm thick. Needle setae (Fig. 16 A) single-pointed with a long sharp tip, 90-132 μm long 3 μm thick, and with a slightly distal nodulus. Ventral setae (Fig. 16 B, C) 2-5 per bundle, in II-V 96-132 μm long, 2.7-3.0 μm thick, much longer, thinner and straighter than rest, with proximal nodulus, teeth equally thick, distal longer than proximal. In VI, 96-105 μm long, 4.5 μm thick, with distal tooth shorter and much thinner than proximal, with distal nodulus. In rest 75-113 μm long, 3.3 μm thick, with distal tooth much thinner and shorter than proximal, and with distal nodulus.

Mouth a transverse slit. Buccal cavity in I-II. Pharynx in III-V wide. Oesophagus in VI narrow. Stomach in VII-VIII, sudden dilatation. Intestine from IX, wide and sacculated. Anus postero-dorsal. Dorsal vessel ventraly attached to left of gut from hind end to VI, and mid-dorsal anteriorly. Lateral vascular vessels from II-IV.

Clitellum in V-VII. Male funnels (Fig. 16 D-mf) large, cup-shaped, ciliated, opening into sperm-sac (Fig. 16 D-ss) and directed backwards. Vasa deferentia (Fig. 16 D-vd) long, sinuous, with prostate gland cells (Fig. 16 D-p), entering atria on their anterior face at base. Atrial ampullae (Fig. 16 D-a) ovoid, when filled elongated backwards, walls muscular, thickened around openings of vasa deferentia. Ejaculatory ducts (Fig. 16 D-ed) short, narrow, opening on rounded papillae ventro-laterally in VI. Spermathecal ampullae elongated (Fig. 16 D-s) thin-walled and stretching to whole

of V, their ducts long, well marked off, dilated distally opening ventro-laterally in V. Penial setae 2-3 per bundle, with a simple hook. Asexual reproduction by developments of budding zones.

Habits : Worms live on Polyzoans, *Plumatella repens* var. *emarginata*, and *P. fruticosa* in fresh-water and swim with spiral movements.

Parasites : Astomatous ciliate (Protozoa) *Radiophrya biacuta* de Puytorac, 1954, and *Juxtaradoiphrya naisensis* de Puytora, 1954 are parasitic in this species (de Puytorac, 1954).

Distribution : India : Chandigarh; Lucknow (Uttar Pradesh); Kolkata (West Bengal). Se-Chen (Tibet); several ocalities in Afghanistan.

World distribution : Asia; Afria, Europe; North America.

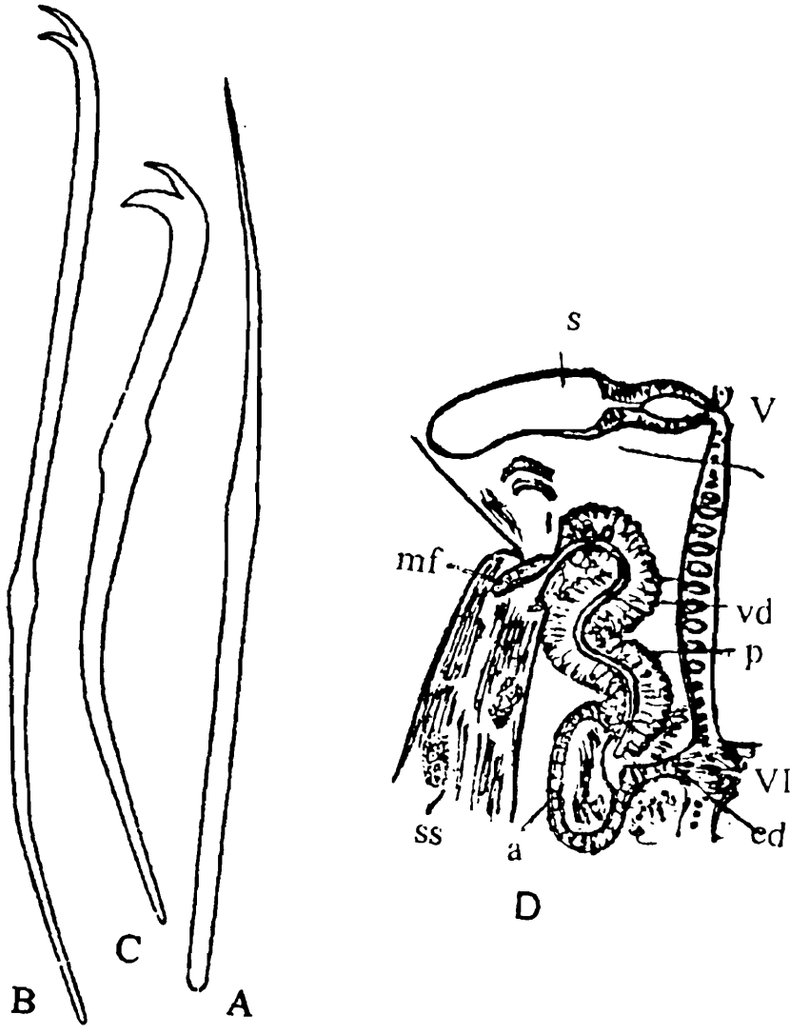

Fig. 16 : *Nais barbata.* A : Needle seta; B, C : Ventral seta of II and middle segment; D : Genital organs (all from Chekanovskaya, 1962). a : atrium; ed : ejaculatory duct; mf : male funnel; p : prostate; s : spermamatheca; ss : sperm sac; vd : vas deferens.

Nais bretscheri Michaelsen, 1899
(Fig. 17)

Nais bretscheri Michaelsen, 1899 : 121; Sperber, 1960 : 157.

Type locality : Unassigned, Switzerland.

l(p.) = 3-7 mm; d(p.) = 0.25-0.30 mm; s = 19-34 + undifferentiated region; n = 13-26.

Description : Worms of small size, delicate with heavy pigmentation, Prostomium bluntly triangular. Eyes present, rarely absent. Dorsal setae from VI, 1-2 hair setae and 1-2 needle setae per bundle. Hair setae simple, smooth; nearly straight, 84-135 μm long. Needle setae bifid, (Fig. 17 I) 52-73 μm long, 2.0-2.5 μm thick, with nodulus about 1/3 from distal end, teeth parallel about equal in length and thickness. Ventral setae of II-V (Fig. 17 A) 2-7 per bundle, thin and straight, 75-105 μm long, 1.6 μm thick, with proximal nodulus; distal tooth curved, twice as long as and equal in thickness as proximal; and in rest 6 per bundle, of three different types : (1) normal setae (Fig. 17 B) with distal nodulus and of three different thicknesses, with distal tooth 1-3 times as long as and thinner than proximal, 70-83 μm long, (2) thick setae (Fig. 17 C, D) in VIII-XIII, longer and thicker than former, with distal tooth as thick as and 2-3 times as long as proximal, 78-86 μm long, 4.5 μm thick; (3) in some cases

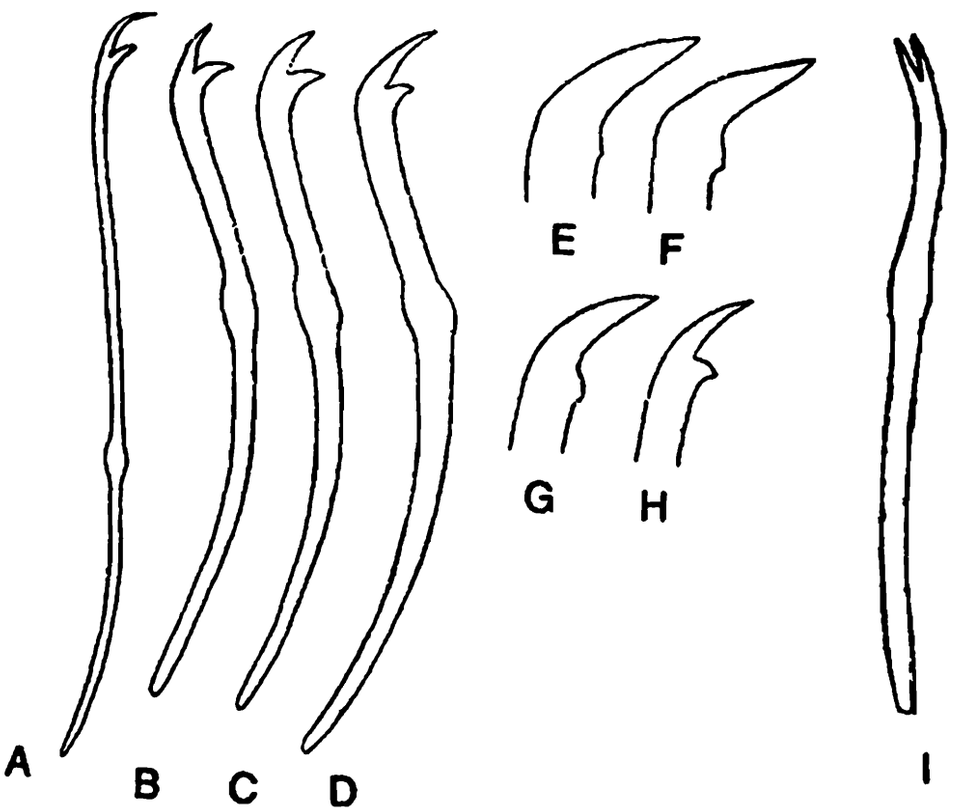

Fig. 17 : *Nais bretscheri.* A : Ventral seta of II; B, C, D : Normal setae of XV; E, F, G : Giant ventral setae of VIII-XI; H : Thick seta from XIII; I : Needle seta. (A-H from Sperber, 1948; I from Yamaguchi, 1953).

giant setae (Fig. 17E-H) very long and thick, 112-125 μm long, 7.5 μm thick with distal tooth 12-15 μm long, abruptly bent at base and with a rudimentary proximal tooth. Giant setae always single, along with 1-2 thick setae per bundle.

Phaynx in II-IV Oesophagus in V-VI. Stomach in VII, wide. Intestine narrow in VIII and wide and sacculated from IX. Chloragocytes from VI. Coelomocytes present. Dorsal vessel to left of gut from hind end to VI and mid-dorsal in anterior five segments.

Clitellum from ½V-VII (2½ segments), absent between male pores. Testes and ovaries, a pair each in V and VI, laterally, on posterior face of septa 4/5 and 5/6 respectively, close to ventral body-wall. Sperm-sac and ovi-sac, each single, back pouchings of septa 5/6 and 6/7 respectively, extending to X and XII. Male funnels on septum 5/6, continued into short vasa deferentia covered with prostate gland cells, and enter globular atria just above short ejaculatory ducts. Penial setae 2 per bundle with a simple hook distally. Spermathecal ampulla ovoid or pear-shaped with a short duct. Asexual reproduction by paratomy, fission zone forming prostomium and 5 head segments to posterior zooid and several posterior segments to anterior zooid before they separate.

Habits : Worms live in fresh water and were never found swimming.

Distribution : Afghanistan : Sar-Haouz.

World distribution : Asia; Afria; Europe; Mississipi, Columbia (North America); South America.

Nais communis Piguet, 1906
(Fig. 18)

Nais communis Piguet, 1906 : 247.

Nais variabilis var. *punjabensis* Stephenson, 1909b : 255; 1010a : 66; 1910b : 237.

Nais communis var. *caeca* Stephenson, 1910b : 238.

Nais communis, Michaelsen, 1910 : 7.

Nais communis var. p*unjabensis*, Stephenson, 1913a : 737; 1915b : 786; 1918 : 12.

Nais communis var *caeca,* Stephenson, 1918 : 12.

Nais communis var. *punja·ensis*, Stephenson, 1920 : 196.

Nais communis, Mehra, 1920 : 457.

Nais communis var. *punjabensis*, Mehra, 1920 : 457; Stephenson, 1923 : 55.

Nais communis var. *caeca*, Stephenson, 1923 : 57; 1924a : 321; 1925b : 44.

Nais communis var. *punjabensis*, Aiyer, 1929a : 21.

Nais communis, Stephenson, 1931a : 39; Sperber, 1960 : 156; Naidu, 1962a : 140; 1966 : 212; Costa, 1967 : 41; Vasisht & Gandhi, 1972, 99; Gates, 1972 : 316; Naidu & Naidu, 1979b : 412; Naidu & Srivastava, 1980 : 263; Naidu, Kalpana & Sureshkumar, 1981 : 104; Naidu & Naidu, 1981b : 113; Sobhana & Nair, 1983a : 103.

Type locality : Zurich, Switzerland.

l(p.) = 2-5 mm; d(p.) = 0.15-0.18 mm; s = 15-32 + undifferentiated region; n = 15-28.

Description : Worms small, delicate, pale white with bright yellow or brown pigmentation in I-V. Prostomium bluntly triangular, anterior border fringed with stiff sensory cilia. Eyes at base of prostomium laterally at level of mouth, deeply purple in colour, rarely absent. Body segmentation distinct. Dorsal setae from VI, 1-2 hair setae and 1-2 needle setae per bundle. Hair setae simple, smooth nearly straight, 190-268 μm long. Needle setae (Fig. 18 A) bifid, slightly sickle-shaped 40-80 μm long, with a weak nodulus a third from distal end, and with distinct teeth, equal and diverging. Ventral setae (Fig. 18 B, C) bifid, 2-6 per bundle, 63-93 μm long, in II-V with median nodulus (D : P :: 1 : 1) hardly longer and slightly straighter and thinner than rest. Setae of rest, 49-56 μm long, slightly thicker, more curved than anterior setae, with slightly distal nodulus (D : P :: 5 : 6), distal tooth longer and thinner than proximal.

Mouth a transerse slit, ventral, with prostomium overhanging. Pharynx in II-V, wide. Oesophagus in VI, narrow. Stomach in VII-VIII, wide anteriorly. Intestine narrow in IX, wide and sacculated from X. Anus postero-dorsal. Chloragogen cells start in VI, brownish. Coelomocytes spherical, about 10 μm in diameter, with greenish granules in living worms. Septa well developed. Brain (Fig. 18 D, I-g) incised deeply behind and less deeply in front. Blood yellowish. Dorsal vessel attached to left of gut from hind end to VI and mid-dorsal in anterior segments, divides into two and unite below pharynx in II to form ventral vessel. Lateral contractile vessels 3 pairs in III-V, first and second pairs branched into two each, third pair unbranched, all of them open into ventral vessel. First nephridium (Fig. 18 E) in VII, with its nephrostome (Fig. 18 E-ns) in VI, its duct piercing through septum and dilates into an ampulla (Fig. 18 E-na), after which with uniform diameter through its numerous coils, partly enclosed in glandular part (Fig. 18 E-g) and open into a terminal dilatation, which opens to exterior by nephropore (Fig. 18 E-np) on a level a little in front of ventral bundles.

Clitellum from ½V-VII (2½ segments). Testes appear first in V close to septum 4/5 on either side, and as they begin to disappear, ovaries (Fig. 19 I-o) appear in VI close to septum 5/6 laterally. Oviduct (Fig. 18 I-d) in VI. Sperm-sac (Fig. 18 I-s) and ovi-sac (Fig. 18 I-i), back-pouchings of septa 5/6 and 6/7 extend to X and XI respectively, former within latter. Male funnels (Fig. 18 I-m) cup-shaped and ciliated, on anterior face of septum 5/6, with their faces turned backwards into sperm-sac. Vasa deferentia turn downwards and make two bends and open into atria on their anterior face, a little below middle. Major part of vasa deferentia covered with prostate gland cells

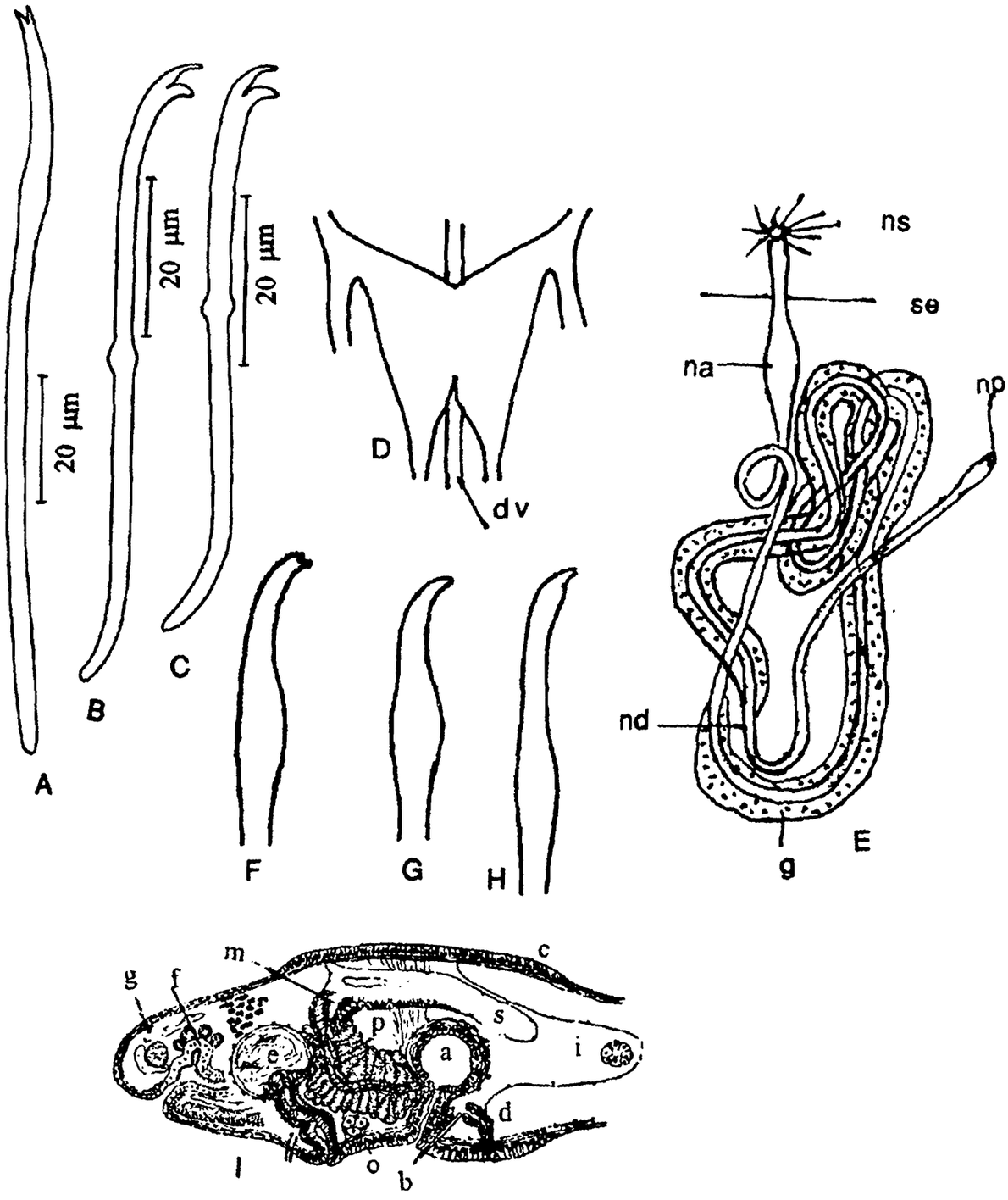

Fig. 18 : *Nais communis.* A : Needle seta; B, C : Ventral seta of II and VII; D : Brain; E : Nephridium; F, G, H : Penial setae; I : Genital organs. (F, G, H from Stephenson, 1923; I from Marcus, 1943). a : atrium; b : penial seta; c : clitellum; d : oviduct; dv : dorsal vessel; e : spermathecal ampulla; f : pharynx, g : brain; i : ovi-sac; m : male funnel; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; o : ovary; p : prostate gland cells around vas deferens; s : sperm-sac; se : septum.

(Fig. 18 I-p). Atrial ampulla (Fig. 18 I-a) spherical, ejaculatory duct as log as atrium, swollen below before opening to exterior ventro-laterally in VI. Penial setae (Fig. 18 F-H) 2-3 per bundle, about 63 μm long, short, curved and swollen near distal end with a blunt, simple hook, simple pointed or slightly bifid. Spermathecae (Fig. 18 I-e) ovoid in V, when full extending to VI, ducts tubular, narrow opening to exterior in front of ventral setae of V. Asexual reproduction by development of budding zones. One budding zone common, 2 and 3 zones rare. In a chain of 4, first fission zone between XVI and XVII, second zone a segment in front, third formed some segments behind first zone. All fission zones are in different stages of development.

Habits : Worms live in fresh and brackish water among aquatic vegetation feeding on it and on Protozoans, Rotifers, etc. They are also reported from *Spongilla carteri* and from mass of polyzoan *Plumatella* sp. at Bheemanagar and Chennai respectively, and also in masses of polyzoan *Plumatella* (*Afrindenella*) *tanganykia* in Chennai. Swimming absent.

Commensals : Protozoans related to *Spirochona* and vorticellids were found attached to setae, more to head segments and smaller number to other parts of body (Naidu & Srivastava, 1980)

Parasites : Three sporozoan parasitise these worms. Numerous cysts of two actinomyxid sporozoans. *Triactinomyxon naidanum* Naidu, 1956 (Naidu, 1956) and *Triactinomyxon* sp. (Naidu, 1959b) were found on intestinal wall of a few worms. Sporocysts of a microsporid sporozoan, *Mrazekia caudata* Lager and Hesse (Naidu, 1959a) were found in coelom of two worms. These parasites cause death of their host.

Distribution : India : Palghat, Malapuza, Bheemanagar, Nagarkoil, Veli Lake, Trivandrum (Kerala); Chennai, Udhakamandalam (Tamil Nadu); Chittoor, Horsley Hills, Cuddapah, Naidupeta, Gudur, Vijayawada, Vizianagaram, Hyderabad (Andhra Pradesh); Bangalore (Karnataka); Mumbai, Khandala, Nagpur (Maharastra); Ujjain (Madhya Pradesh); Agra (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Kausali (Himachal Pradesh); Srinagar (Jammu & Kashmir); Lohktak Lake (Manipur). Lahore, Peshawar (Pakistan); Inle Lake in Shan State (Burma); Parakrama Samudra, Polanuruwa (Sri Lanka); Several localities in Afghanistan.

World distribution : Cosmopolitan.

Nais elinguis Müller, 1773
(Fig. 19)

Nais elinguis Müller, 1773 : 22; Michaelsen, 1909a: 131; 1910 : 7; Stephenson, 1923 : 58; Sperber, 1960 : 157; Naidu, 1966 : 212; Vasisht & Gandhi, 1972 : 99; Mukhopadhyay, 1998 : 108.

Type locality : Unassigned, Germany.

l(p.) = 2.2-12 mm; d(p.) = 0.2-0.3 mm; s = 15-37 + undifferentiated region; n = 12-21.

Description : Worms small, delicate, with brownish or reddish brown pigmentation in anterior segments. Prostomium bluntly triangular. Eyes present and rarely absent. Dorsal setae from VI, 1-3 hair setae and 1-3 needle setae per bundle. Hair setae 200-285 μm long, simple, smooth, nearly straight. Needle setae (Fig. 19 C) bifid 60-87 μm long, 1.5 μm thick, with nodulus about 1/3-1/4 from distal end, teeth long, equally thick, distal slightly longer than proximal. Ventral setae (Fig. 19 A, B) 2-5 per bundle, of II-V, thinner, slightly straighter and longer than rest, 78-97 μm long, 1.5-1.9 μm thick, with nodulus median to slightly distal. In rest 68-93 μm long, 2.4 μm thick, with distal nodulus. In both types, distal tooth twice as long as proximal and about equally thick.

Pharynx in II-IV, wide. Oesophagus in V-VI, narrow. Stomachal dilatation gradual in VII. Intestine narrow in VIII-IX, and wide and sacculated from X. Dorsal vessel mid-dorsal and contractile. Lateral vessels in I and II branching into 2 each, and in III-V unbranched.

Clitellum in V-VII. Sperm-sac and ovi-sac extend to IX and XI respectively, former within latter. Male funnels (Fig. 19 D-mf) ciliated, about 45 μm long, 45 μm wide, turned backwards in sperm-sac. Vasa deferentia (Fig. 19 D-vd) long and winding, about 250-400 μm long, wholly surrounded by prostatic gland cells (Fig. 19 D-p), open into atria on their anterior face immediately above ejaculatory ducts. Atrial ampulla

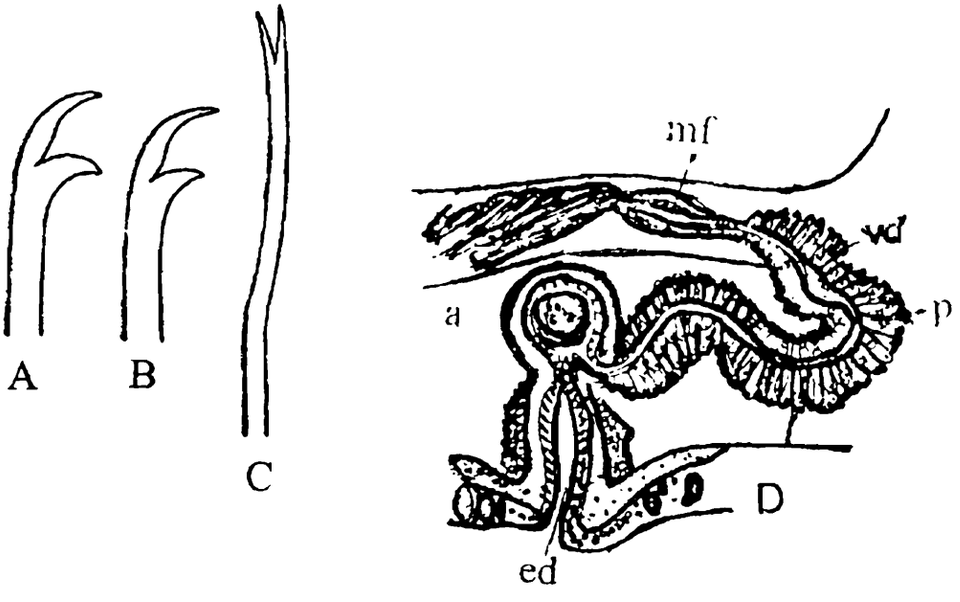

Fig. 19 : *Nais elinguis*. A, B : Distal end of II and posterior segment; C : Distal end of needle seta; D : Genital organs. (A-C from Sperber, 1948 : D from Chekanovskaya, 1962). a : atrial ampulla; ed : ejaculatory duct; mf : male funnel; p : prostate; vd : vas deferens.

(Fig. 19 D-a) spherical 80 μm high, 65-70 μm long and 50 μm wide, with its strongly muscular wall. Ejaculatory duct (Fig. 19 D-ed) 75 μm long, swollen about middle and opens at top of tubular depression of body wall. Penial setae 4-5 per bundle, 108-110 μm long, with simple distal hook. Spermathecae in V, their ampullae large bag-like, somewhat twisted round each other, 225-240 μm long, 90-105 μm wide with 1.5-3.0 μm thick wall, ducts fairly long, about 75 μm long, 24-28 μm thick with an inconspicuous lumen. Asexual reproduction by paratomy, fission zone develop prostomium and head segments to posterior individual, and several posterior segments to anterior individual before separation.

Habits : Worms live in *Spongilla carteri* and *Plumatella emarginata* and also frequently found in brackish water in Europe. Swim with lateral movements.

Predators : Chironomid (Diptera) larva of *Cryptochironomus* sp., *Ablabesmyia* sp., *Conchapelopia* sp. prey upon this species in North America (Loden, 1974).

Distribution : India : Bheemanagar (Kerala); Alipur, Kolkata (West Bengal); Chandigarh; Punjab; Haryana. Lahore (Pakistan); Several localities in Afghanistan.

World distribution : Cosmopoplitan.

Nais pardalis Piguet, 1906
(Fig. 20)

Nais bretscheri var. pardalis Piguet, 1906 : 270.

Nais pardalis Piguet, 1909 : 206; Sperber, 1960 : 156.

Type locality : Unassigned, in Switzerland.

l(p.) = 3-5 mm; d(p.) = 0.20-0.27 mm; s = 14-32 + undifferentiated region; n = 13-21.

Description : Worms of medium size with brown pigmentation in anterior segments. Prostomium bluntly triangular. Eyes present. Dorsal setae from VI, each bundle with 1-2 hair setae, and 1-2 needle setae. Hairs 90-215 μm long, simple and straight. Needle setae (Fig. 20A) bifid, 60-82 μm long, 2 μm thick, with two equal fine teeth of 2 μm long and nodulus about 1/3 from distal end. Ventral setae (Fig. 20 B-D), of II-V, 2-5 per bundle, in II 98-108 μm long, 2 μm thick; in III-V 90-99 μm long, 2.4 μm thick, with median or slightly proximal nodulus, and distal tooth 1½-2 times as long as and slightly thicker than proximal. From VI on 1-5 per bundle, setae of 2 types, (1) normal setae (Fig. 20D), 66-78 μm long, 3.1-3.5 μm thick, of three kinds with equally thick prongs, or distal tooth equal or slightly longer than proximal, (2) usually thick setae (Fig. 20C), 80-92 μm long, 4.5 μm thick, with distal tooth 2-3 times as long as proximal with both teeth equally thick. Thick setae sometimes absent.

Pharynx in II-IV, wide. Oesophagus in V-VI, narrow. Stomach in VII, sudden dilatation, with elongated cells from anterior wall projecting into lumen of stomach.

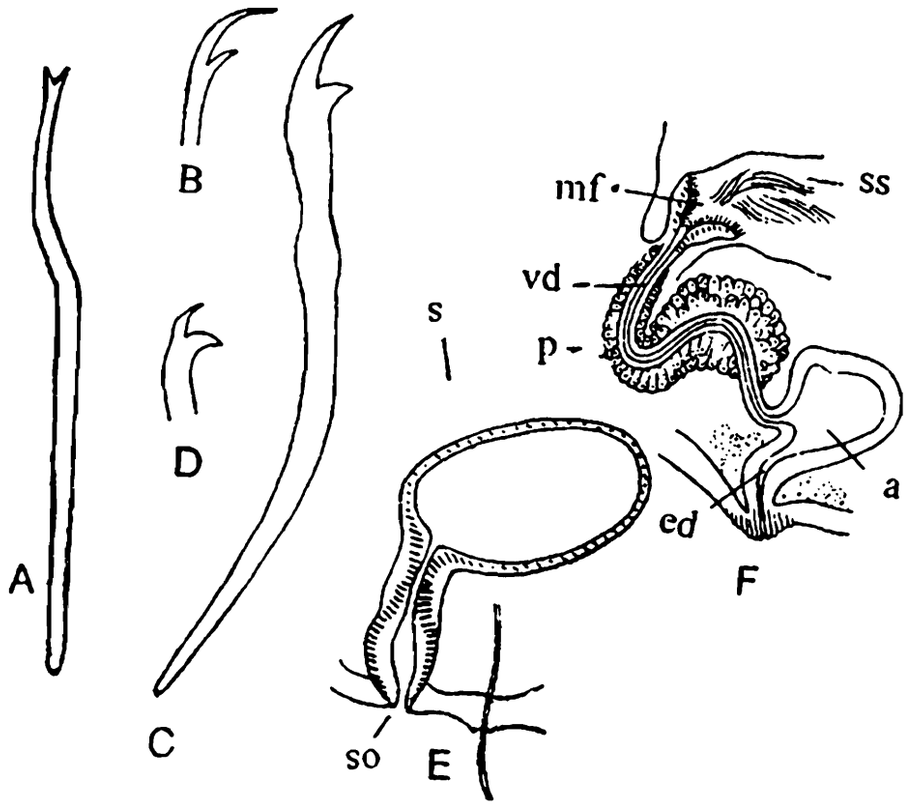

Fig. 20 : *Nais paradalis.* A : Needle seta; B : Distal end of ventral seta of II; C : Thick ventral seta of VI; D : Distal end of ventral seta of XVIII; E : Spermatheca; F : male efferent apparatus. (B-F from Sperber, 1948). a : atrium; ed : ejaculatory duct; mf : male funnel; p : prostate; s : spermatheca ampulla; so : spermathecal pore; ss : sperm-sac; vd : vas deferens.

Intestine narrow in VIII, and wide and sacculated from IX. Chloragogen cells from VI. Dorsal vessel ventro-laterally situated to left of gut from hind end to VI and mid-dorsal anteriorly. Commissural vessels of I-III anastomosing, and of IV-V independent. Nephridia from VII, with nephrostomes laterally on anterior side of septum 6/7 Elongated cardiac cells with a canal similar to stomach cells of *Pristina* present.

Clitellum in ½V-VII (2½ segments), absent between male pores. Sperm-sac (Fig. 20 F-ss) and ovi-sac, back-pouching of septa 5/6 and 6/7 extend to X and XII respectively, former within later. Male funnels (Fig. 20 F-mf) cup-shaped, ciliated on anterior face of septum 5/6, open into sperm-sac and face themselves backwards and continue into vasa deferentia (Fig. 20 F-vd) bent twice, covered with prostatic gland cells (Fig. 20 F-p) and open on anterior face medianally into atrial ampullae. Atrial ampulla (Fig. 20 F-a) pear-shaped, thick-walled, ejaculatory duct (Fig. 20 F-ed) narrow, curving forwards and opening ventro-laterally in VI. Penial setae 3 per bundle of common *Nais* type. Spermathecae ampulla (Fig. 20 E-s) ovoid with thick-walled ducts, with distal swelling and opening ventro-laterally in V. Asexual reproduction by paratomy. Prostomium and five anterior segments to posterior individual and several posterior segments to anterior individual budded off before separation.

Habits : Worms live in fresh water and swim with spiral movements.

Distribution : Afghanistan : Elbak, North of Kandahar.

World distribution : Asia; Africa; Europe; North, Central and South America.

Nais pseudobtusa Piguet, 1906
(Fig. 21)

Nais obtusa var. *pseudobtusa* Piguet, 1906 : 238.

Nais pseudobtusa Piguet, 1909 : 193; Sperber, 1960 : 157.

Type locality : Unassigned, in Switzerland.

l(p.) = 1.7-2.5 mm; d(p.) = 0.2 mm; s = 17-28 + undifferentiated region; n = 11-18.

Descrition : Worms small, delicate, orange red in colour, with brown pigmentation in anterior segments. Prostomium bluntly triangular. Eyes absent. Dorsal setae from VI, 1-3 hair setae and 1-3 needle setae per bundle. Hair setae 163-300 μm long, 1.2 μm thick, simple, smooth and nearly straight. Needle setae (Fig. 21A) 57-75 μm long, 1.2 μm thick, with a long pointed tip, with a weak nodulus 1/3 from distal end. Ventral setae (Fig. 21 B, C) of II-V, 2-5 per bundle, with proximal nodulus, 70-99 μm long, 1.2-1.3 μm thick, longer, straighter and slenderer than rest, and with distal tooth thinner and about 1½ times longer than proximal. In rest, 2-6 per bundle, with a distal nodulus (D : P :: 2 : 3) 54-71 μm long, 1.6-1.7 μm thick, shorter than former, distal tooth thinner and 1¼ times longer than proximal.

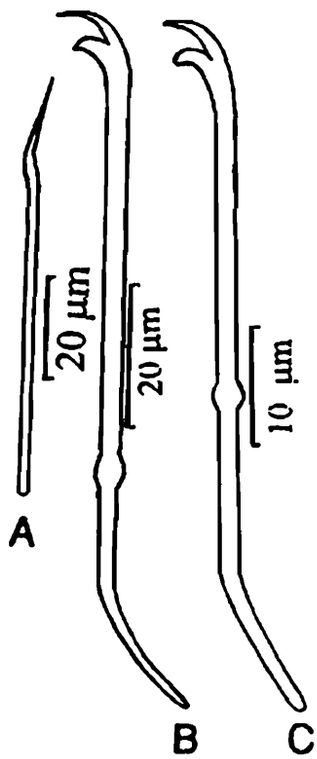

Fig. 21 : *Nais pseudobtusa.* A : Needle seta; B, C : Ventral setae of II and VIII.

Pharynx in II-IV wide. Oesophagus in V-VI, narrow. Stomach suddenly dilating in VII. Intestine narrow in VIII and wide and sacculated from IX. Dorsal vessel lateral to left of gut from hind end to VI and mid-dorsal in II-V.

Clitellum in V-VII. Sperm-sac and ovi-sac when full, extend upto IX and XI respectively. Male funnels very thick with a median ciliated lobe. Vasa deferenti short, thick and nearly straight covered with prostate gland cells whole of their lengths, opening into atria above ejaculatory ducts. Atrial ampulla spherical, with a thick wall, ejaculatory duct narrow and well defined. Penial setae 2-3 per bundle, with a simple hook distally, often with a vestigeal distal tooth. Spermathecal ampulla ovoid, with a long dilated duct. Asexual reproduction by budding zones, one at a time. Prostomium and 5 anterior segments to posterior individual, and several posterior segments to anterior individual budded off by budding zone before separation.

Habits : Worms live in fresh water and swim about with spiral movement.

Distribution : Afghanistan : Several localities.

World distribution : Asia; South-West Africa; Europe; North America; South America; Queensland (Australia); New Zealand.

Nais simplex Piguet, 1906
(Fig. 22)

Nais variabilis var. simplex Piguet, 1906 : 260.

Nais simplex, Piguet, 1909 : 202.

Nais sp. Stephenson, 1909a : 108; Cernosvitov, 1942b : 282.

Nais simplex, Sperber, 1960 : 156; Ali & Issaque, 1975 : 55; Ahmed & Singh, 1987 : 288; Mukhopadhyay, 1998 : 108.

Type locality : Zurich, Switzerland.

l(p.) = 2-5 mm; d(p.) = 0.2-0.25 mm; s = 18-48 + undifferentiated region; n = 14-22.

Description : Worms small, delicate, brownish in life, with variable pigmentation. Prostomium bluntly triangular, with stiff sensory cilia on margin. Eyes present at base of prostomium on either side of mouth. Dorsal setae from VI, 1-2 hair setae and 1-2 needle setae per bundle. Hair setae 190-255 μm long. Needle setae (Fig. 22 C) 80-90 μm long, simple-pointed with weak nodulus about 1/3 from distal end. Ventral setae in II-V, 2-6 per bundle, longer, straighter and thinner than in rest with a proximal nodulus, in II longest 90-105 μm long, in V, 73-85 μm long, 2.5 μm thick, with distal tooth nearly twice as long as and thinner than proximal. In rest 2-5 per bundle, shorter, less straight, thicker, 90-100 μm long, 3.0-3.5 μm thick with a distal nodulus, distal tooth thinner, slightly longer to slightly shorter than proximal.

Pharynx in II-V, wide. Oesophagus in VI, narrow. Stomach dilates abruptly in VII-

VIII. Intestine narrow in IX and wide and sacculated from X. Chloragocytes from VI. Coelomocytes present. Dorsal vessel mid-dorsal in II-V and lateral to left of gut from VI onwards. Nephridia from VII or VIII with a nephridial funnel with thin membrane around border and ciliated in VI or VII.

Clitellum in V-VII. Sperm-sac (Fig. 22 D-ss) and ovi-sac extend upto IX and X respectively. Male funnels (Fig. 22 D-mf) roundish 20-25 μm long, 20-25 μm wide. Vasa deferentia (Fig. 22 D-vd) almost straight, 60-90 μm long 15 μm wide, covered with prostate gland cells (Fig. 22 D-pr) on distal half close to atria and opening into atria on their anterior face at junction with ejaculatory ducts (Fig. 22 D-ed). Atrial ampulla (Fig. 22 D-at) ovoid 40-50 μm long, 30-40 μm wide, 30-45 μm high with 3.5-6 μm thick walls. Ejaculatory duct (Fig. 22 D-ed) 25-40 μm long, 15-20 μm wide with walls of 7-9 μm thick. Penial setae (Fig. 22 D-ps) 2-5 per bundle, 78-96 μm long. Spermathecae with small roundish or ovoid ampullae (Fig. 22 D-sa), when full about 30 μm high, 35 μm long, 35 μm wide, their ducts (Fig. 22 D-sd) distinct 40-45 μm long, 20 μm wide, with a strong dilatation 30 μm thick distally, with a wall thickness of 9-12 μm. Asexual reproduction by paratomy.

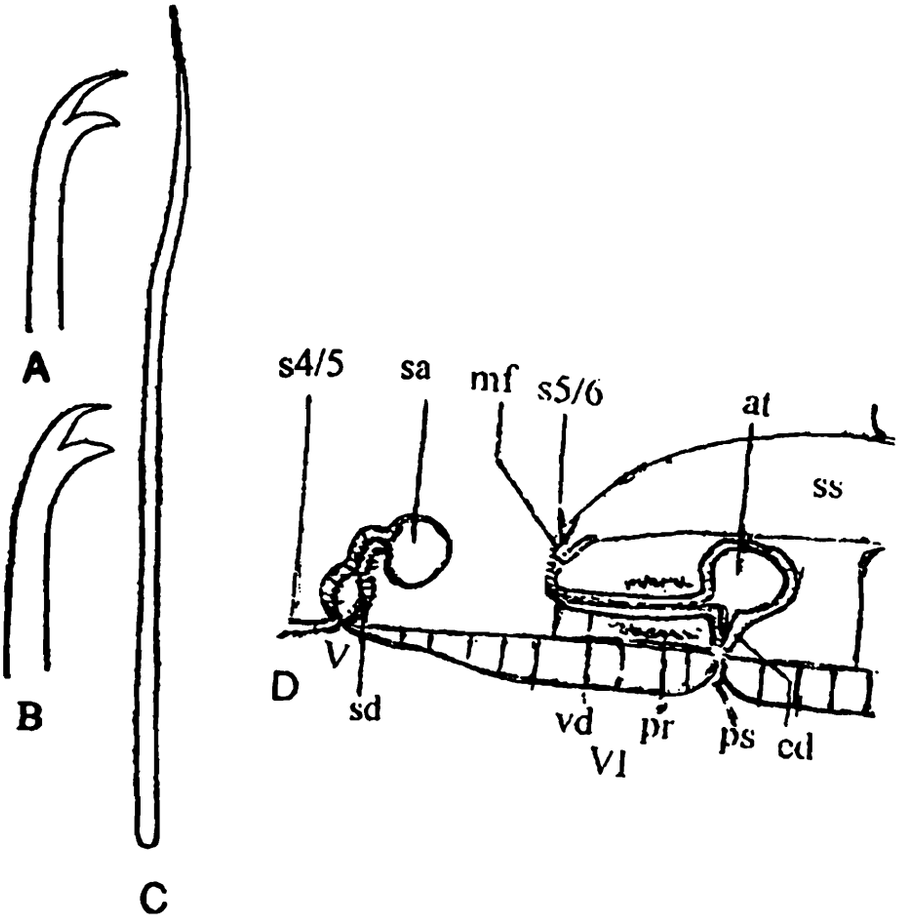

Fig. 22 : *Nais simplex.* A, B : Distal end of ventral seta of II and posterior segment; C : Needle seta; D : Genital organs. (all from Sperber, 1948). at : atrium; ed : ejaculatory duct; mf : male funnel; pr : prostate gland cells; ps : penial seta; sa : spermathecal ampulla; sd : spermathecal duct; ss : sperm-sac; vd : vas deferens; s4/5, s5/6 : septa 4/5 and 5/6.

Habits : Worms live in fresh water and are not observed swimming.

Distribution : India : Patna (Bihar) : Bankura, Howrah Sonarpur, Mourigram (West Bengal); Se-Chen (Tibet); Dhaka (Bangladesh); Several localities in Afghanistan.

World distribution : Cosmopolitan.

Nais variabilis Piguet, 1906
(Fig. 23)

Nais variabilis Piguet, 1906 : 253; Sperber, 1958 : 46; 1960 : 156; Naidu, 1966 : 213; Naidu & Naidu, 1979b : 413; Arunachalam et al., 1980 : 509; Battish & Sharma, 1997 : 82.

Type locality : Unassigned, Switzerland.

l(p.) = 2-3 mm; d(p.) = 0.2 mm; s = 19-38 + undifferentiated region; n = 12-21.

Description : Worms small, delicate with pigmentation in I-V, rarely absent. Prostomium bluntly triangular. Eyes present. Dorsal setae from VI, each bundle with 1-2 hair setae and 1-2 needle setae. Hairs simple, smooth, nearly straight, 180-350 μm long. Needle setae (Fig. 23 A) bifid, sickle-shaped, 50-66 μm long, 1.3-1.7 μm thick, with nodulus a third from distal end, teeth equally thick, short, diverging, distal slightly longer than proximal. Ventral setae (Fig. 23 B, C) 2-7 per bundle, in II-V, 86-107 μm long, 1.7-2.0 μm thick, with slightly proximal nodulus, thinner, longer and straighter than rest, with teeth equally thick, distal longer than proximal. In rest, 67-80 μm long, 2.5-3.0 μm thick, thicker, curved, with distal nodulus wih distal tooth longer and thinner than proximal.

Mouth a transverse slit at base of prostomium. Pharynx in I-IV, wide. Oesophagus in V-VII, narrow. Stomach in VIII, suddenly widens. Intestine narrow in IX and wide and sacculated from X. Chlorogocytes from VI. Coelomocytes present. Blood yellowish. Dorsal vessel mid-dorsal in II-V, lateral to left of gut from VI backwards. Nephridia begin in VII, each with short glandular part.

Clitellum in V-VII. Male funnels (Fig. 24 D-mf) cup-shaped, ciliated on anterior face of septum 5/6 laterally. Vasa deferentia (Fig. 23 D-vd) more or less straight, 70-90 μm long, 8-14 μm wide, surrounded by a dense layer of prostatic gland cells (Fig. 23 D-pr) immediately behind male funnels, last part close to atria may lack gland cells. They open into atria immediately above ejaculatory ducts. Atrial ampullae (Fig. 23 D-a) spherical or pear-shaped about 40 μm in diameter, with walls of 4-7 μm thick, ejaculatory ducts, 20-28 μm long, about 16 μm wide, with a swelling in middle. Penial setae 2-3 per bundle, about 89 μm long, with a simple blunt hook distally, rarely a rudimentary distal tooth present. Spermathecal ampullae (Fig. 23 D-sa) spherical, 40-50 μm in diameter, their ducts (Fig. 23 D-sd) 45-65 μm long, 15-25 μm wide, with a widening in middle. Asexual reproduction by development of budding zones, (Fig. 23 E-ZS) normally one at a time. Prostomium and 5 anterior segments budded off to

posterior zooid (Fig. 23 E-Z2) and several segments to anterior zooid (Fig. 23 EZ1), before they separate.

Habit : Worms live in fresh and brackish waters and swim with spiral movements.

Predators : This species preyed upon by Chironomid (Diptera) larvae of *Endochyronomus* sp., *Ablabesmyia* sp., *Pentaneura* sp., and *Chonchapelopia* sp. (Loden, 1974).

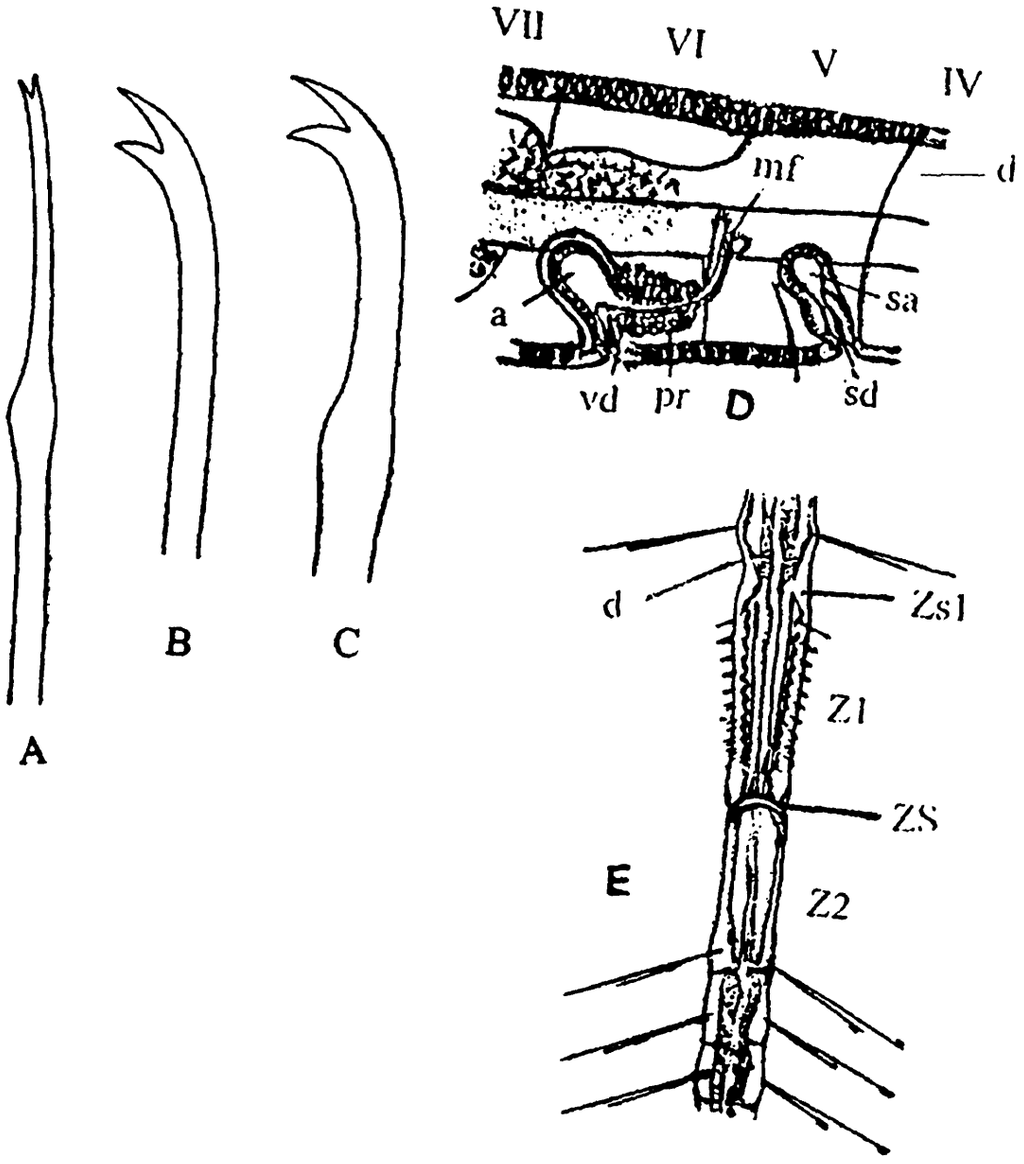

Fig. 23 : *Nais variabilis*. A : Needle seta; B, C : Ventral setae of II and VI; D : Genital organs; E : Budding zone. (A-C from Chekanovskaya, 1962, D from Sperber, 1948, E from Stephenson, 1930). IV, V, VI, VII : segments. a : atrial ampulla; d : septum; mf : male funnel; pr : prostate; sa : spermathecal ampulla; sd : spermathecal duct; vd : vas deferens; Z1 : new zooid; Z2 : posterior part of original worm; ZS : fission zone; Zsl : new fission zone.

Distribution : India : Veli Lake near Trivandrum (Kerala); Yercaud (Tamil Nadu); Horsley Hills, Hyderabad (Andhra Pradesh); Bangalore (Karnataka); Delhi; Chandigarh; Srinagar, Kokanrag, Acchhabal (Jammu & Kashmir). Several localities in Afghanistan.

World distribution : Cosmopolitan.

Genus ***Slavina*** Vejdovsky, 1883

Slavina Vejdovsky, 1883 : 219; Bousfield, 1886 : 267; Stephenson, 1923 : 80; 1930 : 733; Sperber, 1948 : 136; Chekanovskaya, 1962 : 167; Brinkhurst, 1964 : 209; Brinkhurst & Jamieson, 1971 : 344; Persia, 1980 : 88; Mukhopadhyay, 1998 : 109.

Diagnosis : Body wall with rows of sensory papillae, and usually surrounded by adhering foreign matter. Eyes present or absent. Dorsal setae beginning in IV or VI, non-serrated hairs and fine, usually simple needles, slightly curved distally. Stomach present; pharyngeal and oesophageal glands present. Coelomocytes present. Clitellum absent between male pores; vasa deferentia without prostate, joining atria above atrial duct, atria with or without prostate; penial setae present. Cosmopolitan.

Type species : *Slavina appendiculata* (d'Udekem, 1855).

Slavina appendiculata (d'Udekem, 1855)
(Fig. 24)

Nais appendiculata d'Udekem, 1855 : 552.

Slavina appendiculata (d'Udekem) Michaelsen, 1909a : 132.

Slavina punjabensis Stephenson, 1909b : 272.

Slavina appendiculata, Michaelsen, 1910 : 7.

Slavina punjabensis, Stephenson, 1913a : 737.

Slavina appendiculata, Michaelsen, 1913b : 207.

Slavina punjabensis, Stephenson, 1915c : 793.

Slavina sp. Stephenson, 1916 : 302.

Slavina appendiculata, Stephenson, 1923 : 82.

Slavina montana, Stephenson, 1923 : 84.

Slavina appendiculata, Stephenson, 1925b : 46.

Slavina punjabensis, Mehra, 1925 : 413.

Slavina appendiculata, Aiyer, 1929a : 30; Naidu, 1966 : 213; Costa, 1967: 42; Gates, 1972 : 316; Ali & Issaque, 1975 : 56; Naidu & Naidu, 1981b : 115.

Type localty : Unassigned, Belgium.

l = 5-20 mm; d = 0.4 mm; s = 23- 47 + undifferentiated region; n = 19-29.

Description : Worms (Fig. 25A) brownish, somewhat opaque covered with mucous coating with diatoms and mud particles. Prostomium bluntly triangular fringed with sensory cilia. Eyes a pair of black pigment with violet tinge located laterally at level of mouth. Skin bears a number of truncated cone-like sensory papillae with stiff hair like processes, arranged in transverse rows dorso-laterally, principal rows at level of setal bundles, between which accessory rows are located. Dorsal setal bundles from VI, 1-2 hair setae and 1-3 needle setae per bundle, hair setae of VI very long, upto 800 μm long and 3 μm thick, in others 270-450 μm long and 3 μm thick. Needles (Fig. 24 B) thin, straight, without nodulus, distal end gently curved and tapering with tip thickened and blunt, 50-70 μm long, 1.5 μm thick. Ventral setae (Fig. 24 C) 2-5 per bundle, in II-V thinner, in II slightly longer than others 100-147 μm long, 3 μm thick; in others 98-135 μm long, all with proximal nodulus and angular bend near proximal end, distal tooth thinner and longer than proximal, in II longest, with nodulus a third from proximal end.

Pharynx in II-IV Oesophagus in V-VI or V-VII; stomach in VII or VIII, globular; intestine from VIII or IX sacculated. Chlorogogen cells begin in V. Coelomic corpuscles (Fig. 24 D) large, colourless of various sizes, containing opaque dark brown granules. Dorsal vessel situated mid-dorsally. Commissural vessles in II-V forming a network. Nephridia start in VII with their cup-shaped nephrostome on the anterior face of septum 6/7. Clitellum (Fig. 24 F-c) in V-VII. Testes (Fig. 24 F-t) visible only in early stages of sexually. They are large, elongated masses stretching upwards and backwards in V, attached to posterior face of septum 4/5 near ventral body wall. Sperm-sac (Fig. 24 F-e) back-pouching of septum 5/6 with wide anterior opening, extending to X, contained in ovi-sac. Male funnels (Fig. 24 F-m) cup-shaped, ciliated, facing backwards into sperm-sac, vasa deferentia (fig. 24 F-d) narrow 110 μm long, 15 μm wide, curving downwards and entering atria immediately above atrial duct. Prostate (Fig. 24 F-p) surrounds vas deferens. Atria (Fig. 24 F-a) large, thick-walled, spherical or sub-spherical in segment VI, 70-80 μm in diameter, with scattered prostate gland cells. Atrial duct short and narrow leaving atrium ventrally. Spermathecae (Fig. 24 F-s) in V, their ampullae long, club-shaped, about 230 μm long, in sperm-sac. They fill front part of sperm-sac in VI winding round each other. The form of spermathecal ampulla vary considerably. Penial setae (Fig. 24 E) 3 per bundle, straight, stout with simple curved hook distally and with an indistinct nodulus. Asexual reproduction by paratomy.

Habits : Swimming absent. Worms live in fresh water among the polyzoan colonies of *Plumetella* and sponges belonging to *Spongilla* and also in the mud.

Distribution : India : Nagerkoil (Kerala); Udhakamandalam (Tamil Nadu); Bhim Tal (Uttanchal); Alipur, Kolkata (West Bengal); Andaman Island. Lahore (Pakistan); Dhaka (Bangladesh); Hindagala near Peradaniya (Sri Lanka).

World distribution : Cosmopolitan.

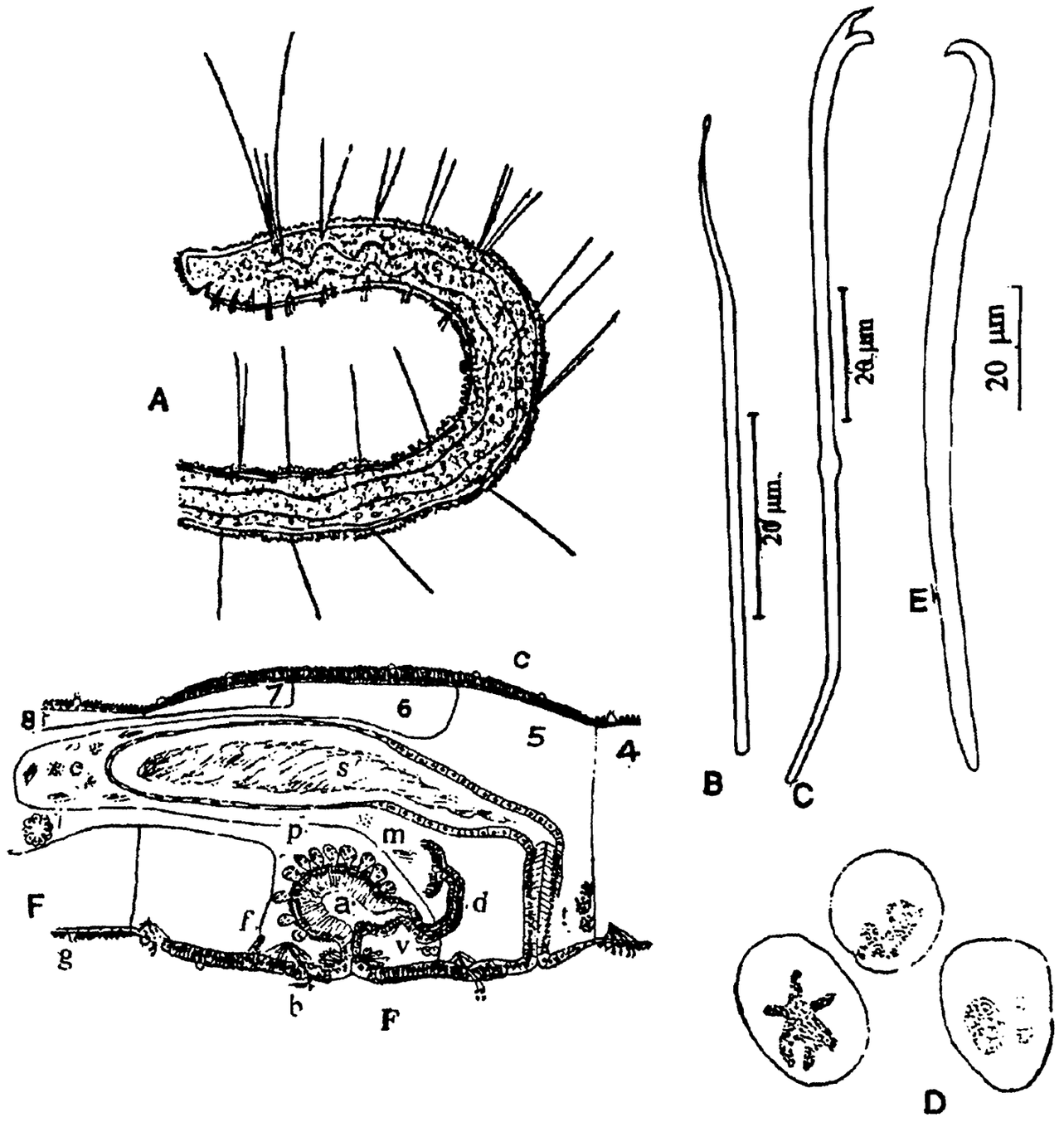

Fig 24 : *Slavina appendiculata.* A : Anterior part of body; B : Needle seta; C : Ventral seta of II; D : Coelomocytes; E : Penial seta; F : Genital organs. (A from Chekanovskaya, 1962; D from Stephenson, 1909b; E, F from Marcus, 1944). a : atrium; b : penial seta; c : clitellum; d : vas deferens; e : sperm sac; f : oviduct; i : ovi sac; m : male funnel; p : prostate gland cell; s : spermatheca; t : testis; v : ovary.

Genus ***Stylaria*** Lamarck, 1816

Stylaria Lamarck, 1816 : 223; Stephenson, 1923 : 85; 1930 : 733; Sperber, 1948 : 147; Naidu, 1962b : 520; Chekanovskaya, 1962 : 159; Brinkhurst, 1964 : 210; Brinkhurst & Jamieson, 1971 : 352; Persia, 1980 : 90.

Diagnosis : Eyes normally present. Pigment present. Prostomium forming a proboscis. Dorsal setae from VI, hairs and straight, simple-pointed needles without nodulus; ventral setae all with proximal tooth weak, nodulus proximal, distal part of setae straight, proximal part angularly bent. Pharyngeal, oesophageal glands and stomach present. Simple transverse vessels in II-V; dorsal vessel in middle line. Coelomocytes present. Clitellum absent around male pores; vasa deferentia with or without prostate glands in their hind most part; atria with prostate glands; penial setae present. Cosmopolitan.

Type species : *Stylaria lacustris* (Linnaeus, 1767).

Stylaria fossularis Leidy, 1852
(Fig. 25)

Stylaria fossularis Leidy, 1852b : 287.

Stylaria lacustris (Linnaeus, 1797). Michaelsen, 1909b : 27; Stephenson, 1909b : 276; Michaelsen, 1910 : 7; Stephenson, 1911 : 209.

Stylaria fossularis, Stephenson, 1913a : 739.

Stylaria kempi Stephenson, 1916 : 303.

Stylaria lacustris, Stephenson, 1920 : 200; 1923 : 85.

Stylaria kempi Stephenson, 1923 : 86.

Stylaria lacustris, Aiyer, 1925 : 31.

Stylaria kempi, Das, 1942 : 173.

Stylaria fossularis, Sperber, 1960 : 157; Naidu, 1962b : 520; 1966 : 213; Vasisht & Gandhi, 1972 : 99; Ali & Issaque, 1975 : 56; Naidu & Naidu, 1979b : 413; Sobhana & Nair, 1983a : 104; Tiwari, Saxena & Kulashrestha, 1988 : 67; Mukhopadhyay, 1998 : 109.

Type locality : Unassigned, North America.

l = single : 4-8 mm; chain : 8-18 mm; d = 0.25-0.30 mm; s = single : 18-36; chain = 27-68 + undifferentiated region; n = 15-34.

Description : Worms (Fig. 25 A) large, pale white with transparent body wall and delicate short, stiff cilia, more on prostomium and anal segment. Eyes a pair, (Fig. 25 A-e) crescent-shaped, blackish purple at base of prostomium on either side of mouth. Prostomium (Fig. 25 A-pr) semi-circular with a median conspicuous long proboscis about 1.6 μm long, 0.07 mm wide at base. Dorsal setae begin in VI, 1-3 hair setae and 23 needle setae per bundle. Hair setae 400-700 μm long, straight and smooth. Needle

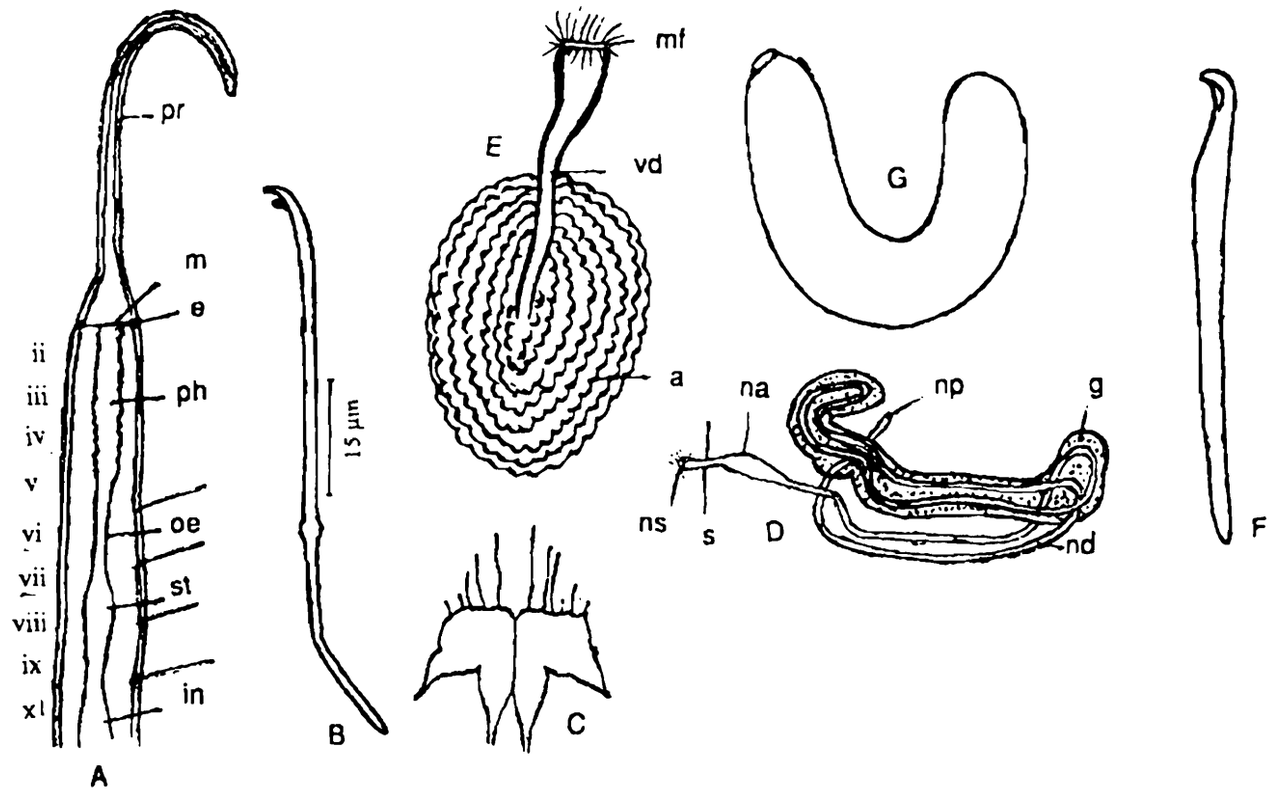

Fig 25 : *Stylaria fossularis.* A : Anterior part of worm; B : Ventral seta of III; C : Brain; D : Nephridium; E : Male efferent apparatus; F : penial seta; G : Spermatheca. (A, C from Stephenson, 1909b, 1911). a : atrium; e : eye; g : gland; in : intestine; m : mouth; mf : male funnel; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; oe : oesophagus; ph : pharynx; pr : proboscis; s : septum; st : stomach; ii-x : segments II-X; vd : vas deferens.

setae 40-70 µm long, simple-pointed without nodulus. Ventral setae (Fig. 25 B) all of one type, 6-14 per bundle in anterior and middle segments and decreasing to 2 per bundle in posterior segments, with a proximal bend, 90-135 µm long, with proximal nodulus (D : P :: 2 : 1) and distal prong very long, thicker and hooked than short proximal prong.

Pharynx (Fig. 25 A-ph) in II-IV, wide, bright yellow, partly eversible through mouth. Oesophagus (Fig. 25 A-oe) in V-VI, narrow. Stomach (Fig. 25 A-st) in VII-IX, barrel-shaped. Intestine (Fig. 25 A-in) from X. Gut ciliated with flame-like ciliary vibration and anti-peristalsis occuring in intestine. Chloragocytes from VI, grayish. Coelomocytes absent, but brownish oil globules present in coelom. Brain (Fig. 26 C) incised deeply behind and less deeply in front and detached from body-wall, with several nerves arising from anteror margin. Blood colourless. Dorsal vessel to left of gut upto VI and mid-dorsal in front. Contractile lateral vessels 3 pairs in III-V Nephridia (Fig. 25 D) paired, begin in VII with pre-septal ciliated funnels with nephrostome (Fig. 25 D-ns) on anterior face of septum 6/7 and post-septal with ampulla (Fig. 25 D-na) continuing as duct (Fig. 25 D-nd) partly enclosed in a glandular mass (Fig. 25 D-g) and opening by nephropores (Fig. 25 D-np) in front of ventral bundles.

Clitellum in V-VII, absent around male pores. Testes and ovaries a pair each, whitish, on either side of oesophagus in V and VI attached to posterior face of septa 4/5 and 5/6 respectively. Sperm-sac single back-pouching of septum 5/6 extending to X or XI. Male funnels (Fig. 25 E-mf) a pair of cup-shaped, strongly enlarged, on anterior face of septum 5/6, followed by a thinwalled vasa deferentia (Fig. 25 E-vd) opening into atria above ejaculatory duct. Atrial ampulla (Fig. 25 E-a) ovoid covered with gland cells, open to exterior ventro-laterally in VI by short ejaculatory duct. Prostates surround both vas deferens and atrium. Penial setae (Fig. 25 F) modified ventral setae of VI 2-3 per bundle, 84-91 μm long and 4.5 μm thick with a simple hook distally. Ovi-sac single, back-pouching of septum 6/7 extending to XI or XII. Female funnels a pair, small on septum 6/7, opening into ovi-sac. Spermathecae (Fig. 25 G) a pair in V, club-shaped, do not enter sperm-sac, opening ventro-laterally in V. Asexual reproduction and development of sex organs occur hand in hand, when worm reaches sexual maturity, asexual fission suspended. Number of budding zones developed. Second budding zone develops one segment in front of first budding zone, and third zone develops one segment in front of second zone, and fourth zone develops several segments behind first budding zone. Prostomium with proboscis and 5 anterior segments budded off to posterior individual and some posterior segments to anterior individual, before they separate.

Predators : This species is preyed upon by chronomid (Diptera) larvae of *Endochironomus* sp., *Tribelos* sp., *Glyptotendipes* sp., *Polypedium* sp., *Ablabesmyia* sp., *Labrundinia* sp., *Procladium* sp., and *Conchapelopis* sp. (Loden, 1974).

Habits : Worms live in fresh water among *Spirogyra* filaments and other filamentous algae feeding on decaying vegetable matter. They do not form tubes. Swim with brisk sagittal movement in horizontal plane.

Distribution : India : Veli Lake, Trivandrum (Kerala); Udhakamandalam (Tamil Nadu); Kambakam, Mamandur, Cuddapah (Andhra Pradesh); Bhopal (Madhya Pradesh); Bhim Tal (Uttaranchal); Lucknow (Uttar Pradesh); Chandigarh; Punjab; Haryana; Srinagar (Jammu & Kashmir); Bishnupur, Katwa, Usani, Lalbagh, Howrah, Bardhaman, Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Several localities in Afghanistan; Seistan (Persia).

World distribution : Cosmopolitan.

Genus ***Haemonais*** Bretscher, 1900

Haemonais Bretscher, 1900 : 16; Stephenson, 1923 : 78; 1930 : 734; Sperber, 1948 : 153; Naidu, 1962b : 522; Chekanovskaya, 1962 : 194; Brinkhurst, 1964 : 211; Brinkhurst & Jamieson, 1971 : 355.

Diagnosis : Eyes absent. Dorsal setae originally from II or VI, hairs and short bifid crotchets; after separation on budding, setae shed in a number of anterior segments

in posterior zooid. Ventral setae in a number of anterior segments differ in shape from posterior ones. Distinct stomachal dilatation absent. Chloragocytes present in all segments. Vascular system complicated, with an anterior network and transverse loops in all other segments, giving rise to longitudinal and transverse vessels along inner side of bodywall; dorsal vessel situated to left of gut. Coelomocytes presnet. Clitellum absent between male pores; vasa deferentia entering atria at upper part of anterior wall; prostate absent; penial setae present. Cosmopolitan.

Type species : *Haemonais waldvogeli* Bretscher, 1900.

Haemonais waldvogeli Bretscher, 1900
(Fig. 26)

Haemonais waldvogeli Bretscher, 1900 : 16.

Haemonais laurentii Stephenson, 1915a : 769; 1915b : 785; 1915d : 85; Mehra, 1920 : 457; Stephenson, 1923 : 79; 1924a : 321.

Haemonais waldvogeli, Naidu, 1962b : 522; 1966, 214; Battish & Sharma, 1997 : 82.

Type locality : Unassigned, Switzerland.

l(p.) = 5-7 mm; d(p.) = 0.3-0.4 mm; s = 40-100 + undifferentiated region; n = 31-56.

Description : Worma of moderate size, light brown, tapering anteriorly. Prostomium bluntly triangular. Dorsal setae primarily begin in VI, losing then as worm matures upto XVII to XIX, and later begin in XVIII, XIX or XX with 1 hair seta and 1 needle seta per bundle. Hair setae (Fig. 26 A) simple 130-160 μm long, 3 μm thick. Needlee sigmoid, bifid, 91-115 long, 4 μm thick at base, distal tooth longer and thicker than proximal, with a distal nodulus (D : P :: 3 : 5). Ventral setae (Fig. 26 B, C) 2-4 per bundle, in anterior 15-17 segments 80-104 μm long, 3 μm thick, straighter than rest, distal tooth longer and about half as trhick as proximal, with proximal to middle nodulus (D : P :: 4 : 3 or 3 : 5), from XVIII more curved, 80-96 μm, 4 μm thick, distal tooth shorter and much thinner than proximal, with distal nodulus (D : P :: 4 : 5 or 2 : 3).

Pharynx in II-IV with pharyngeal glands; oesophagus in V-XII; stomach absent; intestine from XIII, sacculated in each segment. Chloragogen cells begin in II, absent in III and present from IV to end of the gut. Coelomocytes spherical, nucleated, granular, 9-22 μm in diameter. Brain incised in front and behind. Blood red. Dorsal vessel contractile, attached to left of gut upto VI, and mid-dorsal in II-V. Anterior segments have a network of longitudinal and transverse vessels below parietes, former close to one another than latter, which are 2 pairs per segment. Ventral vessel non-contractile, formed by branches of dorsal vessel in II, separated from gut. Nephridia begin in VI, VII or VIII, with cup-shaped nephrostome on anterior face of septum 5/6, 6/7 or 7/8, passes into a narrow neck piercing through septum and connects post-septale in VII, VIIII or IX, consisting of a long cylindrical body followed by a thin long

ciliated coiled duct, partly free and partly enclosed in gland tissue, opening to outside by nephropore ventro-laterally.

Clitellum in ¼V-¼VIII, absent between male pores. Testes and ovaries seen in early part of sexuality, attached to posterior face of septa 4/5 and 5/6 respectively, close to ventral body wall. Sperm-sac (Fig. 26 D-ss) and ovi-sac back-pouchings of septa 5/6 and 6/7 extend to IX and X respectively. Male funnels (Fig. 26 D-mf) cup-shaped, ciliated, placed close to each other in anterior part of sperm-sac. Vasa deferentia (Fig. 26 E-vd) short, sbout, 30 μm thick with slightly twisted course and enter atrium on its upper surface. Atrium (Fig. 26 D-at) small, ovoid, 100 μm long and 70 μm wide. Ejaculatory ducts (Fig. 26 D-ed) shorter than atria. Prostate present. Spermathecae (Fig 26 D-sa) in V, ovoid 140 μm × 105 μm, their ducts (Fig. 26 D-sd) short and narrow, opening to outside about middle of segment V Penial setae (Fig. 26 E) 1-3 per bundle in VI, 110 μm long, 4 μm thick with distal end strongly hooked and bifid. Asexual reproduction by development of budding zone, which proliferates prostomium and 5 anterior segments to posterior zooid, and several hind segments

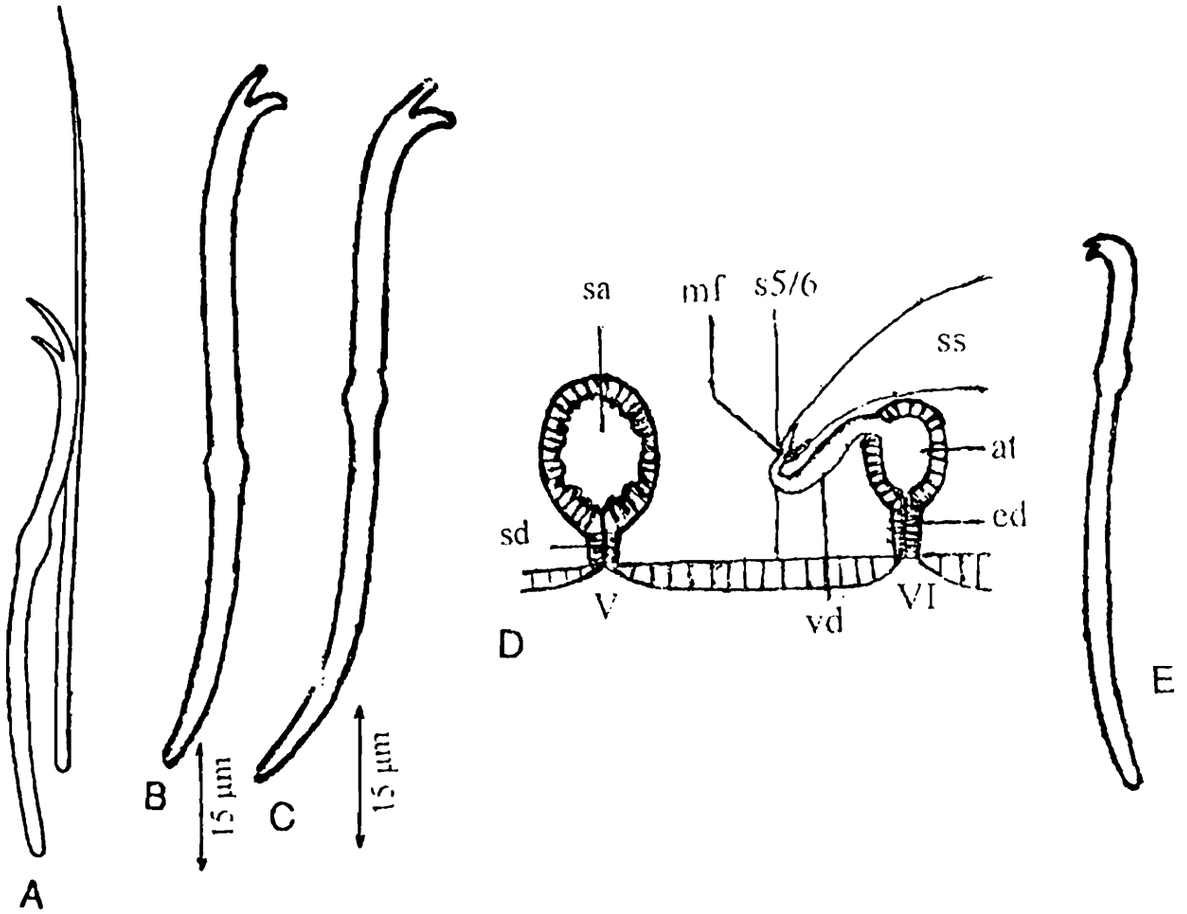

Fig 26 : *Haemonais waldvogeli.* A : Dorsal setal bundle; B, C : Ventral setae of anterior and posterior segment; D : Genital organs; E : Penial seta. (A, D from Sperber, 1948; E from Stephenson, 1923). at : atrium; ed : ejaculatory duct; mf : male funnel; s5/6 : septum 5/6; sa : spermathecal ampulla; sd : spermathecal duct; ss : sperm sac; vd : vas deferens.

to anterior zooid. As budding goes on, dorsal setae of anterior segments of posterior zooid gradually shed, first hair setae, then needle setae, and later thick, short, curved ventral setae gradually replaced, by thin, long, less curved setae.

Habits : Worms live in soft mud but not tube dwelling. On one occasion it was collected from mantle cavity of mollusc, *Vivipara bengalensis* in a shallow water tank in Nagpur. Swimming absent.

Distribution : India : Calicut, Nagerkoil (Kerala); Bangalore (Karnataka); Nagpur (Maharastra); Chandigarh; Kurushetra (Haryana); Bhim Tal (Uttaranchal); Agra, (Uttar Pradesh); Kolkata (West Bengal); Andaman Island; Lohtak Lake (Manipur). Lahore (Pakistan); Inle Lake (Burma).

World distribution : Asia; Africa; Europe; North and South America.

Genus ***Branchiodrilus*** Michaelsen, 1900

Chaetobranchus Bourne, 1890 : 83; Beddard, 1895 : 301.

Branchiodrilus Michaelsen, 1900 : 155; Stephenson, 1912a : 228; 1923 : 74; 1930 : 736; Sperber, 1948 : 155; Naidu, 1962b : 526; Chekanovskaya, 1962 : 176; Brinkhurst, 1964 : 526; Brinkhurst & Jamieson, 1971 : 357; Mukhopadhyay, 1998 : 103.

Diagnosis : Eyes absent. Anterior segments with transverse pigment stripes. Branchial processes from VI onwards on a number of segments, enclosing dorsal setae. Dorsal setae beginning in VI, hair setae, and except in a number of anterior segments, straight or curved, simple-pointed needles. Ventral setae all of one type. Anterior segments with vascular plexus in all other segments one pair of transverse loops, in gill bearing segments each giving off a branch to a gill, and other branches to body-wall; dorsal vessel situated ventrally. Coelomocytes present. Clitellum absent between male pores; vasa deferentia entering atria towards their upper surface; prostate absent; atrial duct surrounded by gland cells. Penial setae present. Budding incomplete; 5 segments normally formed at anterior end. Cosmopolitan.

Type species : *Branchiodrilus semperi* (Bourne, 1890).

Key to Indian species of genus *Branchiodrilus*

Needle setae of posterior segments curved distally ..... *Branchiodrilus semperi*

Needle setae of all segments with straight tips ..... *Branchiodrilus hortensis*

Branchiodrilus hortensis (Stephenson, 1910).
(Fig. 27)

Lahoria hortensis Stephenson, 1910a : 59.

Branchiodrilus hortensis (Stephenson) Michaelsen, 1910 : 7; Stephenson, 1912a : 229; 1913a:

738; Mehra, 1920 : 463; Stephenson, 1923: 77; Naidu, 1966 : 214; Ali & Issaque, 1975: 57; Ali & Rashid-u-Zaman, 1976 : 90; Arunachalam et al., 1980, 509. Shobana & Nair, 1983a : 104; Mukhopadhyay, 1998 : 103.

Type locality : Lahore, Pakistan.

l(p.) = 10-15 mm; d(p.) = 0.5- 0.6 mm; s = 35-150 + undifferentiated region; s = 29-101.

Description : Worms (Fig. 27 A) large, with black granules in anterior 5 segments, but in succeeding segments upto XX pigmentation well marked as transverse bands one in each segment and after XX inconspicuous scattered pigment spots occur for some distance. Prostomium bluntly conical. Gills (Fig. 27 A-g) start in VI and present as dorso-lateral hollow out-pouchings, a pair per segment upto 50 pairs, longest reaching 1.6 mm, gradually diminishing to tubercles about 60th segment. They enclose hair setae and a vascular loop. Dorsal setae from VI, 2-5 hair setae and 1-2 needle setae per bundle. Hair setae smooth, straight, upto 1500 μm long, decreasing considerably backwards. Needle setae (Fig. 27 B) straight, 120-200 μm long, suddenly thinning near tip and ending in a sharp point, without nodulus. Ventral setae (Fig. 27 C, D) all of one type, 4-5 per bundle, 130-230 μm long, in II distal tooth thinner and longer than proximal; and in rest distal tooth thinner slightly longer than proximal, with nodulus middle to distal (D : P :: 7 : 6 or 8 : 7).

Pharynx in II-VII, ovoid; oesophagus narrow, continues imperceptably into intestine, stomach absent. Coelomocytes spherical, 12-20 μm in diameter. Brain composed of two massive ganglia connected by a transverse commissure. Blood yellowish red. Dorsal vessel contractile situated to left of gut from hind end to VI, and mid-dorsal in anterior 5 segments. Chloragocytes cover dorsal vessel from VI. In anterior 5 segments with a plexus of blood vessels and all other segments, with pairs of transverse vascular loops enclosed in gill bearing segments and in others branches given off to body wall. Ventral vessel mid-ventral. Nephridia begin in XI, and end a little distance in front of hind end, becoming smaller and smaller posteriorly and appearing as small loops in contact with ventral vessel.

Clitellum (Fig. 27 E-cl) in V-VIII, opaque white in life, absent between spermathecal pores and in anterior part of V ventrally. Testes and ovaries appear first and disappear before development of other sex organs. Sperm-sac (Fig. 27 E-ss) and ovi-sac, (Fig. 27 E-os) former lying in latter extend to XIX or XX. Male funnels (Fig. 27 E-mf) large, 90 μm wide, reaching back to sperm-sac behind atria. Vasa deferentia (Fig. 27 E-vd) about 0.2 mm long, 30 μm wide, runs forwards, curves upward, entering atria near their upper end. Atrial ampulla (Fig. 27 E-at) a large pear-shaped body, 230-240 μm in height and about 190 μm long, with narrow ejaculatory duct (Fig. 27 E-ed) of about 78 μm long, opening into a depression on ventral body wall and capable of being everted to outside as a short pseudo-penis. Prostate cells (Fig. 27 E-pr) pear-shaped and cover ejaculatory ducts. Penial setae (Fig. 27 F) 2-3 per bundle, about 132 μm long with a simple distal hook and without nodulus. Female funnels (Fig. 27 E-ff) on

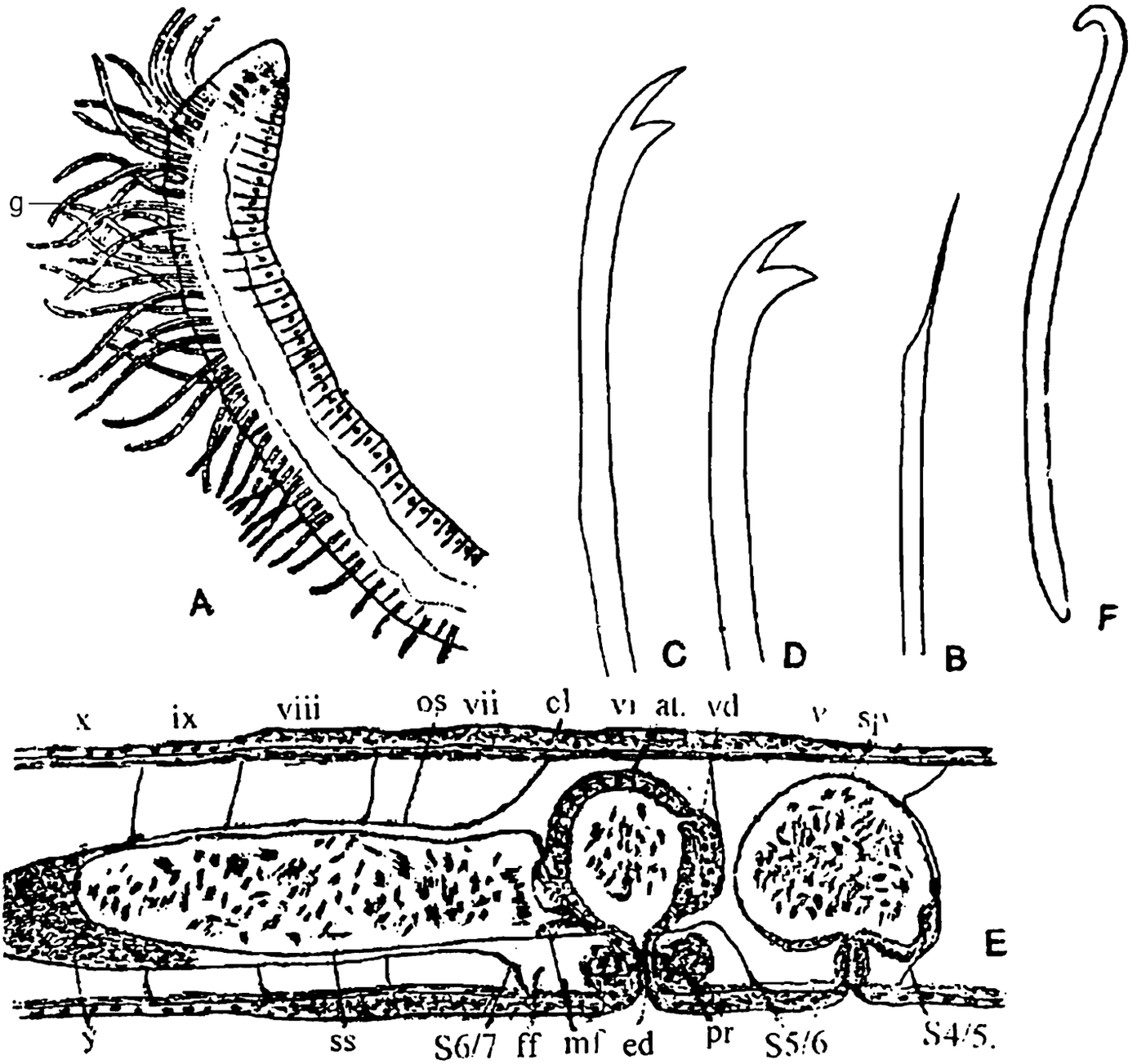

Fig 27 : *Branchiodrilus hortensis.* A : Anterior part of worm; B : Needle; C, D : Ventral setae of II and posterior segment; E : General organs; F : Penial seta. (A-D from Chekanovskaya, 1962; F from Mehra, 1920). at : atrium; cl : clitellum; ed : ejaculatory duct; ff : female funnel; mf : male funnel; os : ovi-sac; pr : prostate; S4/5, S5/6, S6/7 : septa 4/5, 5/6, 6/7; sp : spermatheca; ss : sperm sac; vd; vas deferens; y : ovum; v-x : segments V to X.

septum 6/7, about 45 μm in height, lie over the lower portion of septum 6/7 near ventral parieties of VI. Spermathecae (Fig. 27 E-sp) occupy entire V, with ovoid ampullae, 207-270 μm in height, narrows into ducts of 130-140 μm long with a median bulge and open some distance behind septum 4/5 internal to level of ventral setae in V. Asexual reproduction by development of budding zone, where prostomium and 5 anterior segments to posterior zooid and several hind segments to anterior zooid budded off before they separate.

Habits : Worms live in fresh water, among water weeds. Swimming absent.

Distribution : India : Veli Lake, Trivandrum (Kerala); Bhopal, Ujjain (Madhya Pradesh); Agra (Uttar Pradesh); Bankura, Chinsura, Saltora, Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Inle Lake (Burma).

World distribution : East and South Asia; Africa; England, Russia (Europe); Australia.

Branchiodrilus semperi (Bourne, 1890)
(Fig. 28)

Chaetobranchus semperi Bourne, 1890 : 83; Beddard, 1895 : 302.

Branchiodrilus semperi, Michaelsen, 1900 : 24; 1910a : 7; Stephenson, 1912a : 228.

Branchiodrilus menoni Stephenson, 1912a : 219; 1921 : 752.

Branchiodrilus sp. Stephenson, 1921 : 752.

Branchiodrilus semperi, Stephenson, 1923 : 75.

Branchiodrilus menoni, Stephenson, 1923 : 76; 1924a : 321; 1925a : 882; Aiyer, 1925 : 31; 1929a : 29.

Branchiodrilus semperi, Mendis & Fernando, 1962 : 45; Naidu, 1962b : 526; 1966 : 214; Costa, 1967 : 42; Vasisht & Gandhi, 1972 : 99; Ali & Issaque, 1975 : 56; Ali & Rashid-u-Zaman. 1976 : 90; Tiwari, Saxena & Kulashrestha, 1988 : 67; Battish & Sharma, 1997 : 81, Mukhopadhyay, 1998 : 103.

Type locality : Chennai (Madras), Tamil Nadu, India.

l(p.) = 8-25 mm; d(p.) = 0.6-0.7 mm; s = 70-200 + undifferentiated region; n = 64 87.

Description : Worms large, brownish, with pigmentation of irregular dark brown patches from anterior end to XXIII or XXIX. Prostomium bluntly conical. Anus posterodorsal. Gills about 60-70 pairs, 0.75-1.00 mm long, decreasing in length and disappear beyond 50 segments, cylindrical, hollow enclosing hair setae and a vascular loop. Dorsal setae from V or VI, 1-3 hair setae and 1-3 needle setae per bundle. Hair setae smooth, 330-504 μm long. Needle setae (Fig. 28 A, B) without nodulus, simple pointed, straight in anterior segments, with a peculiar bayonet-shaped distal curve, 100-210 μm long. Ventral setae (Fig. 28 C, D) 1-3 per bundle, in II remarkably slender, 73-

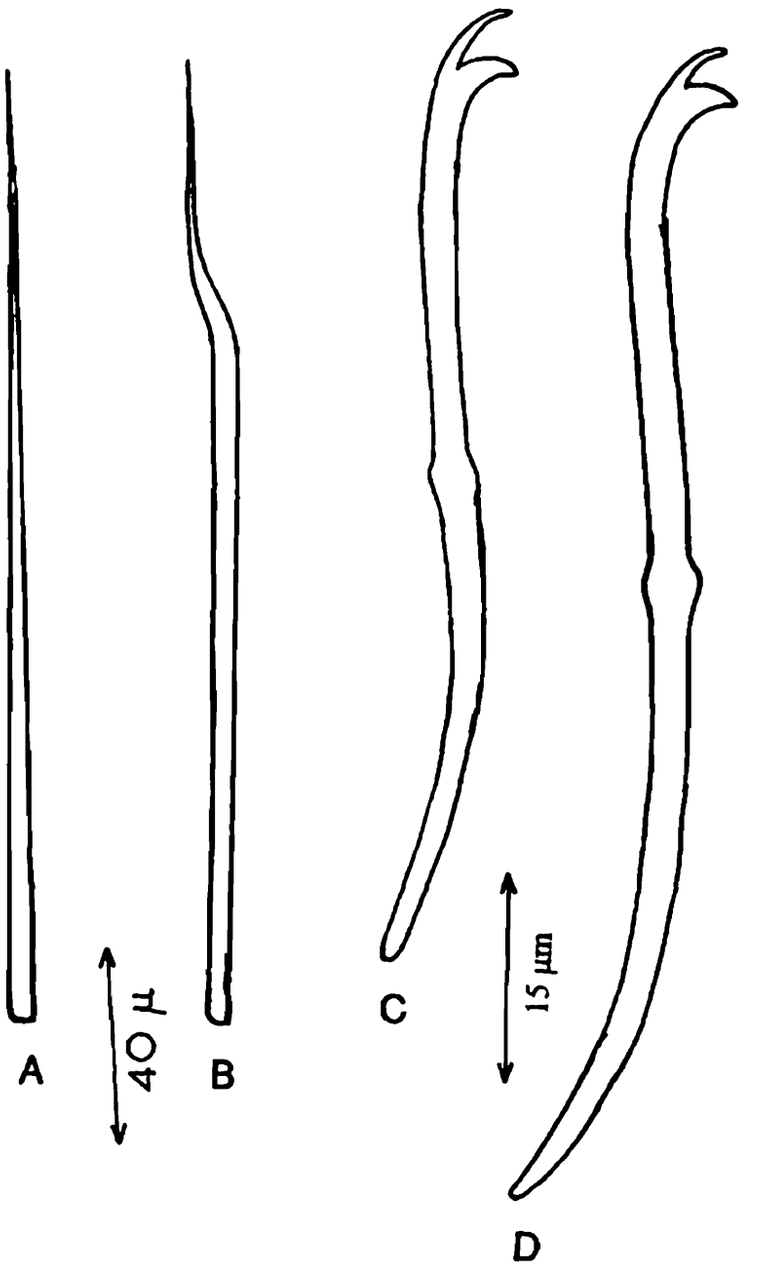

Fig 28 : *Branchiodrilus semperi.* A, B : Needle setae; C, D : Ventral setae of II and XV.

87 µm long, with median nodulus (D : P :: 1 : 1 or 10 : 11), and distal tooth longer and thinner than proximal; in branchial segments setae slender, 100-116 µm long, with nodulus about median (D : P :: 1 : 1 or 19 : 20), teeth equally long and distal thinner than proximal; in remaining segments, thick 100-139 µm long, with distal nodulus (D:P::11:14 or 7:9), teeth equally long, distal half as thick as proximal.

Pharynx in II-VI, wide; oesophagus from VII, narrow, insensibly passing into a wide sacculated intestine without a distinct stomach. Chloragocytes from VI, brown. Septa complete, septal glands absent. Coelomocytes granular, opaque, colourless, spherical, largest about 14 µm in diameter. Blood yellowish-red. Dorsal vessel contractile attached ventro-laterally to left of gut upto VII and mid-dorsal in front. Ventral vessel non-contractile, mid-ventral. Branchial segments with lateral contractile

vascular loops enclosed in gills. In segments with branchial tubercles and succeeding segments, lateral vascular loops short and non-contractile. In I-VI vascular loops form irregular plexus. First nephridium in XII, with pre-septal funnel on anterior face of septum 11/12, a short neck passes through septum and connects to a fusiform, granular post-septal consisting of a long coiled, ciliated duct opening by a nephropore ventro-laterally.

Sex organs not known. Asexual reproduction by paratomy, individuals separating early before formation of head segments to posterior individual and posterior segments to anterior individual.

Habits : Fresh water dwelling, does not make gelatinous tubes but makes burrows in mud and reside in them. Swimming absent.

Distribution : India : Trivandrum, Nagerkoil (Kerala); Chidambaram, Chennai (Tamil Nadu); Cuddapah, Warangal, Hyderabad (Andhra Pradesh); Bellary (Karnataka); Burhanpur, Bhopal (Madhya Pradesh); Varanasi (Uttar Pradesh); Chandigarh; Punjab; Haryana; Ranchi (Bihar); Bankura, Bardwan, Midnapore, Raghunathpur, W. Dinajpur, Katwa, Bangor, Garbeta, Champta, Purulia, Saltora, Nadia, Kolkata (West Bengal); Gauhati (Assam). Dhaka (Bangladesh); Inle Lake (Burma); Maha Oya, Peradeniya (Sri Lanka).

World distribution : South and East Asia.

Genus ***Dero*** Oken, 1815

Dero Oken, 1815 : 13; Bousfield, 1887 : 103; Beddard, 1895 : 297; Stephenson, 1923 : 87; 1930 : 735; Sperber, 1948 : 158; Naidu, 1962b : 527; Chekanovskaya, 1962 : 169; Brinkhurst, 1964 : 212; Brinkhurst & Jamieson, 1971 : 359; Persia, 1980 : 90; Mukhopadhyay, 1998 : 104.

Diagnosis : Eyes absent. Dorsal setae from VI, V or IV onwards, hairs and double-pronged, pectinate, or palmate needles; ventral setae of II-V usually of a shape different from those of rest, with distal tooth longer than proximal, and equally thick, compared with equally long or shorter, and thinner, in latter. Pharynx in II-V, with pharyngeal glands; often with septal glands; stomachal dilatation gradual, beginning in VIII, IX or X or inconspicuous. Anus opening into a ciliated branchial fossa, usually containing gills. A pharyngeal vascular plexus; contractile transverse vessels in a number of segments from VI onwards; dorsal vessel situated ventrally to left; blood reddish. Coelomocytes present or absent. Nephridia often invested with bladder-like peritoneal cells. Clitellum absent between male pores; vasa deferentia joining atria anteriorly on top; usually prostate glands absent; ejaculatory duct surrounded by gland cells; penial setae present or absent. Asexual reproduction by budding or fragmentation. Usually living in tubes of secreted mucus and foreign matter. Cosmopolitan.

Type species : *Dero digitata* (Müller, 1773).

Stephenson (1923, 1930), Marcus (1943), Chekanoskaya (1962) treated *Dero* and *Aulophorus* as distinct, separate genera. And Liang (1964) bestowed generic status to *Allodero.* In the present work they are treated as distinct genera.

Key to Indian species of genus *Dero*

1. Dorsal setae from IV; branchial fossa with 5 pairs of gills ..... *Dero dorsalis*
– Dorsal setae from VI; branchial fossa with less than 5 pairs of gills 2
2. Branchial fossa with 4 pairs of gills 3
– Branchial fossa with 2 or 3 pairs of gills 6
3. Dorsal bundles with 1 hair and 1 needle seta 4
– Dorsal bundles with more than 1 hair and 1 needle seta 5
4. Needle teeth unequal, distal tooth longer than proximal ..... *Dero digitata*
– Needle teeth equal and short ..... *Dero cooperi*
5. Dorsal bundles with 2 hairs and 2 needles in anterior and middle segments .. .. *Dero indica*
– Dorsal bundles with 3 hairs and 3 needles in anterior and middle segments .. .. *Dero zeylanica.*
6. Hair bayonet shaped and plumose 7
– Hairs simple 8
7. Needles bifid, nodulus at 1/5-1/6 length from distal end ..... *Dero plumosa*
– Needles trifid, nodulus at ¼ length from distal end ..... *Dero pectinata*
8. Needles palmate ..... *Dero palmata*
– Needles simply bifid 9
9. Ventral setae of II-V twice as long as those of rest ..... *Dero raviensis*
– Ventral setae of II-V slightly longer than those of rest 10
10. Needle teeth unequal, proximal longer, thicker than distal ..... *Dero sawayai*
– Needle teeth equal 11
11. Stomach beginning in VIII ..... *Dero obtusa*
– Stomach beginning in IX or X ..... *Dero nivea*

Dero cooperi Stephenson, 1932
(Fig. 29)

Dero limosa Leidy, 1852a : 226; Stephenson, 1914b : 330; Stephenson, 1915b : 785; 1915c : 789; Mehra, 1920 : 457; Stephenson, 1923 : 88.

Dero cooperi Stephenson, 1932 : 231; Naidu, 1962b : 538; 1966 : 215; Costa, 1967 : 43; Vasisht & Gandhi, 1972 : 99; Naidu & Srivastava, 1980 : 266; Vasisht & Angrish, 1981a : 17; 1981b : 23; Naidu, Kalpana & Sureshkumar, 1981 : 106; Naidu & Naidu, 1981a : 531; Vasisht, 1981 : 74; Tiwari, Saxena & Kulashrestha, 1988 : 67; Battish & Sharma, 1997 : 82.

Dero (*Dero*) *cooperi*, Mukhopadhyay, 1998 : 105.

Type locality : Addis Abeba, Abyssinia, Africa.

l(p.) = 3.0-4.3 mm, d(p.) = 0.3-0.35 mm, s = 33-51 + undifferential region and branchial fossa; n = 18-27.

Description : Worms small, reddish with epidermal orange spots lateral to dorsal bundles in all segments except head segments in living worms. Postomium short, bluntly triangular with sensory stiff cilia on rounded margin. Dorsal bundles from VI, each with 1 slightly bayonet-shaped hair seta, 190-237 μm long, and 1 bifid sickle-shaped needle seta (Fig. 29 A) 102-107 μm long, with distal nodulus (D : P :: 1 : 2) with equal and short teeth. Ventral setae (Fig. 29 B, C) 3-5 per bundle, decreasing to 3-2 posteriorly, in II-IV thinner, less curved, 131-135 μm long, with proximal nodulus (D : P :: 10 : 7), distal tooth thicker and 1½ times as long as proximal. In rest, 71-77 μm long, with a distal nodulus (D : P :: 5 : 6), distal tooth thinner and equal or longer than proximal. Branchial fossa (Fig. 29 D, E) with antero-dorsal margin flat, broad, ciliated and slightly convex, posterior margin prolonged into a convex lip, which in contraction spout-like. Gills 4 pairs, 1 pair dorsal, digitiform and short, 1 pair lateral and 2 pairs ventral, latter both foliate.

Pharynx in II-V wide, with an eversible dorsal diverticulum. Oesophagus in V-VIII narrow and wavy. Stomach in IX-X, fusiform. Intestine narrow in XI and wide and sacculated from XII on. Septal glands in III-V. Chloragocytes from VI, grayish brown. Brain (Fig. 29 F) deeply incised in front and behind. Dorsal essel ventro-lateral to gut upto VI and mid-dorsal in front. Five pairs of contractile vascular vessels in VI-X. First nephridium (Fig. 29 G) in VII with its nephrostome (Fig. 29 G-ns) to left in VI. Post-septale composed of a greenish gray fusiform ampulla (Fig. 29 G-na) followed by a long, coiled, ciliated nephridial duct (Fig. 29 G-nd), anterior 1/3 free and thin-walled, middle 1/3 enclosed in gland tissue (Fig. 29 G-g) and posterior 1/3 thick-walled, swelling into a vesicle before opening by a nephropore (Fig. 29 G-np) in front of left ventral bundle.

Clitellum in ½V-VII. Sperm-sac and ovi-sac extend to IX and XI respectively. Male funnels cup-shaped, ciliated on the anterior face of septum 5/6 laterally. Vasa deferentia

long and bend downwards and open into atria on their anterior face. Atrial ampulla ovoid with a short ejaculatory duct opening at position of ventral setae of VI. Ventral setae of VI and penial setae absent. Spermathecae in V, ovoid with short ectal duct opening to outside in a shallow depression in front and lateral to ventral bundles of V Diverticulum absent above anus. Asexual reproduction by development of budding zones, generally only one budding zone formed at a time.

Habits : Worms live in tubes of mucous, sand and mud, protruding either end from the tubes. Swim with spiral movements.

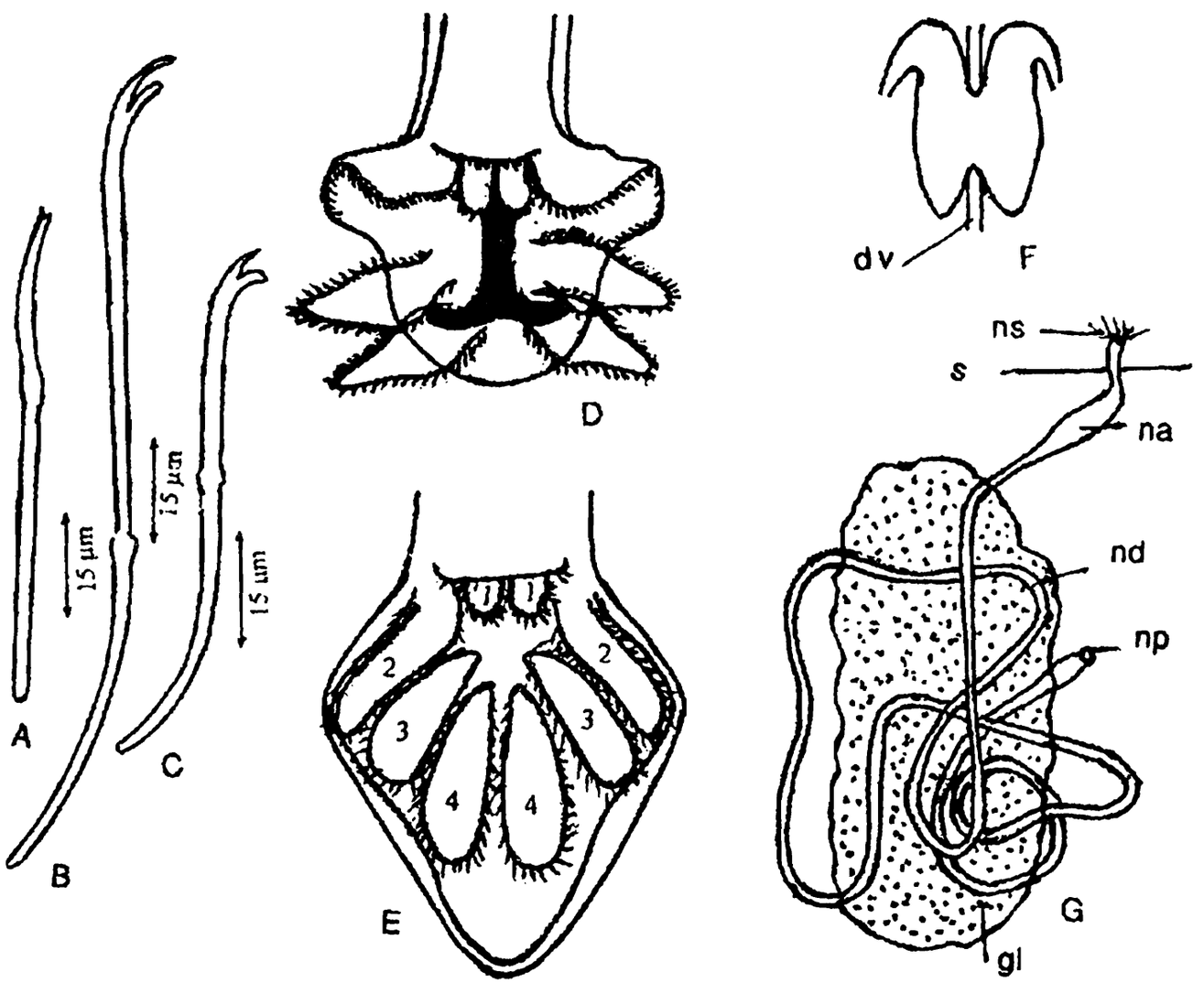

Fig 29 : *Dero cooperi.* A : Needle setae; B, C : Ventral setae of II and middle segment; D, E : Branchial fossa relaxed and contracted; F : Brain; G : Nephridium. dv : dorsal vessel; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum; 1, 2, 3, 4 : gills.

Distribution : India : Kottayam, Trivandrum (Kerala); Chittoor, Mamandur, Cuddapah, Gudur, Kakinada, Vizianagaram, Hyderabad (Andhra Pradesh); Bangalore, Bellary (Karnataka); Vehar Lake, Powai Lake, Mumbai, Bandra, Nagpur (Maharastra); Ujjain, Bhopal (Madhya Pradesh); Agra (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Bankura, Burdwan, Malda, Midnapore, Saltora, Susunia, Aral Bansi, Andal, Raina, Midnapore, Bamangola, Champta (West Bengal). Lahore (Pakistan); Kandy (Sri Lanka).

World distribution : Abyssinia (Africa); Germany, Italy (Europe); Argentina (South America).

Dero digitata (Müller, 1773)
(Fig. 30)

Nais digitata (coeca) Müller, 1773 : 22.

Dero limosa Leidy. 1852a : 226; Stephenson, 1914b : 330; 1915c : 789; Mehra, 1920 : 457; Stephenson, 1923 : 88; Aiyer, 1929a : 33; Weerakonn & Samarasinghe, 1958 : 160.

Dero digitata, Sperber, 1958 : 49; Mendis & Fernando, 1962 : 45; Naidu, 1962b : 531; 1966 : 215; Costa, 1967 : 43; Vasisht & Gandhi, 1972 : 99.

Dero (Dero) digitata, Ali & Issaque, 1975 : 57; Ali & Rashid-u-Zaman, 1976 : 91.

Dero digitata, Naidu & Srivastava, 1980 : 265; Naidu & Naidu, 1981a : 529; Tiwari, Saxena & Kulashresrha, 1988 : 67; Vasisht, 1989 : 147.

Dero limosa, Singh, 1989 : 274.

Type locality : Unassigned, Germany.

l(p.) = 4-6 mm; d(p.) = 0.25-0.30 mm; s = 25-50 +undifferentiated region and branchial organ; n = 16-21.

Description : Worms of medium size, tube-dwelling, reddish, epidermis with uniform orange red or pink pigment, more concentrated in head segments and branchial organ in life. Body surface covered with slender fuzzy delicate outgrowths. Prostomium bluntly triangular with stiff sensory cilia on margin. Dorsal bundles from VI, each with 1 hair seta, slightly bayonet-shaped, 175-326 μm long, and 1 bifid needle seta (Fig. 30 A), 63-95 μm long, with distal nodulus (D : P :: 1 : 2) and outer tooth longer and slightly thinner than inner tooth. Ventral setae (Fig. 30 B, C) of II-V, 4-5 per bundle, thin, less curved than others, 127-157 μm long, 2.5 μm thick with proximal nodulus (D : P :: 3 : 2), teeth equally thick, distal 1½ times as long as proximal. In others 2-4 per bundle, 79-120 μm long, with distal nodulus (D : P :: 1 : 2), distal tooth about equal or slightly shorter and thinner than proximal. Branchial fossa (Fig. 30 D, E) with antero-dorsal margin entire, convex and ciliated and a postero-ventral margin prolonged into a non-ciliated rounded lip. Gills 4 pairs, 1 pair dorsal and small, 1 pair lateral and 2 pairs ventral, all foliate.

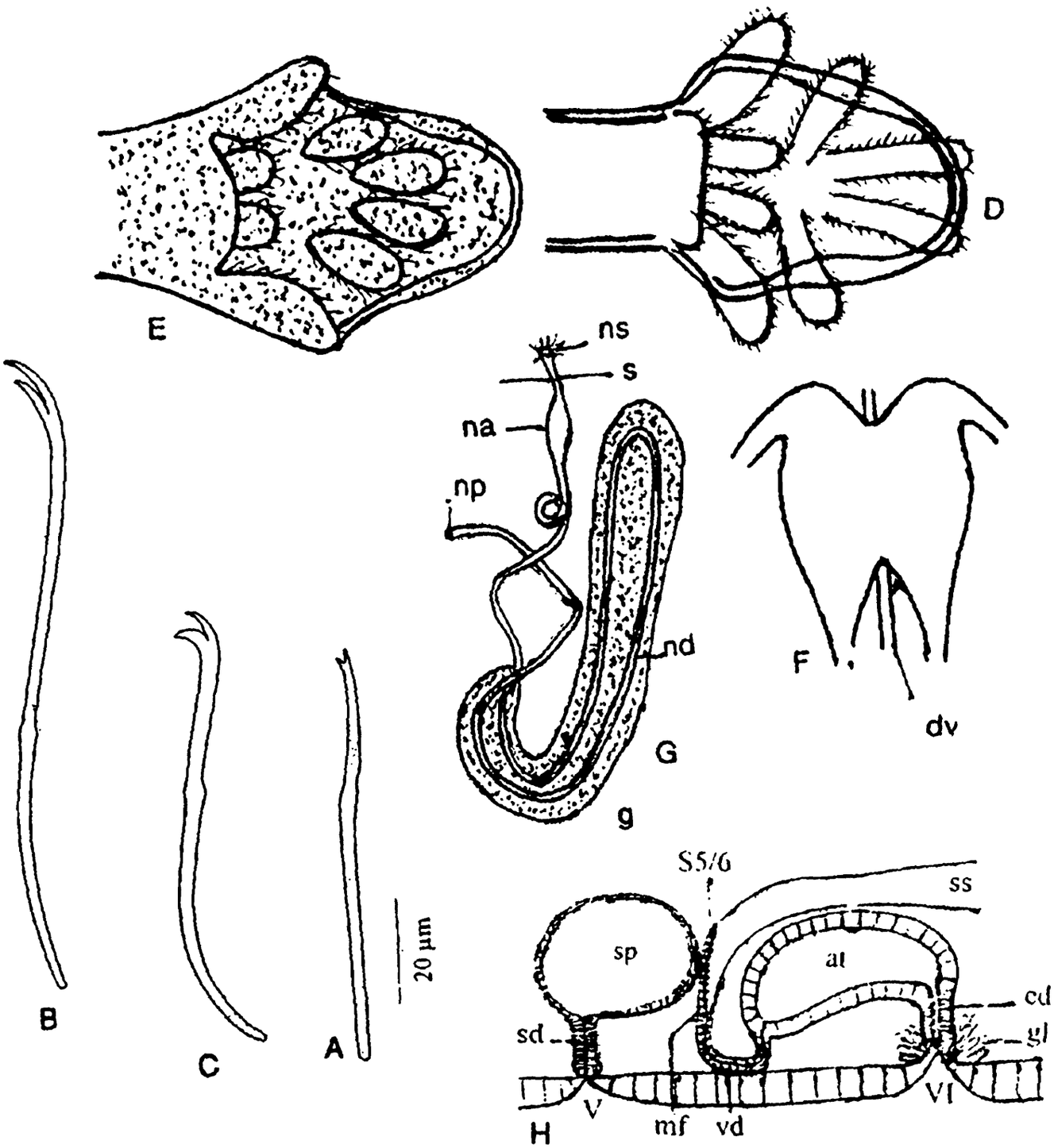

Fig 30 : *Dero digitata.* A : Needle setae; B, C : Ventral setae of II and VI; D, E : Relaxed and contracted branchial fossa; F : Brain; G : Nephridium; G : Genital organs. (A-C from Ercolini, 1970; H from Sperber, 1948) at : atrium; dv : dorsal vessel; ed : ejaculatory duct; g : glandular part; gl : glandular cell; mf : male funnel; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum; sd : spermathecal duct; sp : spermathecal ampulla; ss : sperm-sac; vd : vas deferens; S5/6 : septum 5/6.

Pharynx in II-IV wide, with an eversible dorsal diverticulum. Oesophagus in V-VIII, narrow and wavy. Stomach in IX or IX-X, wide. Intestine from X or XI, wide. Chloragocytes from VI, brownish. Septal glands in IV-VI. Coelomocytes absent. Brain (Fig. 30 F) incised less deeply in front and deeply behind. Blood red. Dorsal vessel ventro-lateral to left of gut for a major part of body and mid-dorsal in anterior 5 segments. Contractile lateral vessels, 5 pairs in VI-X. First nephridium (Fig. 30 G) in VII, with its nephrostome (Fig. 30 G-ns) in VI, post-septale with ampulla (Fig. 30 G-na) and nephridial duct (Fig. 30 G-nd) partly free and partly enclosed in gland (Fig. 30 G-g) and opening by nephropore (Fig. 30 G-np).

Clitellum in ½V-VII (2½ segments). Male funnels (Fig, 30 H-mf) very large, on septum 5/6 ventrally. Vasa deferentia (Fig. 30 H-vd) narrow about 175 μm long 8-11 μm wide, bends abruptly upon itself and runs anteriorly and enter atria on antero-median face of atrium. Atrial ampulla (Fig. 30 H-at), ovoid, when mature 240 μm long and 100 μm in diameter; anteflected so that top is directed backwards reaching septum 5/6. At its base ampulla narrows gradually into a short ejaculatory duct (Fig. 30 H-ed) about 60 μm long, opening on a clitellum free space, in invaginated pit about 35 μm deep. Duct surrounded by long prostate gland cells (Fig. 30 H-gl), not attached to it, but to wall of pit. Sperm-sac (Fig. 30 H-ss) and ovi-sac extend to IX and XI. Ovaries on posterior face of septum 5/6. Female funnels not observed. Oviducal pores paired in posterior part of VI midway between line joining ventral bundle and one joining dorsal bundles of VI and VII. Spermathecae (Fig. 30 H-sp) occupy 2/3 of V, their ampullae subglobular, about 105 μm by 150 μm by 140 μm, spermathecal duct (Fig. 30 H-sd) well defined 60 μm long and 20 μm wide, and opens ventro-laterally in V Alimentary canal degenerates during sexual maturity in anterior part of body. Asexual reproduction by development of budding zone, normally one zone developed at a time.

Habits : Lives in tubes of mucous and sand in fresh water. Swim with spiral movements.

Parasites : Puytorac (1969) reported a Hoplitophryid ciliate parasite *Juxtamesniella deronis* Puytorac 1969 from the intestine of this species from Gabon, Africa. *Aurantiactinomyxon* sp. (Actinospora : Tetractinomyxida) in the gut of this species is reported by Pote & Waterstract (1993).

Predators : This species is preyed upon by chironomid (Diptera) larvae belonging to *Polypedilum* sp., *Ablabesmyia* sp., *Anatopynia* sp., and *Procladius* sp. (Loden, 1974).

Commensals : Sessile vorticellids (Protozoa) are found attached to setae of hind segments.

Distribution : India : Kottayam, Trivandrum (Kerala); Coimbatore (Tamil Nadu); Chittoor, Chandragiri, Tirupati, Tirumala, Mamandur, Srikalahasti, Gudur, Nayudupeta, Cuddapah, Anantapur, Kurnool, Vijayawada, Kakinada, Visakhapatnam, Vizianagaram, Warangal, Hyderabad (Andhra Pradesh); Bangalore, Mysore, Bellary

(Karnataka); Powai Lake, Mumbai, Bandra, Nagpur (Maharastra); Bhopal, Ujjain (Madhya Pradesh); Agra, Varanasi (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Inle Lake in Shan State (Burma); Galle, Peradeniya, Meegoda near Colombo (Sri Lanka).

World distribution : Cosmopolitan.

Dero dorsalis Ferronière, 1899
(Fig. 31)

Dero dorsale Ferroniere, 1899 : 255.

Dero austrina Stephenson, 1925a : 882; Aiyer, 1929a : 34.

Dero dorsalis (Ferroniere), Naidu, 1962b : 529; 1966 : 215; Vasisht & Gandhi, 1972 : 99; Sobhana & Nair, 1983a : 104.

Dero (Dero) dorsalis, Ali & Issaque, 1975 : 57; Ali & Rashid-u-Zaman, 1976 : 90; Mukhopadhyay, 1998 : 106.

Type locality : Loire Inferieure, France.

l = 10-30 mm; d = 0.3-0.4 mm; s = 23-150 + undifferentiated region and branchial fossa; n = 36-42.

Description : Worms of large size, yellowish and tube dwelling. Prostomium bluntly triangular and rounded. Dorsal setae from IV, each bundle with 1 hair seta and 1 needle seta. Hair setae (Fig. 31 A) bayonet-shaped, 245-360 μm long. Needle setae (Fig. 31 B) faintly sickle-shaped, bifid, 85-120 μm long, with distal nodulus (D : P :: 1 : 2), distal tooth longer and slightly thinner than proximal. Ventral setae (Fig. 31 C, D) 4-6 per bundle in anterior segments, gradually decreasing to 2 per bundle posteriorly. In II 123-135 μm long, in III-IV 108-110 μm long, in rest 88-105 μm long, nodulus about middle in anterior segments, slightly distal in others, distal tooth longer and thinner than proximal in anterior segments, slightly longer and thinner than proximal in others. Branchial fossa (Fig. 31 E, F) with two broad palp-like, non-contractile diverging flat processes on postero-ventral border and 5 pairs of foliate gills, I pair arising from supra-anal diverticulum, broader than long, II and III pairs arise from inner surface of lateral margin, ventral and lateral to I pair, IV and V pairs from floor of fossa, all foliate.

Pharynx in II-III, wide with glands. Oesophagus in IV-VIII narrow and wavy continuing into a wide and sacculated intestine from IX. Stomach absent. Chloragogen cells from VI, greenish. Septal glands 2 pairs in IV-V, highly vascular, supplied by branches from dorsal vessel. Blood red. Dorsal vessel contractile, ventro-lateral to left of gut from hind end to VI and mid-dorsal in anterior 5 segments. Contractile lateral vessels 9 pairs from VI-XIV. Brain (Fig. 31 G) widely, deeply incised in front and narrowly less deeply incised behind. First nephridium (Fig. 31H) in VII, with its

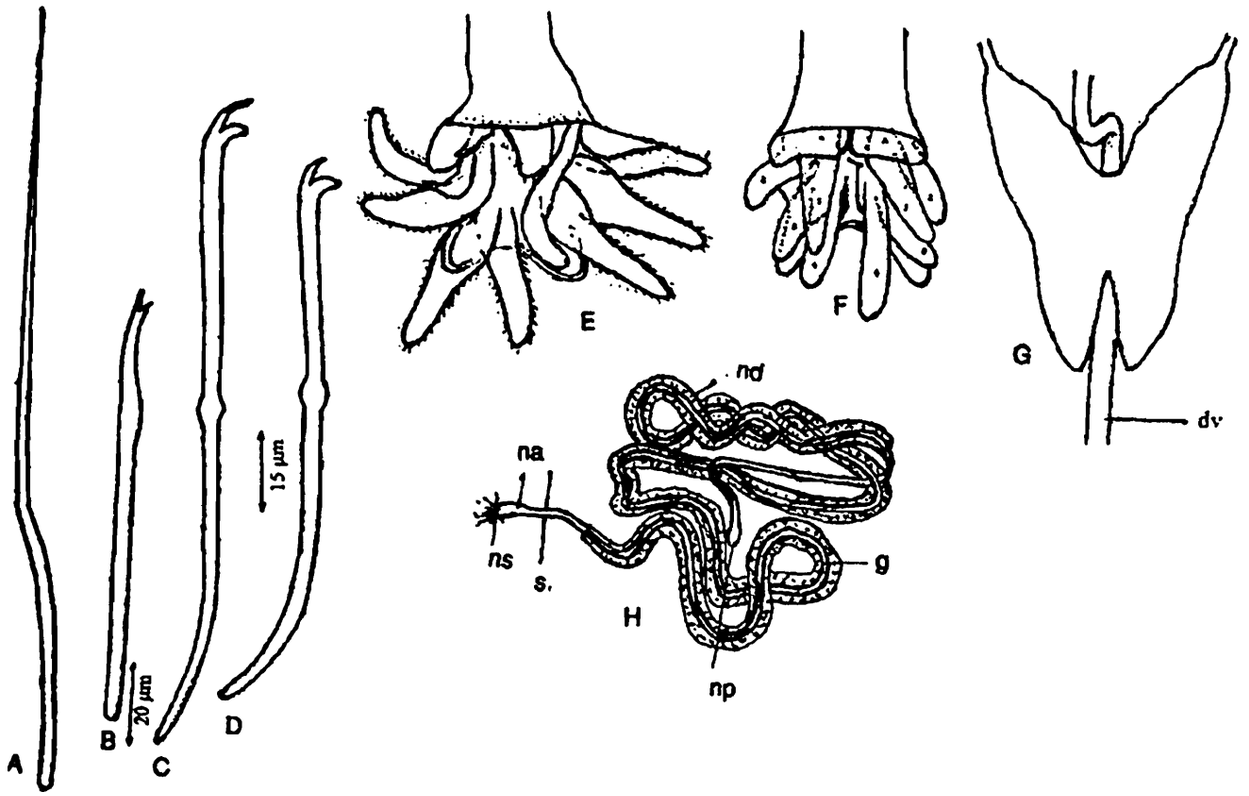

Fig 31 : *Dero dorsalis.* A : Hair seta; B : Needle setae; C, D : Ventral setae of II and XVI; E, F : Branchial fossa relaxed and contracted; G : Brain; H : Nephridium; (E-G from Aiyer, 1929a). dv : dorsal vessel; g : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

nephrostome (Fig. 31 H-ns) in VI, continues into nephridial duct (Fig. 31 H-nd) enclosed. in glandular tissue (Fig. H-g) and opening to exterior by nephropore (Fig. 31 H-np) ventrally.

Clitellum in ½V-VII. Male funnels large cup-shaped, 32 µm long, 32 µm wide; vasa deferentia slender, 14 µm wide, 150 µm long, entering atrium antero-dorsally. Atrial ampulla large, almost globular, thick-walled, its duct fairly long, well defined opening into an invagination piercing an aggregation of gland cells surrounded by muscles. Sperm-sac and ovi-sac extend to X and XI respectively. Spermathecae in V, ovoid, about 70 µm wide, their ducts 42 µm long, opening to outside midway between dorsal and ventral setae where clitellum begins. Penial setae absent. Asexual reproduction by paratomy, one budding zone common and when two, second budding zone always develops in posterior zooid. Branchial fossa develops but no new segments are budded off at posterior end of anterior zooid. Five new segments at anterior end of posterior zooid developed after separation.

Habits : Worms live in tubes in fresh-water. Swimming absent.

Distribution : India : Trivandrum, Veli Lake (Kerala); Chennai (Tamil Nadu); Chittoor, Tirupati, Kambakkam, Cuddapah, Kakinada, Visakhapatnam, Warangal,

Hyderabad (Andhra Pradesh); Bhopal, Ujjain (Madhya Pradesh); Chandigarh; Punjab; Haryana; Bankura, Bardwan, Saltora, Andal, Galsi, Katwa, Raina, West Dinajpur, Bangar, Raigunje, Pandooah, Kamarpukur, Kaliachawk, Champta, Paraz, Midnapore, Kolkata (West Bengal). Dhaka (Bangladesh).

World distribution : South and East Asia; Europe; Uruguay, Argentina (South America); Queensland (Australia).

Dero indica Naidu, 1962
(Fig. 32)

Dero indica Naidu, 1962b : 533; 1966 : 215; Vasisht & Gandhi, 1972 : 99; Sharma, Handa & Sahi, 1976 : 102; Vasisht & Angrish, 1981a : 17; Naidu & Naidu, 1981a : 532; Naidu, Kalpana & Sureshkumar, 1981 : 106; Battish & Sharma, 1997 : 82.

Dero (Dero) indica Naidu. Ali & Issaque, 1975 : 58; Mukhopadhyay, 1998 : 106.

Type locality : Cuddapah, Andhra Pradesh, India.

l = 6.5-8.5 mm; d = 0.35-0.4 mm; s = 36-70 + undifferentiated region and branchial fossa; n = 24-32.

Description : Worms of medium size, sturdy, pale red. Prostomium bluntly triangular with sensory stiff cilia on its margin. Dorsal bundles of setae begin in VI, each with 2 hair setae and 2 needle setae in anterior half of body, and 1 of each in posterior half of body. Hair setae 226-280 μm long; needle setae (Fig. 32 A) bifid, sickle-shaped, 88-105 μm long, with distal nodulus (D : P :: 1 : 2), distal tooth longer and slightly thinner than proximal. Ventral setae (Fig. 32 B, C) of II-V, 4 per bundle, longer, thinner, less curved than others, 112-126 μm long, with nodulus about middle (D : P :: 1 : 1), teeth equally thick, distal 1½ times longer than proximal; in others 2-3 per bundle, 80-102 μm long, with distal nodulus (D : P :: 11 : 16), distal tooth thinner and longer than proximal. Branchial organ (Fig. 32 D) with its anterior margin flat, entire and convex, posterior margin flat, broad, entire with a conspicuous transverse dark brown band. Gills 4 pairs, foliate, first pair short arising from supra-anal diverticulum, second pair broad, flat, arising from lateral surface, third and fourth pairs long, flat, arising from floor of fossa.

Pharynx in II-IV, wide; oesophagus in V-VIII, narrow and wavy; stomach in IX-½X, barrel-shaped, wide; intestine thin in XI-XII, wide and sacculated from XIII onwards. Chloragogen cells from VI, brownish. Coelomocytes absent. Septal glands in IV-V. Brain incised in front and behind. Blood orange red. Dorsal vessel mid-dorsal in I-V and ventrally attached to gut on left side from VI backwards. Contractile vascular loops, 5 pairs in VI-X. First nephridium (Fig. 32 E) in VII, its pre-septal funnel with a ciliated nephrostome (Fig. 32 E-ns) in VI, connected by a thin duct to post-septal part consisting of a brownish fusiform ampulla (Fig. 32 E-na), followed by a highly coiled ciliated duct (Fig. E-nd) partly passing through gland tissue (Fig. 32 E-gl) and opening by a nephropore (Fig. 32 E-np) ventro-laterally in middle of segment.

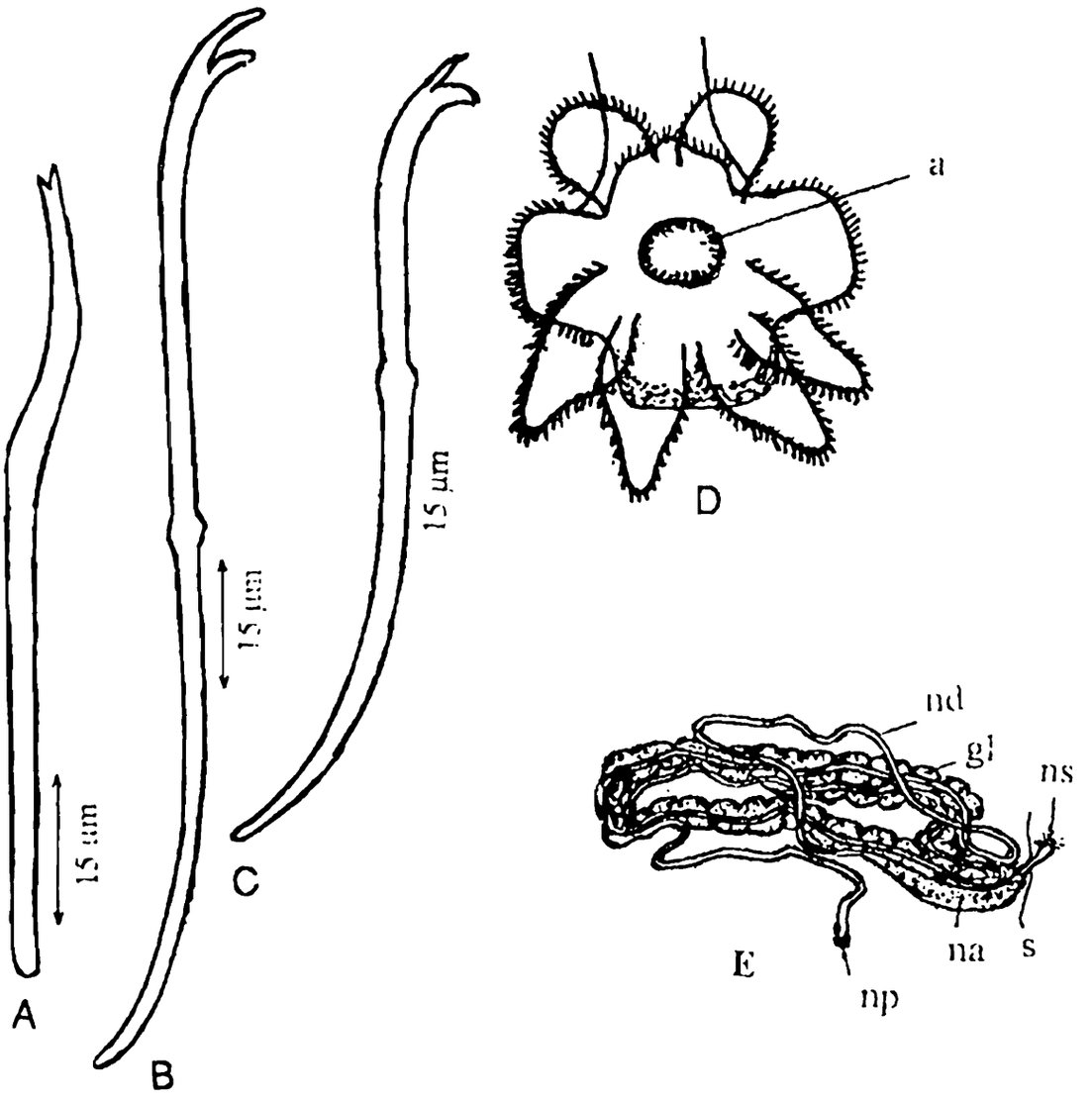

Fig 32 : *Dero indica.* A : Needle setae; B, C : Ventral setae of II and middle segment; D : relaxed Branchial fossa; E : Nephridium. a : anus; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

Sex organs not known. Asexual reproduction by paratomy. Normally one and rarely two budding zones developed. Before zooids separate prostomium and 5 anterior segments to posterior zooid and an indefinite number of posterior segments and branchial fossa to anterior zooid developed.

Habits : Worms live in soft black mud without tubes along with *Branchiodrilus semperi*, *Dero digitata*, *Branchiura sowerbyi*, *Limnodrilus hoffmeisteri*, *Aulophorus hymanae* and *A. furcatus*. They coil into spiral balls when disturbed. They swim with spiral movements.

Chromosomes : 2n = 36 (Sharma, Handa & Sahi, 1976).

Distribution : Trivandrum (Kerala); Chittoor, Tirupati, Cuddapah, Kakinada,

Visakhapatnam, Vizianagaram, (Andhra Pradesh); Bangalore (Karnataka); Powai Lake, Mumbai, Bandra (Maharastra); Ujjain (Madhya Pradesh); Varanasi (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Bankura, Saltora, Domjur, Howrah, Hooghly, Malda, (West Bengal). Dhaka (Bangladesh).

World distribution : Known only from the Indian subcontinent.

Dero nivea Aiyer, 1929
(Fig. 33)

Dero niveum Aiyer, 1929a; 40.

Dero nivea, Sperber, 1958 : 49; Naidu, 1962b : 540; 1966 : 215; Costa, 1967 : 44; Naidu & Naidu, 1981a : 532; Naidu, Kalpana & Sureshkumar, 1981 : 107; Sobhana & Nair, 1983a : 104.

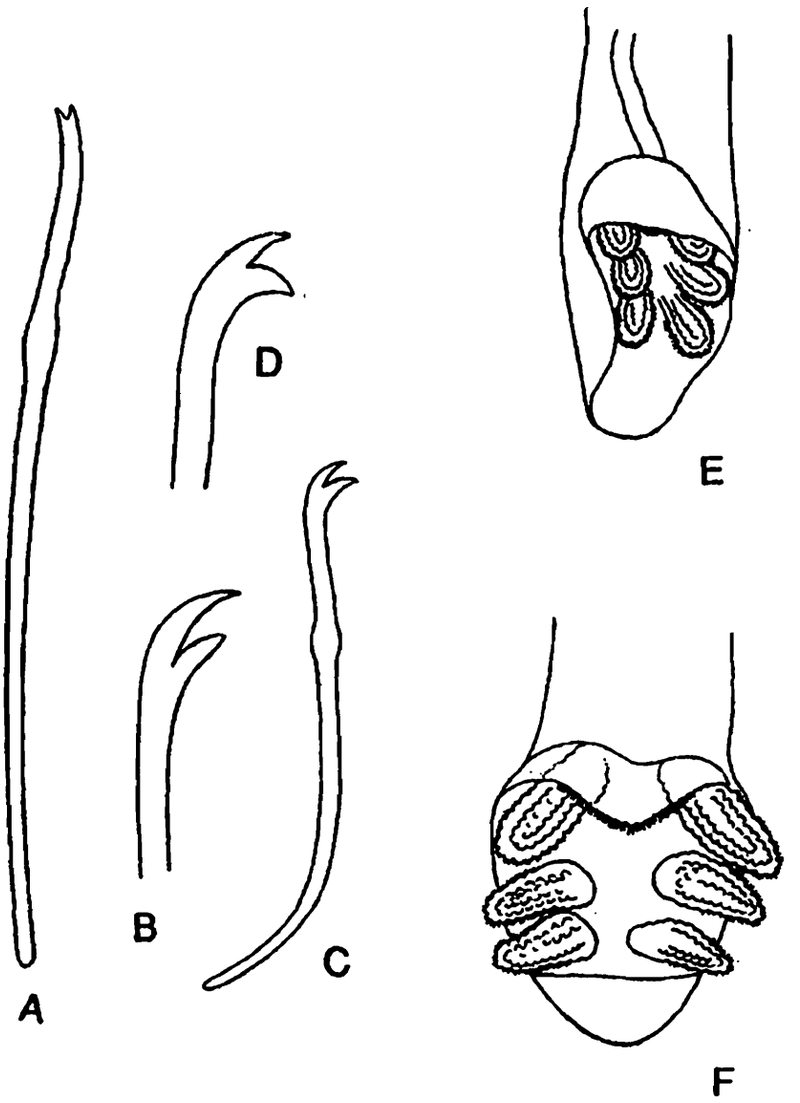

Fig 33 : *Dero nivea*. A : Needle setae; B : Distal end of ventral setae of II; C : Ventral seta of VI; D : Distal end of ventral seta of VI; E, F : Contracted and relaxed branchial fossa. (all fron Aiyer, 1929a).

Type locality : Trivandrum, Kerala, India.

l(p.) = 1.8-2.5 mm; d(p.) = 0.13-0.15 mm; s = 23-45 + undifferentiated region and branchial fossa; n = 14-18.

Description : Worms mininute, slender and yellowish. Prostomium bluntly triangular with sensory stiff cilia on its margin. Dorsal bundles begin in VI, with 1 simple, smooth hair seta of 140-160 μm long, and 1 bifid needle seta (Fig. 33 A) with minute equal teeth, 40-56 μm long, 1 μm thick with distal nodulus (D : P :: 4 : 9). Ventral setae (Fig. 33 B, C, D) of II-V, 4 per bundle, longer and less curved than others, 65-84 μm long, 2 μm thick, with proximal nodulus (D : P :: 3 : 2), and with equally thick teeth, distal 1½ times as long as proximal. In others 2-4 per bundle, shorter, less curved, 59-70 μm long, with distal nodulus (D : P :: 2 : 3), distal tooth equal to and thinner than proximal. Branchial fossa (Fig. 33 D, E) funnel-shaped with antero-dorsal margin either straight or produced into a median bluntly triangular lobe, with cilia and postero-ventral margin rounded and non-ciliated, with 3 pairs of ciliated gills. First pair of gills longest arising from antero-dorsal diverticulum, into which it can contract completely. Second and third pairs of gills arise from floor of fossa.

Pharynx in II-IV wide; oesophagus in V-VII narrow and sinuous; stomach in VIII barrel-shaped; intestine narrow in IX and wide, sacculated from X. Chloragocytes from VI, brownish. Septal glands 3 pairs in IV-VI. Brain incised in front and behind. Dorsal vessel ventro-laterally attached to left of gut upto VI and mid-dorsal anteriorly. Contractile lateral vessels 3 pairs in VI-VIII, those of VII shorter than others. First nephridium in VIII with its funnel-shaped ciliated nephrostome on anterior face of septum 7/8 in VII.

Sex organs not known. Budding common, normally with one budding zone developing at a time.

Habits : Worms live in fresh water and swims briskly by wriggling movements.

Commensals : *Rhabdostyla* sp. (Protozoa, Peristricha, Epistylidae) were attach to body wall of these worms (Smith, M. E. 1985).

Distribution : India : Veli Lake, Trivandrum (Kerala); Tandikoudi, Ouralpatti, Palni Hills (Tamil Nadu); Chittoor, Tirupati, Chandragiri, Cuddapah, Nayudupeta, Vizianagoram, Hyderabad (Andhra Pradesh); Bangalore (Karnataka); Mumbai (Maharastra); Ujjain (Madhya Pradesh); Delhi; Dhaka (Bangladesh); Kandy (Sri Lanka).

World distribution : Cosmopolitan.

Dero obtuse d'Udekem, 1855
(Fig. 34)

Dero obtusa d'Udekem, 1855 : 549; Naidu, Kalpana & Sureshkumar, 1981 : 106.

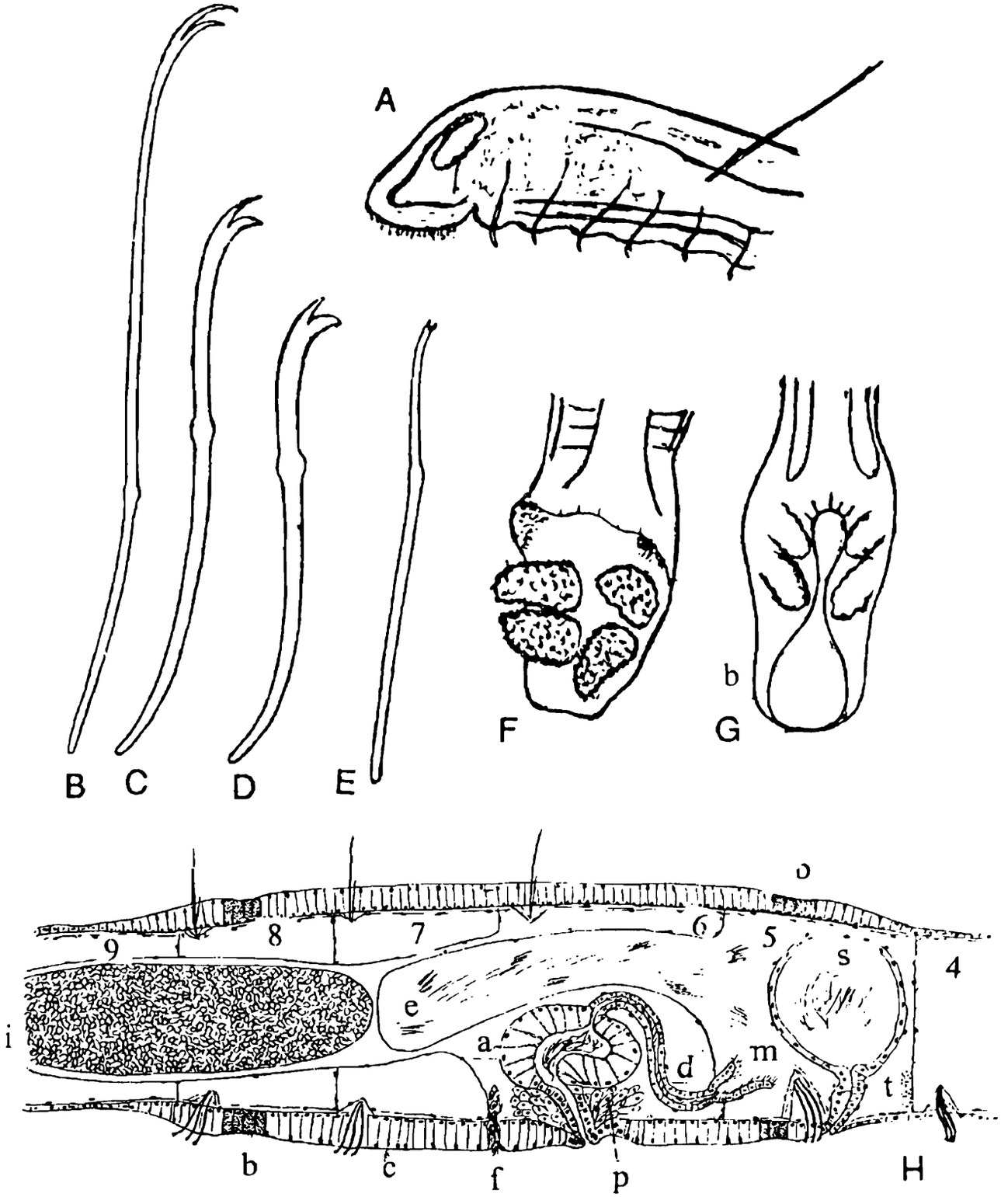

Fig 34 : *Dero obtusa.* A : Anterior part of worm; B, C, D : Ventral setae of II, VI and XXX; E : Needle seta; F, G : Relaxed and contracted branchial fossa; H : Genital organs. (A-G from Cernosvitov, 1942a; H from Marcus, 1944). a : atrium; b : basophil cells of clitellum; c : clitellum; d : vas deferens; e : sperm sac; f : oviduct; i : oocyte; m : male funnel; p : prostate gland cells; s : spermatheca; t : testis. 4, 5, 6, 7, 8, 9 : segments IV-IX.

Type locality : unassigned Belgium.

l = 5-7 (simple), upto 17 mm (chain); d = 0.3 mm; s = 21-65 + undifferentiated region and branchial organl; n = 18-29.

Description : Worms (Fig. 34 A) of moderate size. Prostomium bluntly triangular, covered with long and sharp, stiff sensory cilia ventrally. Dorsal setae from VI, 1-2 hair setae and 1 needle seta per bundle. Hair setae straight, smooth, 130-182 μm long. Needle seta (Fig. 34 E) finely bifid, 58-72 μm long, 1.7 μm thick, with fine equal teeth about 1.5 μm long, and with distal nodulus (D : P :: 1 : 2), distal 1/3 curved. Ventral setae (Fig. 34 B, C, D) in II-V 2-5 per bundle, longer, less curved, thinner than rest, 100-120 μm long, 2 μm thick, with proximal nodulus (D : P :: 3 : 2), teeth equally thick at base, distal longer and more curved, about 12 μm long, proximal tooth about 6.5-8.0 μm long. In rest thicker, 3-6 per bundle, 57-82 μm long, 2.5-3 μm thick, with distal nodulus (D : P :: 2 : 3 or 3 : 4) with unequal prongs, thickness of proximal tooth gradually increasing and length of distal gradually decreasing backwards. Branchial fossa (Fig. 34 F, G) roundish, with its antero-dorsal margin straight or concave, entire and postero-ventral margin prolonged backwards to form a convex lip and with 3 pairs of gills, 2 pairs postero-ventral and digitate and 1 pair dorso-lateral and foliate, or 2 pairs of ventral and 1 pair dorsal and ciliated.

Pharynx in II-III, wide. Oesophagus in IV-VIII, narrow and wavy. Stomach in IX-X, wide. Intestine narrow in XI-XII and wide and sacculated from XIII. Chloragogen cells from VI containing numerous brown granules. Septal gland in IV-VI. Dorsal vessel contractile, situated ventro-laterally to left of gut from hind end to VI and mid-dorsal in anterior 5 segmetns. Ventral vessel non-contractile and mid-ventral. Five pairs of contractile lateral vessels in VI-X.

Clitellum (Fig. 34 H-c) in V-VII. Testes (Fig. 34 H-t) in V Male funnels (Fig. 34 H-m) on anterior face of septum 5/6. Sperm-sac (Fig. 34 H-e) back-pouching of VI. Ovi-sac back-pouching of 6/7. Vas deferens (Fig. 34 H-d) short, S-shaped opening into atrium (Fig. 34 H-a) on its antero-dorsal face. Atrial ampulla large, subglobular, its duct well defined, dilated at middle and surrounded by prostate gland cells (Fig. 34 H-p). Penial setae absent. Spermathecae (Fig. 34 H-s) in V, their ampulla round or elongated with a well defined duct, swollen in middle, opening to outside close to anterior border of V. Asexual reproduction by budding.

Habits : Live in mucous tubes in fresh water. Swims by spiral movements similar to *Dero digitata.*

Distribution : India : Trivandrum (Kerala); Cuddapah, Hyderabad, Visakhapatnam, Vizianagaram (Andhra Pradesh); Delhi.

World distribution : Asia; Africa; Europe; North America; Costa Rica (Central America); Brazil, Argentina (South America).

Dero palmata Aiyer, 1929
(Fig. 35)

Dero palmata Aiyer, 1929a : 39; Naidu, 1966 : 215.

Type locality : Trivandrum, Kerala, India.

l = 2.5-3.0 mm (single), upto 3.5 mm (chain); d : 0.15 mm; s = 19-33 + undifferentiated region and branchial organ; n = 14-15.

Description : Worms small and slender. Prostomium bluntly conical with a rounded anterior margin. Dorsal setae from VI, 1 hair seta and 1 needle seta per bundle. Hair setae 90 μm long, simple and smooth. Needle setae straight, palmate (Fig. 35 A), 52 μm long, with distal nodulus (D : P :: 3 : 5), 13.5-15.0 μm wide at distal end with 2 lateral margins slightly raised. Ventral setae (Fig. 35 B, C, D) of II-V 4 per bundle, twice as long as others, 90 μm long, with proximal nodulus (D : P :: 3 : 2), teeth equally thick, outer twice as long as inner. In others 2-4 per bundle, 48-50 μm long, with distal nodulus (D : P :: 15 : 23), distal tooth thinner and much shorter than proximal. Branchial fossa (Fig. 35 E) with a straight antero-dorsal margin and a rounded postero-ventral border, with 3 pairs of digitate gills, 1 pair lateral and 2 pairs ventral.

Pharynx in II-IV wide. Oesophagus in V-VII narrow. Stomach in VIII barrel-shaped. Intestine narrow in IX and wide from X. Chloragocytes from VI. Dorsal vessel ventrally to left of gut from hind end to VI and mid-dorsal anteriorly, dividing into

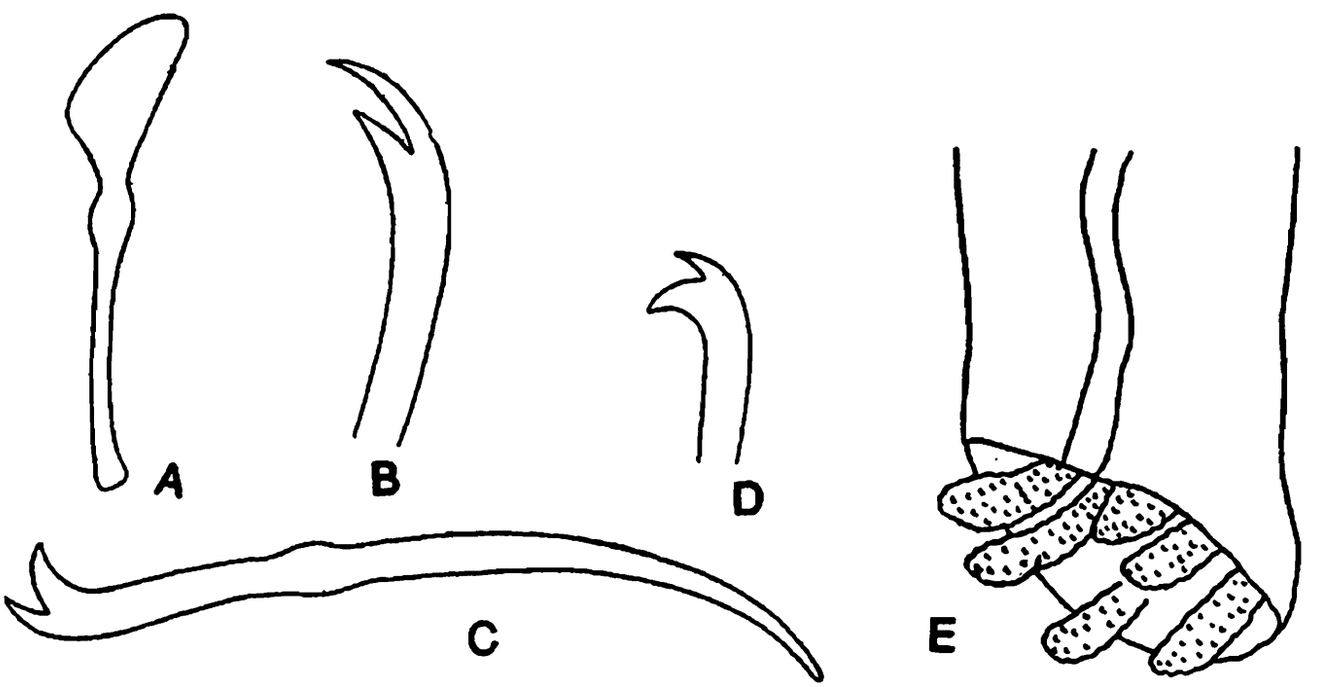

Fig 35 : *Dero palmata.* A : Palmate needle seta; B : Distal end of ventral seta of III; C : Ventral seta of posterior segment; D : Distal end of ventral seta of posterior segment; E : Branchial fossa. (all from Aiyer, 1929a).

2 branches and uniting below pharynx to form ventral vessel. Contractile vascular vessels 3 pairs in VI-VIII. Coelomocytes absent. First nephridium in VIII, one per segment. Brain deeply incised in front and less so behind.

Sex organs not observed. Asexual reproduction by development of budding zones.

Distribution : India : Trivandrum (Kerala).

World distribution : India (Asia); South America.

Dero pectinata Aiyer, 1929
(Fig. 36)

Dero pectinata Aiyer, 1929a : 36; Naidu, 1966 : 215.

Type locality : Trivandrum, Kerala, India.

l = 2.0-2.5 mm (single), upto 3 mm (chain); d : 0.12 mm; s = 19-25 + undifferentiated region and branchial fossa; n = 14-18.

Description : Worms minute, slender, transparent. Prostomium bluntly conical with a few stiff cilia along anterior margin. Dorsal setae from VI, 1 hair seta and 1

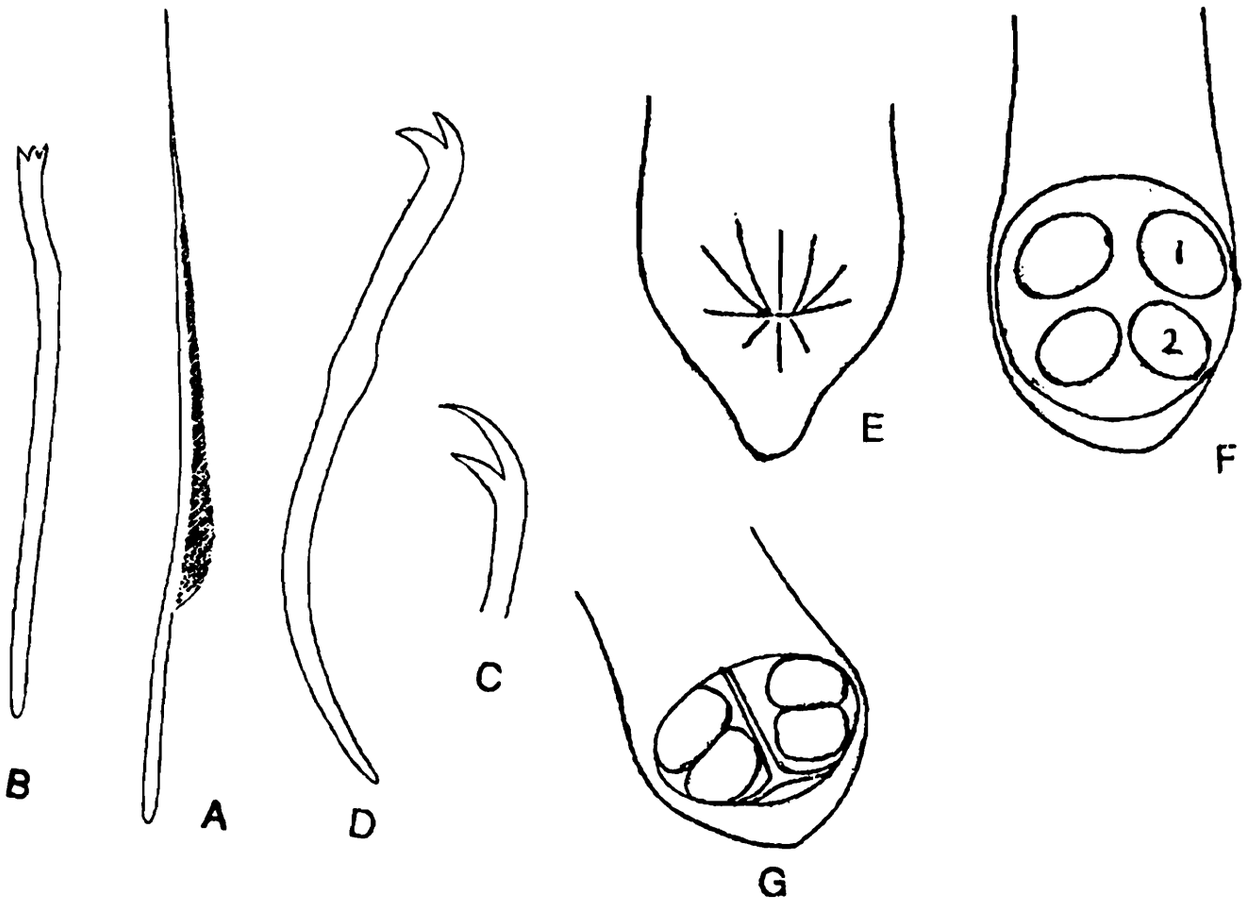

Fig 36 : *Dero pectinata.* A : Plumose hair seta; B : Pectinate needle seta; C : Distal end of ventral seta of II; D : Ventral seta of posterior segment; E-G : Closed, open and preserved branchial fossa. (all from Aiyer, 1929a). 1, 2 : gills.

needle seta per bundle. Hair setae (Fig. 36 A) plumose 68-90 μm long, bayonet-shaped with a row of closely set oblique barbs giving the seta appearance of a feather. Needle setae (Fig. 36 B) pectinate with 3 teeth at distal end, 37-42 μm long, with weak distal nodulus (D : P :: 2 : 7, 1 : 5). Ventral setae (Fig. 36 C, D) of II-V 4 per bundle, much longer, straighter and thinner than those of other segments, 70-84 μm long, with a proximal nodulus (D : P :: 3 : 2), teeth equal in thickness, outer longer than inner. In others 2-4 per bundle, 39-46 μm long, with distal nodulus (D : P :: 1 : 2), outer tooth shorter and thinner than inner. Branchial fossa (Fig. 36 E, F, G) with a rounded postero-ventral border and a ciliated, straight antero-dorsal border, and 2 pairs of small knob-like gills arising from floor, do not project beyond margin of fossa.

Pharynx in II-V, wide. Oesophagus in VI-VII narrow. Stomach in VIII wide. Intestine narrow in IX and wide from X. Chloragocytes from VI. Coelomocytes absent. Dorsal vessel ventro-lateral to left of gut from hind end to VI and mid-dorsal anteriorly. Two pairs of contractile vessels in VI and VIII. First nephridium in VIII, with its funnel-shaped nephrostome on anterior face of septum 7/8 and continued into a nonciliated, non-glandular bladder-like ampulla, which narrows posteriorly and forms a coiled ciliated duct lying in VIII and opening by a nephropore ventro-laterally. One nephridium per segment. Brain deeply incised both in front and behind.

Clitellum in V-VII (3 segments). Ventral setae of VI and penial setae absent. Asexual reproduction by development of budding zone, a single budding zone develops at a time. The individuals of fission sometimes separate before anterior segments fully formed for posterior individual.

Chromosome : 2n = 10 (McGee & French, 1977).

Distribution : India : Trivandrum (Kerala).

World distribution : India (Asia); Africa; U.S.A. (North America); West Indies, Costa Rica (Central America); Argentina, Surinam, Guatemala (South America); Queensland (Australia).

Dero plumosa Naidu, 1962
(Fig. 37)

Dero plumosa Naidu, 1962b : 543; Naidu, 1966 : 215.

Type locality : Cuddapah, Andhra Pradesh, India.

l(p.) = 1.2-1.5 mm; d(p.) = 0.15 mm; s = 19-25 + undifferentiated region and branchial organ; n = 14-17.

Description : Worms minute, slender, delicate, pale white and nearly transparent. Prostomium bluntly triangular, longer than broad, with sensory stiff cilia on its margin. Body surface covered with delicate outgrowths. Dorsal bundles from VI, each with 1 bayonet-shaped plumose hair seta (Fig. 37 A) with close-set oblique barbs on its

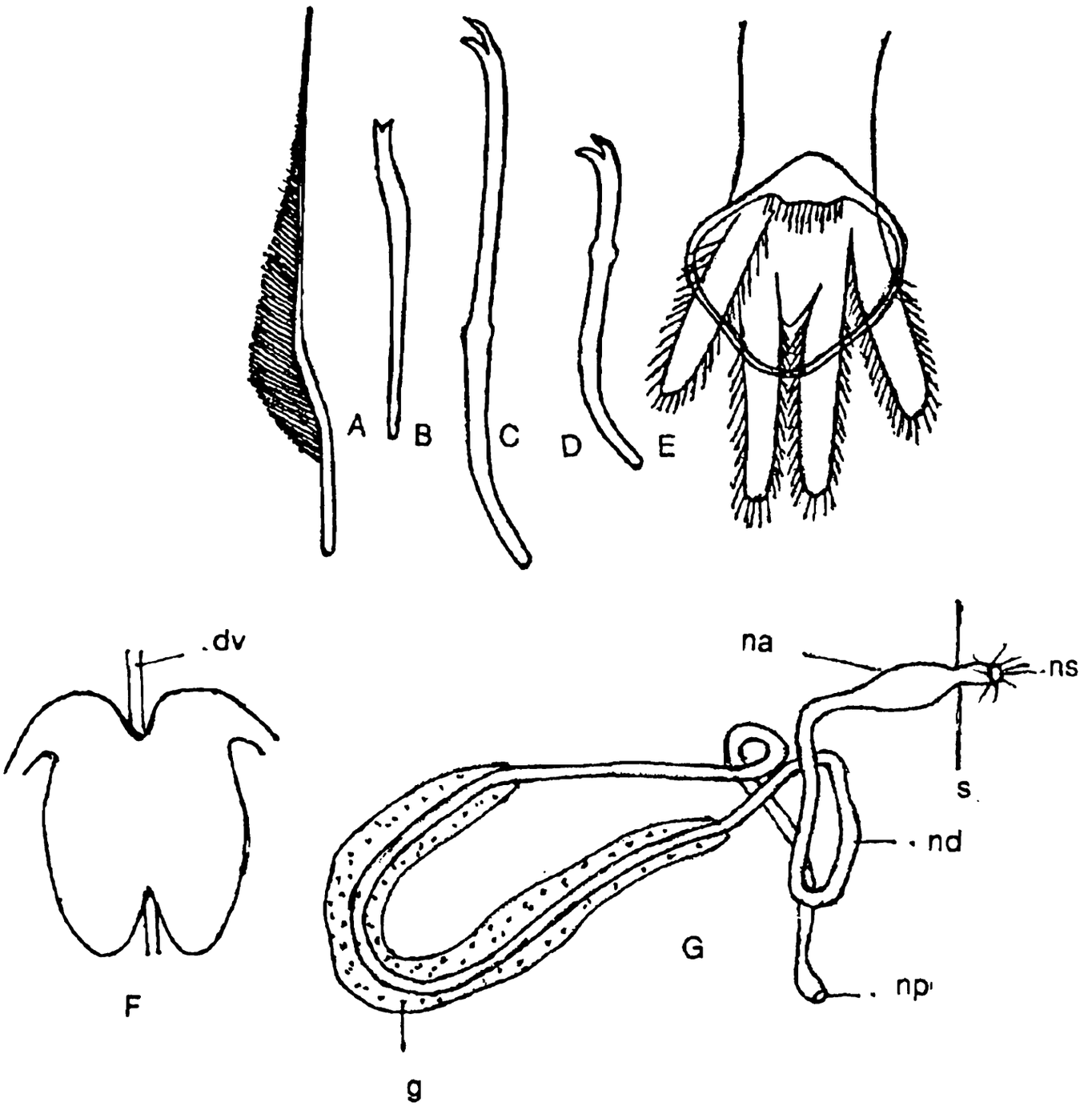

Fig. 37 : *Dero plumosa.* A : Plumose hair seta; B : Needle setae; C, D : Ventral setae of II and VII; E : Branchial fossa fully relaxed; F : Brain; G : Nephridium. dv : dorsal vessel; g : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

convex border, 77-88 μm long; and 1 bifid needle seta (Fig. 37 B) with two minute teeth, 36-39 μm long, with distal nodulus (D : P :: 1 : 3). Ventral setae (Fig. 37 C, D) 4 per bundle, decreasing to 3 and 2 posteriorly; in II-V less curved, thinner than rest, 70-88 μm long, with a proximal nodulus (D : P :: 3 : 2), teeth equally thick, distal 1½ times as long as proximal; in rest 37-44 μm long, with a distal nodulus (D : P :: 5 : 7), distal tooth thinner, shorter than proximal. Branchial fossa (Fig. 37 E) with antero-dorsal margin convex and ciliated, postero-ventral margin converging to a non-ciliated blunt point, with 2 pairs of digitiform gills, anterior pair lateral and short, posterior pair ventral and long.

Pharynx in II-III, wide, with an eversible dorsal diverticulum; oesophagus in IV-VII, narrow and wavy; stomach in VIII, fusiform; intestine narrow and bent in IX, wide and sacculated behind. Chloragogen cells from VI; septal glands in IV-VI. Brain (Fig. 37 F) longer than wde incised in front and behind. Coelomocytes absent. Blood yellowish. Dorsal vessel ventro-lateral to left of gut upto VI and mid-dorsal in anterior 5 segments. Contractile lateral vessels 2 pairs in VI-VII. First pair of nephridia (Fig. 37 G) in VII, with their nephrostomes (Fig. 37 G-ns) on anterior face of septum 6/7; their post-septal part with fusiform, brown, granular ampulla (Fig. G-na) followed by thin, long, ciliated duct opening (Fig. 37 G-nd) to outside by nephropore (Fig. 37 G-np) in front and slightly median to right of ventral bundle.

Clitellum in ½V-VII (2½ segments). Sexual cells present, but gonads absent in sexually mature worms. Sperm-sac and ovi-sac extend to VIII and IX respectively, former within latter, when full. Atrial ampulla ovoid with thick, short ejaculatory duct, opening in position of ventral bundles of VI. Penial setae absent. Male funnels on anterior face of septum 5/6 laterally. Oviducal funnels not observed. Spermathecae twice as long as broad, and open in front of ventral setae of V Asexual reproduciton by paratomy, budding zone develops prostomium and 5 anterior segments to posterior zooid and an indefinite posterior segments and branchial fossa to anterior zooid before separation.

Habits : Worms live in transparent gelatinous tubes covered with sand and mud particles. Tubes fused parallel to each other. Swim by brisk serpentine movements.

Distribution : India : Cuddapah (Andhra Pradesh); Bellary (Karnataka).

World distribution : India (Asia); Costa Rica (Central America); Argentina (South America).

Dero raviensis (Stephenson, 1914)
(Fig. 38)

Nais raviensis Stephenson, 1914b : 324; 1915b : 785; 1923 : 65; Naidu, 1966 : 213;

Dero raviensis (Stephenson) Grimm, 1985 : 111.

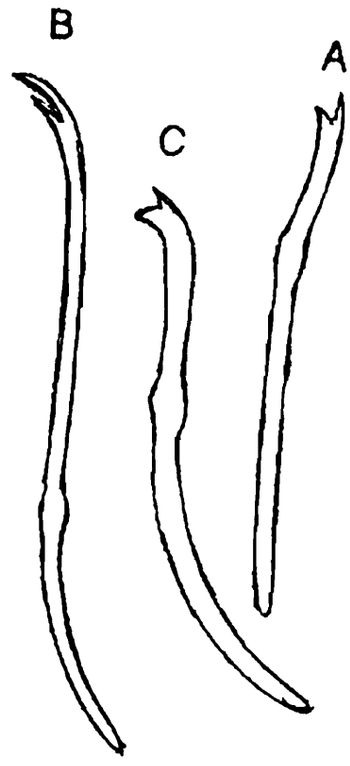

Fig 38 : *Dero raviensis.* A : Needle seta; B, C : Ventral seta of anterior and posterior segment. (all from Stephenson, 1923).

Dero (Dero) raviensis, Battish & Sharma. 1997 : 82.

Type locality : Ravi River, Lahore, Pakistan.

l(p.) = 3 mm; d(p.) = 0.12 mm; s = 26 (in a chain of 2) + undifferentiated region and branchial fossa; n = 13.

Descriptoon : Worms small, delicate, slender and pale white. Prostomium bluntly triangular and short. Dorsal setae from VI, 1 short hair seta and 1-2 needle setae per bundle. Hair setae 83-110 μm long, simple, smooth and nearly straight. Needle setae (Fig. 38 A) bifid, 35-40 μm long, with distal nodulus about 2/7 from distal end, shaft almost straight, distally curved above nodulus, with short, stout and diverging teeth. Ventral setae (Fig. 38 B, C) 3-4 per bundle, in II-V thinner, much longer, straighter than others, about 90 μm long, 2.2 μm thick, with proximal nodulus, teeth equally thick, distal 7-8 μm long, much longer than proximal. In rest less than half length of anterior segments, about 35-48 μm long, 2.5 μm thick, with distal nodulus, distal tooth thinner and slightly shorter than proximal.

Pharynx in II-V, wide. Oesophagus in VI-VII narrow, continuing into intestine from VIII. Stomach absent. Chloragocytes from VI. Coelomocytes absent. Brain deeply incised behind with nearly straight anterior border. Dorsal vessel lie laterally to left of gut from hind end to VI and mid-dorsal in II-V, contractile lateral vessels atleast one pair in VI.

Sex organs not known. Asexual reproduction by formation of budding zone, one at a time. Prostomium and anterior 5 segments to posterior individual and several posterior segments and branchial fossa to anterior individual budded off before separation.

Habits : Worms live among aquatic vegetation in fresh water.

Remarks : On finding small branchial fossa with gills and *Dero* type of setae in II-V, in type material of *Nais raviensis* Stephenson, Grimm (1985, 1987) transferred it to genus *Dero*.

Distribution : India : Kurushetra (Haryana). Lahore (Pakistan).

World distribution : Asia; Kenya, Transvaal (Africa); Surinam, Argentina, Peru (South America).

Dero sawayai Marcus, 1943
(Fig. 39)

Dero sawayai Marcus, 1943 : 35; Naidu, 1962b : 541; 1966 : 215; Costa, 1967 : 44.

Type locality : Sao Paulo, Brazil, South America.

l(p.) = 2.0-2.5 mm; d(p.) = 0.20-0.25 mm; s = 26-40 + undifferentiated region and branchial organ; n = 13-14.

Description : Worms small, delicate and pale yellow. Prostomium bluntly triangular with stiff sensory cilia on anterior margin. Dorsal setae begin in VI, each bundle with 1-2 smooth hair setae (Fig. 39 A) of 80-100 μm long, and 1-2 bifid needle setae (Fig. 39 B) 35-38 μm long, with strong distal nodulus (D : P :: 1 : 4), distal tooth thinner and shorter than proximal. Ventral setae (Fig. 39 C, D) 4 per bundle, in II-V thinner, less curved than rest, 66-78 μm long, with a proximal nodulus (D : P :: 4 : 3), teeth equally thick, distal much longer than proximal. In rest 38-45 μm long, with distal nodulus (D : P :: 5 : 7), distal tooth thinner and slightly longer to shorter than proximal. Branchial organ (Fig. 39 E, F) cup-shaped with 2 pairs of small digitiform gills, 1 pair dorsal and 1 pair ventral.

Pharynx in II-IV; oesophagus in V-VII, narrow; stomach in VIII, abrupt and distinct, with a plexus of transverse vessels on its wall, similar to those in *Chaetogaster*; intestine narrow in IX and X, and wide and sacculated from XI. Chloragocytes from VI, brownish. Septal glands in IV-VI. Blood yellowish. Dorsal vessel ventrally to left of gut upto VI and mid-dorsal anteriorly. Contractile vascular vessels 2 pairs in VI-VII. First nephridium (Fig. 39 G) in VII to left, with nephrostome (Fig. 39 G-ns) in funnel, continued into an ampulla (Fig. 39 G-na) and long coiled nephridial duct (Fig. 39 G-nd), proximal third enclosed in glandular mass (Fig. 39 G-g) and distal part free opening to exterior by nephropore (Fig. 39 G-np) ventro-laterally.

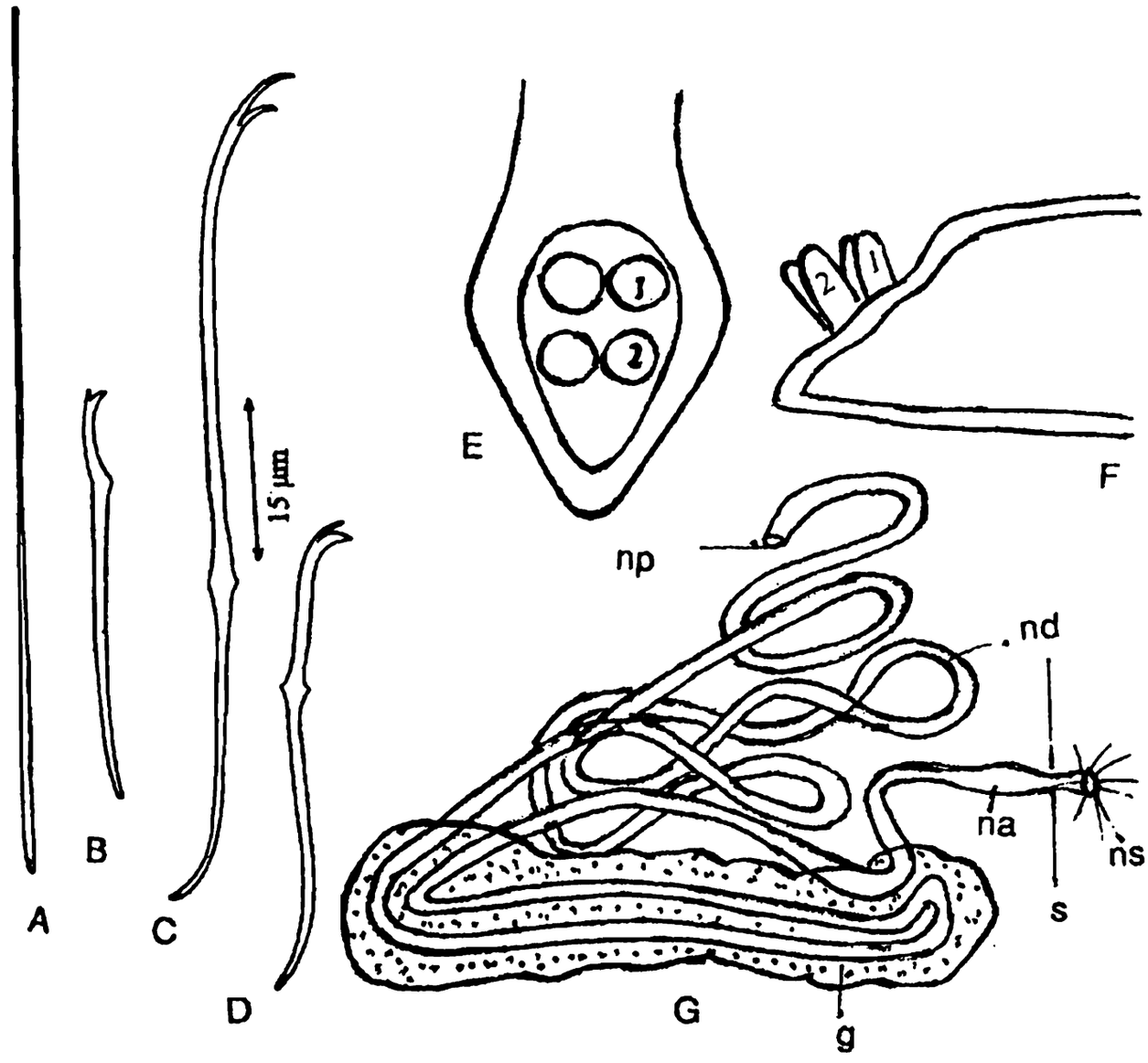

Fig 39 : *Dero sawayai.* A : Hair seta; B : Needle setae; C, D : Ventral setae of II and middle segment; E : Branchial fossa; F : Relaxed branchial fossa lateral view; G : Nephridium; (A-D from Marcus, 1943). g : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum; 1, 2 : gills.

Sex organs not known. Asexual reproduction by paratomy, one budding zone develops at a time and continues during beginning and middle phases of sexual maturity.

Habits : Tube-dwelling in fixed mucous tubes covered with foreign particles in fresh water and swims with brisk wriggling movements.

Distribution : India : Chittoor, Tirupati (Andhra Pradesh); Bangalore (Karnataka); Mumbai, Nagpur (Maharastra); Peradeniya (Sri Lanka).

World distribution : Asia; Louisiana (North America); Trinidad (West Indies); Brazil, Argentina (South America).

Dero zeylanica Stephenson, 1913
(Fig. 40)

Dero zeylanica Stephenson, 1913b : 252; 1923 : 89; Aiyer, 1929a : 30; Mendis & Fernando, 1962 : 45; Naidu, 1962b : 536; 1966 : 215; Costa, 1967 : 45; Vasisht & Gandhi : 1972 : 99; Naidu & Srivastava, 1980 : 266; Naidu & Naidu. 1981a : 532; Sobhana & Nair, 1983a : 104; Nair, Dharmaraj, Aziz, Arunachalam & Krishnakumar, 1984 : 477; Battish & Sharma, 1997 : 82.

Dero (Dero) zeylanica Stephenson. Ali & Issaque, 1975 : 58; Mukhopadhyay, 1998 : 107.

Type locality : Kandy, Sri Lanka.

l(p.) = 5-7 mm (single), 10-12 mm (chain); d(p.) = 0.3-0.4 mm; s = 42-82 + undifferentiated region and branchial fossa; n = 23-33.

Description : Worms of medium size, sturdy, pale red in colour, with whitish branchial fossa. Prostomium bluntly triangular with stiff cilia on margin. Dorsal setae begin in VI, each bundle with 3 hair setae and 3 needle setae (rarely 4 of each) in anterior segments, 2 each in middle segments and 1 each in posterior segments. Hair setae slightly bayonet-shaped, 210-320 μm long. Needle setae (Fig. 40 A) bifid, sickle-shaped, 82-102 μm long, with distal nodulus (D : P :: 9 : 17), teeth small, distal longer than proximal. Ventral setae (Fig. 40 B, C, D) in II-V 4-6 per bundle, longer, thinner, straighter than rest, 108-128 mm long, with median nodulus (D : P :: 16 : 17), teeth equally thick, distal twice as long as proximal. In rest 4-6 per bundle, 80-95 μm long, with distal nodulus (D : P :: 5 : 8), teeth equally thick, distal slightly longer to equal than proximal. Branchial fossa (Fig. 40 E, F, G) with its anterior margin flat, convex, ciliated and posterior margin, flat, non-ciliated with a transverse brown band in older worms, with anterior diverticulum above anus and 4 pairs of foliate gills, I pair dorsal, ovoid, flat, arise from supra-anal diverticulum, II pair arise from lateral margin, large and broadest, circular in outline, but its anterior lateral 1/3 part usually fold backwards over rest, III and IV pairs triangular, arise from floor of fossa, one behind other.

Pharynx in II-IV, wide, ciliated with a dorsal diverticulum protrusible as a disc-like sucker through mouth. Oesophagus in V-VIII, narrow and wavy. Stomach in IX-X, fusiform. Intestine narrow in XI-XII, wide, sacculated from XIII. Chloragocytes from VI, grayish brown. Septal glands and coelomocytes absent. Brain (Fig. 40 I) widely and deeply incised in behind and less deeply in front. Blood orange red. Dorsal vessel ventro-lateral to left of gut from hind end to VI and mid-dorsal anteriorly. Contractile lateral vessels 4 pairs in VI-IX. First nephridium (Fig. 40 H) in VIII with its nephrostome (Fig. 40 H-ns) in VII, followed by narrow neck expanding into an ampulla (Fig. 40 H-na), continues as nephridial duct (Fig. 40 H-nd), 1/3 of its length free and rest enclosed in glandular mass (fig. 40 H-gl), ending in nephropore (Fig. H-np) ventrally.

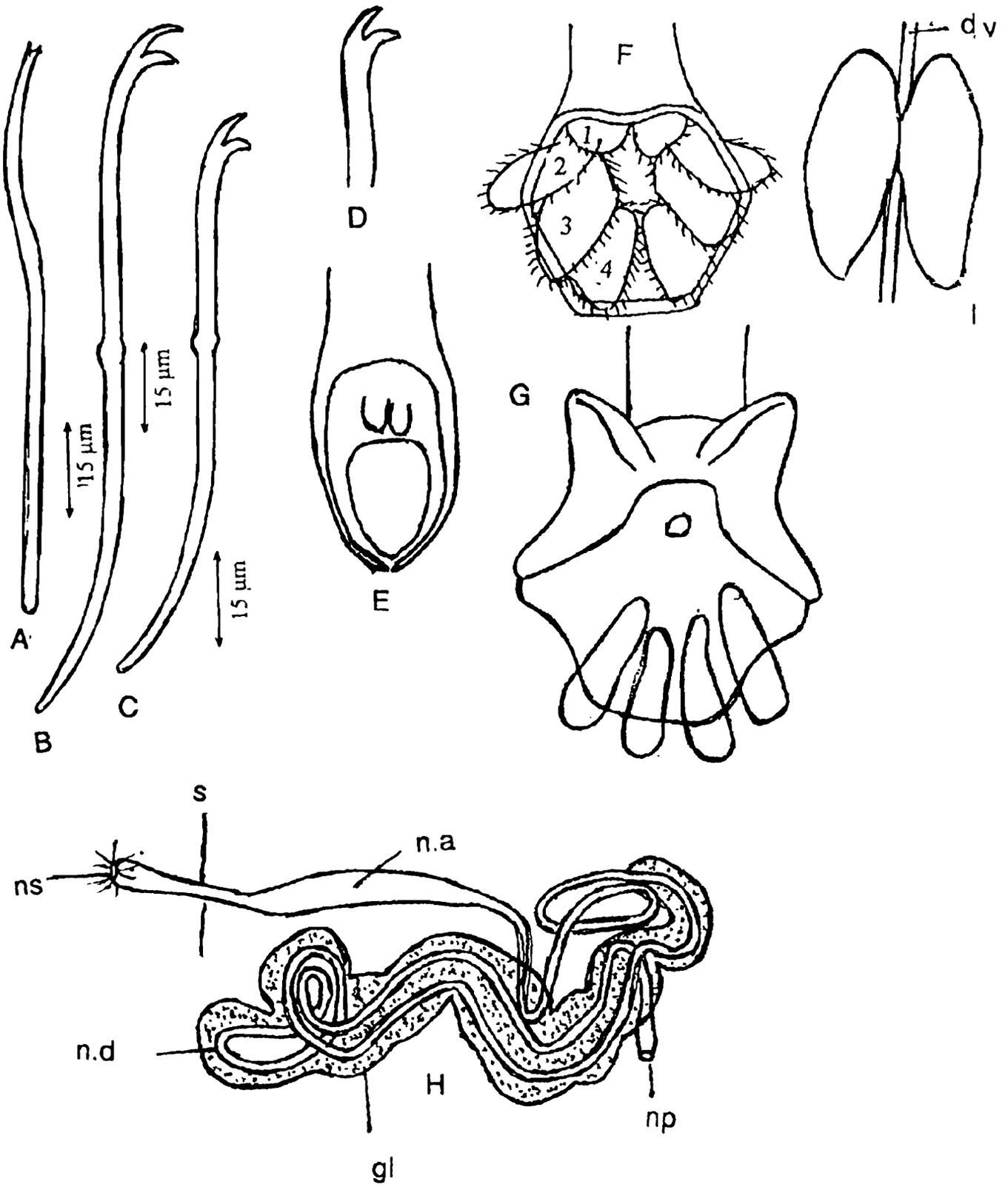

Fig 40 : *Dero zeylanica.* A : Needle setae; B, C : Ventral setae of II and VI; D : Distal end of ventral seta of posterior segment; E : Contracted branchial fossa; F, G : Moderately relaxed and fully relaxed branchial fossa; H : Nephridium; I : Brain. dv : dorsal vessel; gl : glandular part; n.a : nephridial ampulla; n.d : nephridial duct; np : nephropore; ns : nephrostome; s : septum; 1, 2, 3, 4 : gills.

Clitellum in ½V-½VIII (3 segments). Sperm-sac and ovi-sac extend to IX and XIII respectively. Male funnels a pair, laterally situated on anterior face of septum 5/6, followed by vasa deferentia entering large, thin-walled globular atrial ampullae in VI. Ejaculatory duct short and open to outside in an invagination of body wall ventrally in VI. Spermathecae club-shaped, thin-walled in V, enter sperm-sac, open to outside lateral to ventral setae of V. Ventral setae of VI and penial setae absent. In sexually mature worms anterior part of alimentary canal degenerates. Budding zone usually appears between last segment with 3 hair and 3 needle setae and first segment with 2 hair and 2 needle setae and second budding zone between last segment with 2 hair and 2 needle setae and first segment with 1 hair and 1 needle seta normally. Prostomium and 5 anterior segments to posterior zooid and indefinite number of segments and branchial fossa to anterior zooid form before they separate.

Habits : Worms bury their head ends in soft mud. Rarely they are found in tubes of mucous, sand and clay particles. Swim by slow spiral movements.

Distribution : India : Veli Lake, Trivandrum, Nagerkoil, Chirayinkil Kadinamkulam (Kerala); Chidambaram (Tamil Nadu); Chittoor, Tirupati, Cuddapah, Gudur, Anantapur, Kurnool (Andhra Pradesh); Bangalore, Bellary (Karnataka); Powai Lake, Mumbai, Nagpur (Maharastra); Varanasi (Uttar Pradesh); Chandigarh; Ludhiana (Punjab); Haryana; Aral Bansi, Saltora, Susunia, Katwa, Galsi, Raina, Bamangola, Kaliachawk, Midnapore, South and North 24 Paraganas districts (West Bengal); Chirrapunji (Meghalaya). Dhaka (Bangladesh); Meegoda, Kandy, Hindgala near Peradeniya (Sri Lanka).

World distribution : Asia; Brazil (South America).

Genus ***Aulophorus*** Schmarda, 1861.

Aulophorus Schmarda, 1861 : 9; Stephenson, 1923 : 90; 1930 : 736; Sperber, 1948 : 190; Chekanovskaya, 1962 : 175; Naidu, 1963a : 897; Brinkhurst, 1964 : 214; Brinkhurst & Jamieson, 1971 : 374; Mukhopadhyay, 1998 : 104.

Diagnosis : Eyes absent. Dorsal setae present from IV, V or VI onwards; ventral setae of II-V different or not different in shape from those of following segments. Stomachal dilatation present or absent. Posterior border of branchial fossa projecting into two palps. Coelomocytes present or absent. Spermathecae rarely absent; vasa deferentia entering atria at anterior end; prostate glands absent; usually penial setae absent. Asexual reproduction by budding or fragmentation. Usually living in portable tubes. Cosmopolitan.

Type species : *Aulophorus furcatus* (Müller, 1773).

Key to Indian species of *Aulophorus*

1. Dorsal setae begin in V 2

– Dorsal setae begin in VI 7

2. Needle setae bifid with intermediate tooth ..... *Aulophorus indicus*
- Needle setae simply bifid 3
3. Distal tooth of needle setae thinner, shorter than proximal..... *Aulophorus furcatus*
- Distal tooth thinner, longer than proximal 4
4. Gills 3 pairs 5
- Gills 4 pairs 7
5. Gills 3 pairs, foliate ..... *Aulophorus hymanae*
- Gills 4 pairs, digitiform 6
6. Hairs setae bayonet-shaped; coelomocytes absent ..... *Aulophoruds moghei*
- Hairs setae not bayonet-shaped; coelomocytes present..... *Aulophorus michaelseni*
7. Needle setae simply bifid ..... *Aulophorus gravelyi*
- Needle setae palmate 8
8. Ventral setae of II-V more than twice as long as rest..... *Aulophorus flabelliger*
- Ventral setae of II-V less than twice as long as rest 9
9. Gills 2 pairs; spermatheca absent ..... *Aulophorus tonkinensis*
- Gills 3 pairs; spermathecae present ..... *Aulophorus carteri*

Aulophorus carteri Stephenson, 1931
(Fig. 41)

Aulophorus carteri Stephenson, 1931b : 303; Sobhana & Nair, 1983a : 104.

Type locality : Swamp in Makthlawaiya in Chaco, Paraguay, South America.

l(p.) = 2 mm (single); 4-5 mm (chain); d(p.) = 0.14-0.21 mm; s = 21-24 + undifferentiated region and branchial fossa; n = 17-23.

Description : Worms small, delicte. Prostomium rounded equilateral triangle. Dorsal setae from VI, each bundle with 1-2 hair setae and 1-2 needle setae. Hair setae straight, smooth 160-210 μm long; needle setae (Fig. 41 A, B, C), almost straight, bifid with slightly unequal teeth, with a smooth web without ribs stretching between teeth, 80-120 μm long. The teeth diverge 7-9 μm at tip. Ventral setae (Fig. 41 D, E) bifid, 5-7 per bundle in anterior segments, 5-6 in middle and 3-4 in posterior segments. In II-V longer and thinner, upto 120 μm long, and 2.5 μm thick, with proximal nodulus, distal tooth considerably longer and slightly thinner than proximal; in rest 60-72 μm long, with distal nodulus, teeth short, distal thinner and shorter than proximal. Branchial fossa with slightly diverging palps of about 0.14-0.21 mm long, and 3 pairs of short gills, 1 pair dorsal, 1 pair lateral and 1 pair ventral.

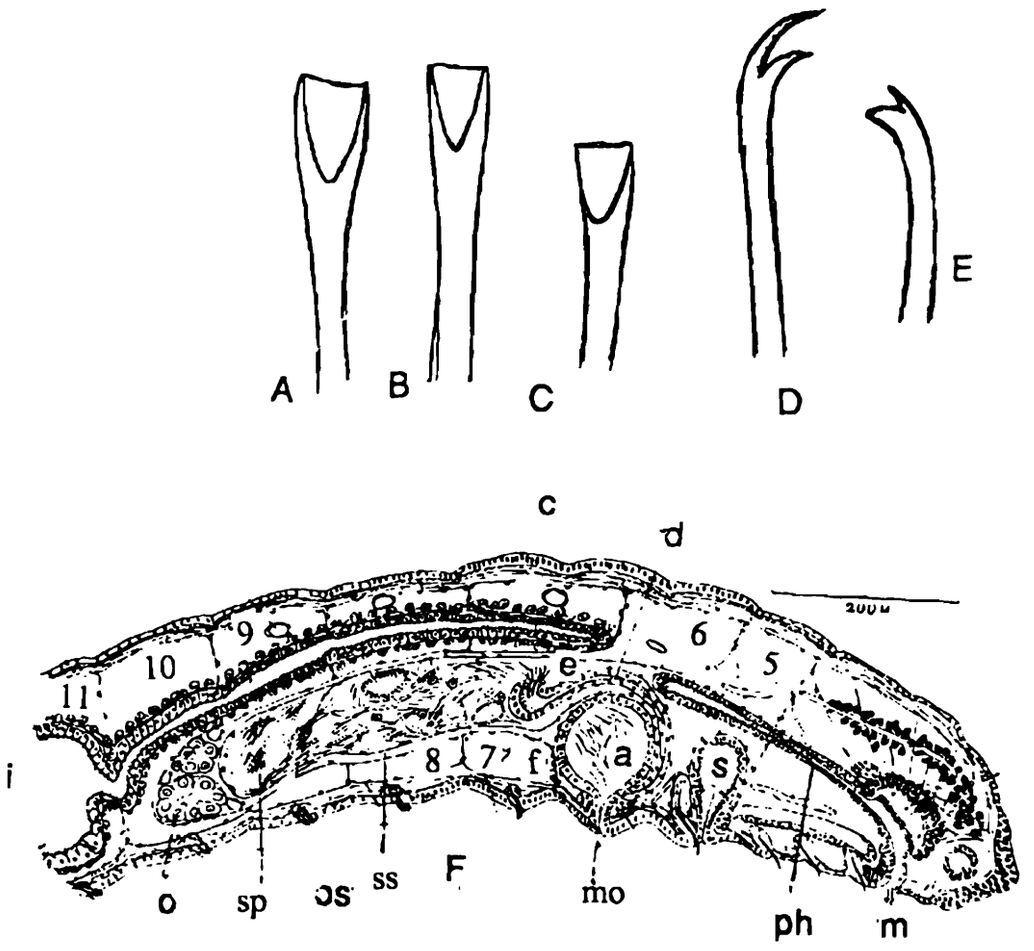

Fig 41 : *Aulophorus carteri.* A-C : Needle setae; D, E : Ventral setae of anterior and middle segments; F : Genital organs. (F from Marcus, 1943). a : atrium; c : clitellum; d : vas deferens; e : male funnel; f : vestigial oviduct; i : intestine; m : mouth; mo : male pore; o : ovum; os : ovi-sac; ph : pharynx; s : spermatheca; sp : spermatozoa.

Buccal cavity in I; pharynx in II-V wide with circumscribed plate of high cells similar to that found in Enchytraeidae, eversible to outside through mouth for purpose of feeding, locomotion and construction of tube; oesophagus in VI-IX, narrow, straight continuing into intestine imperceptability; intestine narrow in X and wide from XI. Stomach absent. Chromophile cells not connected with digestive tract. Anus opens in branchial fossa. Septa well developed, septal glands absent. Coelomocytes absent. In II and III masses of gland cells present.

Clitellum (Fig. 41 F-c) in V-½VIII (3½ segments), it attains full size after copulation. Testes a pair in V located laterally on posterior face of septum 4/5, but disappear soon after full development. Sperm-sac (Fig. 41 F-ss) a back-pouching of septum 5/6 extend to VIII. Male funnels (Fig. 41 F-e) a pair in V, cup-shaped located laterally on anterior face of septum 5/6, enter sperm-sac. Vasa deferentia (Fig. 41 F-d) long, run forward, and open into atria on their anterior face below middle. Atrial ampulla (Fig. 41 F-a) spherical or ovoid in VI with short ejaculatory ducts, surrounded by prostate

glands before opening to exterior ventro-laterally by male pore (Fig. 41 F-ms) in VI. Partial ovaries leave ovary as oogonia and enter ovi-sac (Fig. 41 F-os) with generally 32 oocytes (Fig. 41 F-o). Oviduct (Fig. 41 F-f) on posterior face of septum 6/7 Spermathecae (Fig. 41 F-s) a pair in V, spherical or ovoid with short ducts opening ventro-laterally in front of ventral setae close behind septum 4/5. Penial setae absent. Asexual reproduction by budding, budding zone produces prostomium and 5 anterior segments to posterior individual, and some segments and branchial fossa to anterior animal, before they separate. Asexual and sexually mature worms develop epidermal glands in pregenital segments similar to those in *Allonais paraguayensis* and *Aulophorus furcatus* (Marcus, 1943).

Habits : Worm lives in straight, portable dark tubes of 4-8 mm long, 0.6 mm wide. It employs pharynx plate for feeding and feeds on diatoms, desmids and *Arcella* and organic detritus. Its primary mucous tube is secreted by epidermis and later adds spores of *Azolla*, *Salvinia*, statoblasts of Polyzoans and mud particles put together by protruded roof of pharynx. (Carter & Beadle, 1931). For locomotion it fixes protruded pharynx to substratum, pulls itself forward and crawls forward by jerks. One jerk advances the worm 3-6 μm. After division by paratomy anterior worm turns around in the tube and movements of both worms bend the tube and tear a hole into it, and with protruding and retracting of heads, hole is widened into a broad slit and tube divides into two (Marcus, 1943). When drawn out of tubes, they swim with horizontal wriggling movements.

Distribution : India : Veli Lake, Trivandrum (Kerala).

World distribution : India (Asia); El Salvadore (Central America); Brazil, Surinam, Paraguay, Peru, Central Amazon inundated forest area (South America).

Aulophorus flabelliger Stephenson, 1931
(Fig. 42)

Aulophorus flabelliger Stephenson, 1931a : 44; Radhakrishna & Saibaba : 1977 : 564; Kalpana & Naidu, 1979 : 273.

Type locality : Naivasha, Kenya, Africa.

l (p) = 2.2-3.5 mm; d(p) = 0.16-0.2 mm; s = 22-34 + undifferentiated region and branchial fossa; n = 16-18

Description : Worms small pale white, transparent. Prostomium bluntly triangular, margin rounded. Dorsal setae begin in VI, 1 hair and 1 needle seta per bundle. Hair setae simple; 84-115 μm long. Needle setae (Fig. 42 A) palmate, nearly straight, 50-62 μm long and 2.5 μm thick, with distal nodulus (D : P :: 4 : 7), distal end with 2 strongly diverging unequal teeth, longer tooth about 18 μm long, shorter tooth about 13 μm long, connected by an oblique 15-18 μm wide web with minute serrations adjacent to longer tooth. Ventral setae (Fig. 42 B, C), of II-IV 4-7 per bundle, less

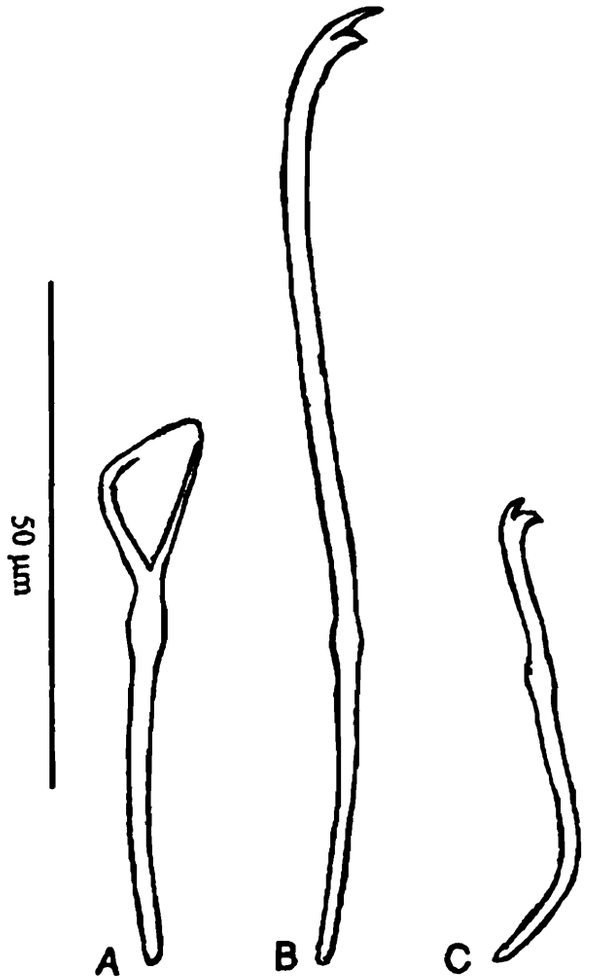

Fig 42 : *Aulophorus flabelliger*. A : Needle seta; B, C : Ventral setae of anterior and posterior segment. (all from Ercolini, 1970).

curved, 100-127 µm long, 3 µm thick, with proximal nodulus (D : P :: 11 : 6, 5 : 3), with distal tooth thinner and twice as long as proximal. In rest 2-4 per bundle more curved 47-55 µm long, 2 µm thick, with distal nodulus (D : P :: 6 : 11 or 10 : 17), with distal tooth thinner and half as long as proximal. Branchial fossa cup-shaped with a pair of non-contractile palps 0.35 mm long and 0.15-0.17 mm thick, and 3 pairs of contractile and digitiform gills, 1 pair dorsal short, 1 pair lateral and 1 pair ventral both long.

Mouth a transverse slit. Pharynx in II-V, with a dorsal diverticulum, eversible as a circular disc-like sucker used for feeding, locomotion and construction of tubes. Oesophagus in VI-VIII, narrow. Stomach in IX, barrel-shaped. Intestine from X. Coelomocytes absent. Chlorogocytes from VI. Blood yellowish. Dorsal vessel for most part ventral to left of gut and mid-dorsal in anterior 5 segments.

Sex organs have not been observed. Paratomy occurs, budding zone develops prostomium and 5 anterior segments to posterior individual and some posterior segments and branchial fossa to anterior individual produced before separation.

Habits : Live in thin delicate, cylindrical hyaline tubes of 3.5-4.5 mm long, 0.3 mm wide studded withi bits of filamentous algae etc.

Distribution : India : Vizianagaram, Morappu near Guntur (Andhra Pradesh).

World distribuition : Asia; Abyssinia, Ghana, Somalia, Kenya (Africa); Italy (Europe); Florida (North America); South America; Queensland (Australia).

Aulophorus furcatus (Müller, 1773)
(Fig. 43)

Nais furcata Müller, 1773 : 23.

Dero sp. Stephenson, 1910a: 71.

Aulophorus furcatus, Stephenson, 1914b: 332; 1915b : 784; 1916 : 306; 1923 : 92; 1925b : 46; 1926b : 253; Aiyer, 1929a : 43; Cernosvitov, 1942a : 201; Sperber, 1958 : 49; Naidu, 1963a : 899; 1966 : 216; Costa, 1967 : 45; Vasisht & Gandhi, 1972 : 99; Gates, 1972 : 316; Sharma, Handa & Sahi, 1976 : 104; Naidu & Naidu, 1979b : 414; Sureshkumar & Ramasarma, 1979 : 347; Naidu & Srivastava, 1980 : 267; Naidu & Naidu, 1981a : 532; Naidu, Kalpana & Sureshkumar, 1981 : 107; Sobhana & Nair, 1983a : 104.

Dero (Aulophorus) furcatus, Ali & Issaque, 1975 : 58. Khatoon & Ali, 1993 : 532.

Type locality : Unassigned, Germany.

l(p.) = 4-8 mm; d(p.) = 0.22-0.24 mm; s = 25-47 + undifferentiated region and branchial organ; n = 15-22.

Description : Worms of medium size, pale brown in colour. Prostomium bluntly conical with stiff cilia on margin. Dorsal setae from V, 1-2 hair and 1-2 needle setae per bundle. Hair setae 107-187 μm long, smooth, slightly curved. Needle setae (Fig. 43 A) 50-64 μm long, with distal nodulus (D : P :: 5 : 9), distal tooth thinner, about equal to and straighter than proximal. Ventral setae (Fig. 43 B, C) 3-5 per bundle decreasing to 2-3 posteriorly; in II-IV 54-76 μm long, slender, less curved with median nodulus (D : P :: 1 : 1), teeth equally thick, distal nearly twice as long as proximal, in rest 53-68 μm long, more curved, thick, with distal nodulus (D : P :: 7 : 9), distal tooth shorter and thinner than proximal. Lengths and thickness of seta, length of distal tooth and position of nodulus vary from seta to seta in a bundle. Branchial fossa (Fig. 43 D, E) cup-shaped with a pair of non-contractile palps 0.4-0.5 mm long, 7 μm wide at base, fringed with cilia, and 3 pairs of contractile foliate gills, 1 pair arise from supra-anal diverticulum, 1 pair from lateral margin and 1 pair from floor of fossa.

Pharynx in II-V, wide, its dorsal plate eversible through mouth. Oesophagus in VI-VII, insensibly continuing into intestine. Stomach absent. Chloragocytes begin in VI greenish gray. Coelomocytes absent. Septal glands 2 pairs in IV and V. Brain incised deeply in front and less deeply behind. Blood yellowish. Dorsal vessel mid-dorsal in I-VI and ventro-lateral to left of gut from VII onwards. Simple non-contractile lateral

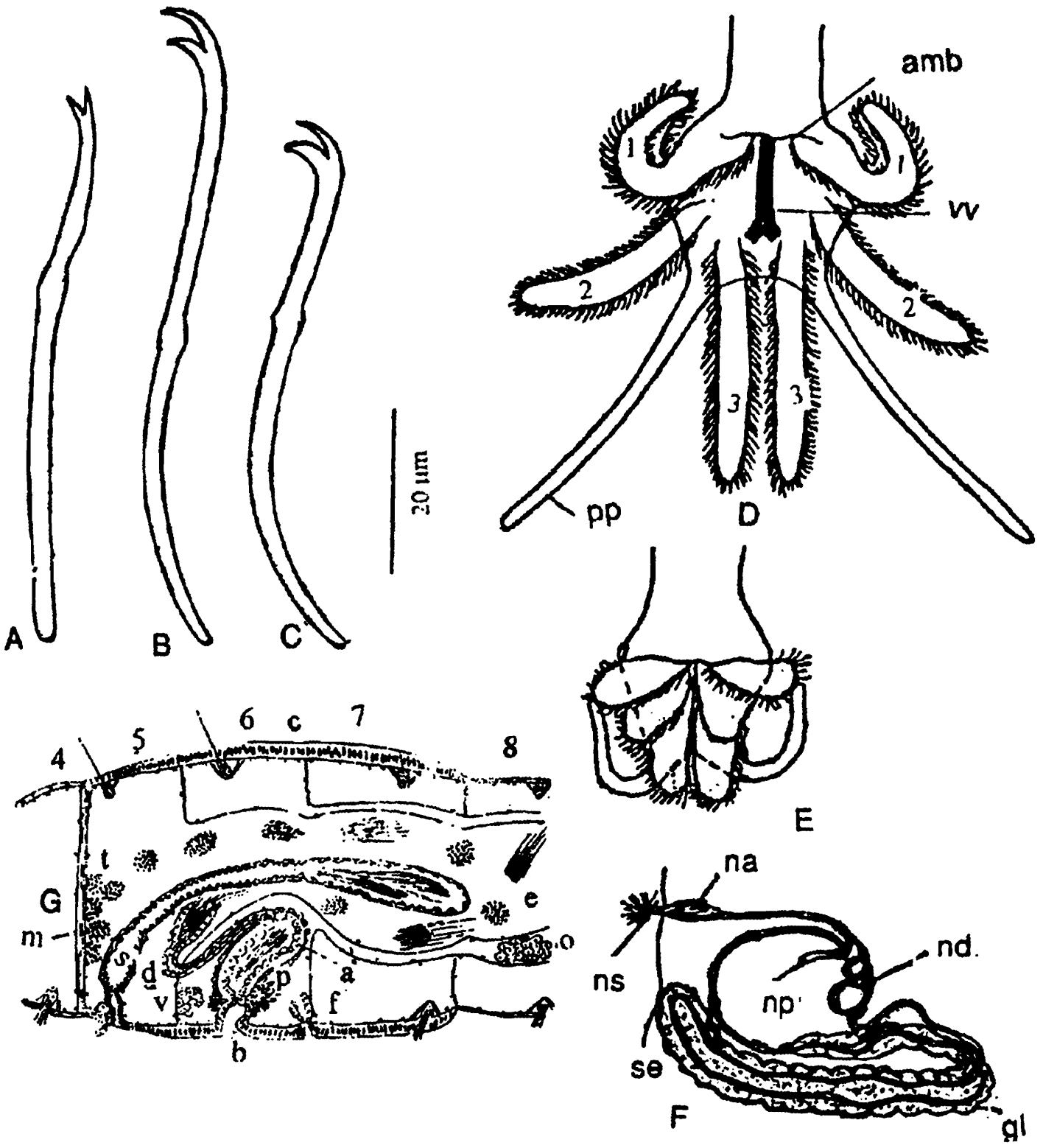

Fig 43 : *Aulophorus furcatus.* A : Needle seta; B, C : Ventral setae of II and VI; D, E : Branchial fossa relaxed and contracted; F : Nephridium; G : Genital organs (A-C from Ercolini, 1970; G from Marcus, 1943). a : atrium; amb : anterior margin of branchial fossa; b : male pore; c : clitellum; d : vas deferens; e : sperm sac; f : female funnel; gl : glandular part; m : male funnel; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; o : oocyte; p : prostate; pp : palp; s : spermatheca; se : septum; t : testis; v : ovary; vv : ventral vessel; 1, 2, 3 : gills, 4, 5, 6, 7, 8 : segments IV-VIII.

vessels connect dorsal and ventral vessels in II-V and 5 pairs of contractile lateral vessels in VI-X. First pair of nephridia (Fig. 43 F) in VII, with their pre-septal funnels with nephrostome (Fig. 43 F-ns) in VI, and a post-septal part with ampulla (Fig. 43 F-na) and of highly coiled duct (Fig. 43 F-nd), its early part free, later part covered by gland tissue (Fig. 43 F-gl), opening ventro-laterally by nephropores (Fig. 43 F-np).

Clitellum in ½V-VII (2½ segments), weak between male pores. In sexually mature worms, gonads absorbed after production of sexual elements. Sperm-sac and ovi-sac extend to VIII and XI respectively when filled with sex cells. Male funnels (Fig. 43 G-m) cup-shaped on anterior face of septum 5/6, vasa deferentia (Fig. 43 G-d) enter atrial ampulla antero-dorsally. Atrial ampulla (Fig. 43 G-a) small, ovoid with a short ejaculatory duct opening to exterior at position of ventral bundles of VI. Penial setae absent. Spermathecae (Fig. 43 G-s) a pair in V, long club-shaped, thin walled, with ampullae twice as wide as ectal duct, extend to VII or VIII within sperm-sac, opening slightly laterally to ventral bundles of V Asexual reproduction by paratomy. Worms with 1-5 fission zones common. First fission zone develops about middle of body, and successive fission zones develop in 2 individuals alternatively and a chain of 5 individuals, I and III individuals composed of more segments than others. Division goes on till the time of copulation. Asexual and sexually mature worms develop epidermal glands in pregenital segments similar to those in *Allonais paraguayensis* and *Aulophorus carteri* (Marcus, 1943). A chain of 4 zooids contained: I zooid, 18 segments, II zooid, head and 15 segments + unsegmented region and branchial fossaa, III zooid 17 segments and unsegmented region, and IV zooid 17 segments + unsegmented region and branchial fossa (Cernosvitov, 1942a).

Habits : Worms live in attached or portable mucous tubes covered with foreign matter, burying anterior part of body in mud, keeping posterior part and branchial fossa protruded in water. Swims with brisk transverse horizontal movements. Contructs attached or portable tubes. Also reported from Polyzoa covering stick in Bangalore.

Chromosomes : 2n = 30 (Sharma, Handa & Sahi, 1976).

Commensals : Epizoic vorticellids (Protozoa) were found attached to branchial fossa of worms from Nagpur (Naidu & Srivastava, 1980).

Distribution : India : Veli Lake, Trivandrum (Kerala); Chennai, Coimbatore, Tandikoudi, Ouralpatti, Thanjavur, Udhakamandalam (Tamil Nadu); Chittoor, Tirupati, Tirumala, Mamandur, Chandragiri, Horsley Hills, Anantapur, Cuddapah, Gudur, Nayudupeta, Kakinada, Hyderabad, Warangal, Vishakhapatnam, Vizianagaram, (Andhra Pradesh); Bellary, Bangalore, Mysore (Karnataka);); Mumbai, Vehar Lake, Khed, Nagpur (Maharastra); Bhopal (Madhya Pradesh); Varanasi (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Srinagar (Jammau & Kashmir); Ranchi (Bihar); Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Rangoon (Burma); Hindgala, Peradeniya, Kandy (Sri Lanka).

World distribution : Cosmopolitan.

Aulophorus gravelyi Stephenson, 1925
(Fig. 44)

Aulophorus gravelyi Stephenson, 1925b : 46; Naidu, 1966 : 216.

Type locality : Ennur near Chennai, Tamil Nadu, India.

l(p.) = 5-8 mm; d(p.) = 0.35 mm; s = 46-73 + undifferentiated region + branchial fossa.

Description : Worms of medium size and white. Prostomium short, very blunt, truncated. Dorsal setae begin in VI, each bundle with 2-3 hair and 2-3 needle setae. Hair setae simple, smooth, 190-240 μm long. Needle setae (Fig. 44 A) finely bifid, separated by an acute angle, slightly sickle-shaped 66-80 μm long, 2 μm thick with delicate distal nodulus (D : P :: 7 : 9), distal tooth slightly longer and a little thicker than proximal. Ventral setae 3-4 per bundle, in II-V longer and less curved than rest, upto 115 μm long, 3 μm thick, with median nodulus (D : P :: 1 : 1), teeth equally thick, distal longer than proximal. In rest shorter, more curved, 62-90 μm long, 3 μm thick, with slightly distal nodulus (D : P :: 5 : 7), teeth equally long, proximal thicker than distal. Branchial fossa with a pair of palps and 4 pairs of gills, 1 pair dorsal and short, 2 pairs lateral and digitiform and 1 pair ventral, broad and massive.

Stomach absent. Chloragocytes start in VI. Dorsal vessel contractile situated ventrally to left of gut upto VI and mid-dorsal in front.

Sex organs not known. Budding ones not observed. Probably fragmentation occurs.

Fig 44 : *Aulophorus gravelyi.* A : Needle seta (from Stephenson, 1925)

Distribution : India : Ennur near Chennai (Tamil Nadu).

World distribution : South and East Asia; Argentina (South America).

Aulophorus hymanae Naidu, 1963
(Fig. 45)

Aulophorus hymanae Naidu, 1963a : 905; 1966 : 216; Costa, 1967 : 46; Vasisht & Gandhi, 1972 : 99; Naidu & Srivastava, 1980 : 267; Naidu & Naidu, 1981a : 533; Naidu, Kalpana & Sureshkumar, 1981 : 106.

Dero (*Aulophorus*) *hymanae,* Ali & Issaque, 1975 : 58; Battish & Sharma, 1997 : 82.

Type locality : Cuddapah, Andhra Pradesh, India.

l(p.) = 8-10 mm; d(p.) = 0.3-4.0 mm; s = 45-80 + undifferentiated region and branchial fossa; n = 22-39.

Description : Worms large. Prostomium bluntly conical, longer than broad, with stiff, fine cilia on margin. Dorsal setae from V, each bundle with 1 hair and 1 needle seta. Hair setae (Fig. 45 A) simple, smooth, bayonet-shaped, 200-300 μm long. Needles setae (Fig. 45 B) smooth, sickle-shaped, bifid, with distal nodulus (D : P :: 1 : 2) shaft above nodulus curved with a longitudinal ridge medianally on convex border, 73-81 μm long, distal tooth straight, thinner and slightly longer than gently curved proximal. Ventral setae (Fig. 45 C, D) 4-5 per bundle, decreasing to 2-3 posteriorly; in II-IV 91-98 μm long, slender and less curved than in others, with median nodulus (D : P :: 14 : 14 or 13 : 14), distal tooth longer and thinner than proximal. In others 73-88 μm long, distal tooth thinner and about equal in length to proximal, position of nodulus, lengths of setae and outer tooth vary from seta to seta in a bundle :

Seta length	D : P	Relative length of distal prong to proximal
84.0 μm	11 : 13	Longer
80.5 μm	10 : 13	Slightly longer
80.5 μm	10 : 13	Slightly longer
78.5 μm	9 : 13.5	Shorter

Branchial fossa (Fig. 45 E) funnel-shaped with 1 pair of non-contractile palps and 3 pairs of digitiform gills, first pair arise from supra-anal diverticulum, second and third pairs spring from floor of fossa, longest gills shorter than palps.

Pharynx in II-V, wide, yellowish in life, with a dorsal diverticulum eversible through mouth during feeding. Oesophagus from VI, narrow insensibly continues into intestine. Stomach absent. Chloragocytes greenish gray from VI. Coelomocytes absent. Septa well developed, each with 2 lateral colourless glassy swellings. Brain incised anteriorly and posteriorly. Blood red. Dorsal vessel contractile attached ventro-laterally to left of gut from hind end to VI, mid-dorsal in head segments, divides into 3 branches

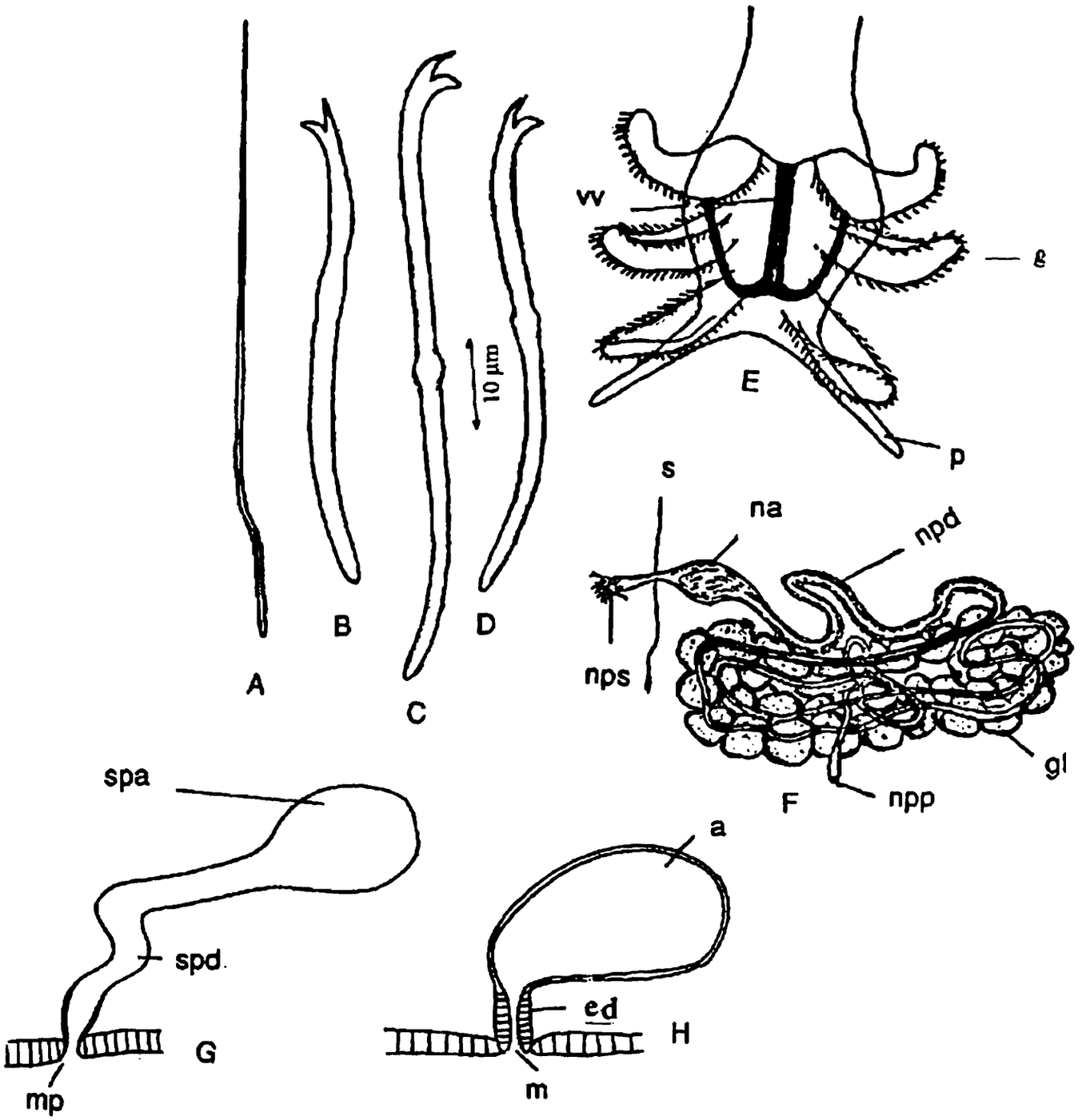

Fig 45 : *Aulophorus hymanae.* A : Hair seta; B : Needle seta; C, D : Ventral setae of II and middle segment; E : Branchial fossa relaxed; F : Nephridium; G : Spermatheca; H : Atrium. a : atrium ampulla; ed : ejaculatory duct; g : gills; gl : glandular part; m : male pore; mp : spermathecal pore; na : nephridial ampulla; npd : nephridial duct; npp : nephropore; nps : nephrostome; p : palp; s : septum; spa : spermathecal ampulla; spd : spermathecal duct; vv : ventral vessel.

anteriorly and unite ventrally in II into a non-contractile mid-ventral vessel. Non-contractile simple lateral vessels in II-V, and contractile vessels 6 pairs in VI-XI. First nephridium (Fig. 45 F) in VII, with its pre-septal funnel and nephrostome (Fig. 45 F-nps) in VI, a slender neck connecting it to post-septal consisting of a fusiform ampulla (Fig. 45 F-na) followed by a duct (Fig. 45 F-npd), whose proximal portion thick-walled, middle portion glandular and distal portion thin-walled, with a vesicle before opening in nephropore (Fig. 45 F-npp) ventro-laterally.

Clitellum in ½V-VII (2½ segments), weaker between male pores. In fully mature worms gonads absent, but male sexual elements present. Sperm-sac and ovi-sac, back-pouchings of septa 5/6 and 6/7 extend to X and XI respectively, former with in latter. Male funnels thick-walled cups on anterior face of septum 5/6 with vasa deferentia entering atria in VI. Atrial ampullae (Fig. 45 H-a) ovoid, their ejaculatory ducts (Fig. 45 H-ed) short and open on papillae near ventral bundles of VI by male pores (Fig. 45 F-m). Female funnels not observed, female pores indistinct in VII ventrally. Spermathecae (Fig. 45 G) a pair in V, club-shaped, extend to VIII within sperm-sac, open laterally to ventral bundles of V Penial setae absent. Asexual reproduction by paratomy; prostomium and 5 head segments budded off to posterior zooid. One to two fission zones common. In a chain of 3 zooids, first fission zone behind XXIV, after some segments are budded off for anterior zooid, second zone developed at same place as first between XXIV and first new segment. Composition of 3 zooids in one chain; anterior zooid with 24 segments of parent body, middle zooid has all newly budded segments, and posterior zooid has posterior segments of parent body and some newly budded segments.

Habits : Worms live in mucous tubes in fresh water with anterior ½ or 2/3 of body buried in mud, rest projecting vertically upwards with fully distended branchial fossa. They swim with horizontal transverse undulations.

Commensals : Epizoic vorticellids (Protozoa) were found attached to branchial fossa of worms from Nagpur (Naidu & Srivastava, 1980).

Distribution : India : Coimbatore (Tamil Nadu); Chittoor, Tirupati, Tirumala, Chandragiri, Horsley Hills, Mamandur, Cuddapah, Gudur, Nayudupeta, Vizianagaram, Warangal, Hyderabad (Andhra Pradesh); Bellary, Bangalore (Karnataka); Powai Lake, Mumbai, Bandra, Thane, Nagpur (Maharastra); Delhi; Chandigarh; Punjab; Haryana; Ranchi (Bihar). Dhaka (Bangladesh); Rangoon (Burma); Peradeniya, Mewanella (Sri Lanka).

World distribution : South and East Asia; South America.

Aulophorus indicus Naidu, 1962
(Fig. 46)

Aulophorus indicus Naidu, 1963a : 909; Naidu, 1966 : 216.

Type locality : Cuddapah, Andhra Pradesh, India.

l(p.) = 3-6 mm; d(p.) = 0.2 mm; s = 47-60 + undifferentiated region and branchial fossa; n = 30 (in one).

Description : Worms of medium size, crimson coloured. Prostomium bluntly triangular without any sensory cilia on margin. Dorsal setae begin in V, each bundle with 1 smooth, boyanet-shaped hair seta, upto 200 μm long; and 1 bifid needle seta (Fig. 46 A, B) with outer and inner teeth 1.5 long, with a short intermediate tooth between them, thick in old segments, fine in newly budded segments, proximal slightly thicker or equal to distal, nodulus distal, about 21 μm from distal end. Ventral setae (Fig. 46 C, D) in II-V, 3 per bundle, 2 μm thick, with a proximal nodulus, and teeth equally thick, distal more than twice as long as proximal; in others 3-4 per bundle decreasing to 2 and 1 in posterior segments, with a distal nodulus, 2.8 μm thick, teeth equally long in anterior and middle segments, distal decreasing in length in posterior segments, proximal tooth thicker than distal. Branchial fossa cup-shaped with 1 pair of palps and 1 pair of dorsal and 2 pairs of ventral gills. Palps narrow and close over fossa in contraction.

Mouth a transverse slit. Pharynx in II-V, wide; oesophagus in VI-VII, narrow; stomach in VIII-IX, wide; intestine narrow in X and XI and wide behind. Chloragogen

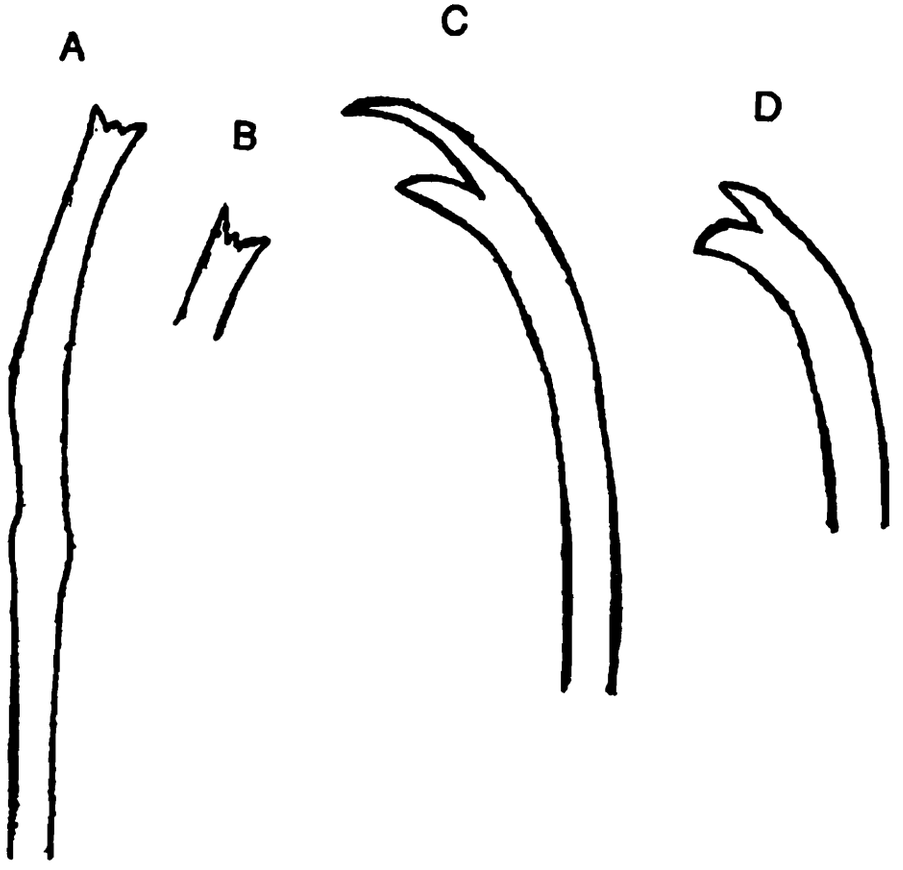

Fig 46 : *Aulophorus indicus.* A : Needle seta; B : Distal end of needle seta; C, D : Distal end of ventral setae of II and VIII.

cells begin in VI. Coelomocytes spherical, opaque and morula-like. Septa well develpoed, septal glands absent. Blood crimson red. Dorsal vessel contractile attached ventrally to left of gut from hind end to VI, and mid-dorsal anteriorly. Ventral vessel non-contractile and mid-ventral. Contractile vascular vessels 4 pairs in VI-IX. First nephridium in X, with its pre-septal funnel in IX. Brain incised medianally at either end.

Sex organs not known. No budding zones observed in 8 fully formed worms. Fragmentation appears to occur. In one worm segments behind XXX smaller and younger, evidently regenerated after fragmentation. From newly developed first dorsal bundle in V, it is obvious that 5 anterior segments regenerated anteriorly for posterior fragment.

Distribution : India : Cuddapah, Andhra Pradesh.

World distribution : India (Asia); South America.

Aulophorus michaelseni Stephenson, 1923
(Fig. 47)

(?)*Aulophorus palustris* Michaelsen, 1905 : 308; Stephenson, 1913b : 255; Stephenson, 1916 : 306.

Aulophorus michaelseni Stephenson. 1923 : 93; Aiyer, 1929a : 43; Mendis & Femando, 1962 : 45. Naidu, 1963a : 902; 1966 : 216; Vasisht & Gandhi, 1972 : 99; Sureshkumar & Ramasarma, 1979 : 347; Naidu & Srivastava, 1980 : 267; Naidu & Naidu, 1981a : 533.

Type locality : Kandy, Sri Lanka.

l(p.) = 3-5 mm; d(p.) = 0.3 mm; s = 25-52 + undifferentiated region and branchial fossa; n = 19-27.

Description : Worms of medium size with pale red colour. Prostomium bluntly conical. Dorsal setae from V, each bundle with 1 hair and 1 needle seta. Hair setae 175-269 μm long, smooth, nearly straight. Needle setae (Fig. 47 A) 53-73 μm long, sickle-shaped, bifid, with distal nodulus (D : P :: 7 : 11 or 2 : 3), and with small teeth, equally thick and distal longer than proximal. Ventral setae (Fig. 47 B, C, D) 2-4 per bundle, in II-V, 77-98 μm long, with proximal nodulus (D : P :: 7 : 5 or 13 : 11) less curved and thinner, with distal tooth much longer and thinner than proximal. In rest 60-82 μm long, curved, thicker, with distal nodulus (D : P :: 8 : 11) with distal tooth about equal to or slightly longer and thinner than proximal. Branchial fossa (Fig. 47 E, F) funnel-shaped with anterior dorsal margin entire, ciliated and posterior ventral margin with 2 non-contractile palps (Fig. 47 E-p, F-p) 438-626 μm long, 60 μm wide at base tapering to 16 μm, thin, diverging. Gills (Fig. 47 E-g, F-g) 4 pairs, rarely 5 pairs, long, digitiform, I pair dorsal, II pair lateral, III and IV pairs ventral, they increase in length from I-IV In full distention, they curl in all directions like tentacles.

Buccal cavity tubular in I-II. Pharynx in III-V, wide. Oesophagus in VI-VIII, narrow, wavy continues into intestine without stomach intervening. Septa well developed. Septal glands on anterior face of septa 4/5 and 5/6. Chloragocytes brownish from VI. Coelomocytes spherical, colourless, 14-15 μm in diameter. Blood deep orange red. Dorsal vessel contractile, ventro-lateral to left of gut for most part and mid-dorsal in I-V. Ventral vessel non-contractile, mid-ventral. Simple contractile vessels 4 pairs, connect dorsal and ventral vessels in VII-X. First nephridium in VII with is pre-septal nephrostome opening in VI, post-septal nephridial duct partly enclosed in gland mass opening to exterior by a nephropore ventro-laterally in VII.

Sex organs not known. Budding occurs, budding zone 1, rarely 2, and second budding zone always appears about middle of posterior zooid.

Habits : Worms live in tubes in freshwater along with *Limnodrilus hoffmeisteri* and move by wriggling movement. When disturbed they coil into loose spirals.

Remarks : Stephenson (1923) gave a new name, *Aulophorus michaelseni* for earlier (?)*A. palustris* (Michaelsen, 1905). This was validated by Naidu (1963a) as he found needles distinctive with equally thick teeth at base with distal tooth 1½ times longer than proximal, with four pairs of digitiform gills and very long palps both curling like tentacles in contraction as opposed to needles with proximal tooth thicker and equal or slightly shorter than distal, with three pairs of stumpy foliate gills and shorter palps not curling like tentacles in contraction of *A. furcatus*. Ercolini (1969, 1970) has revalidated *A. michaelseni* from Somalia with photographs of setae and branchial fossa of this species.

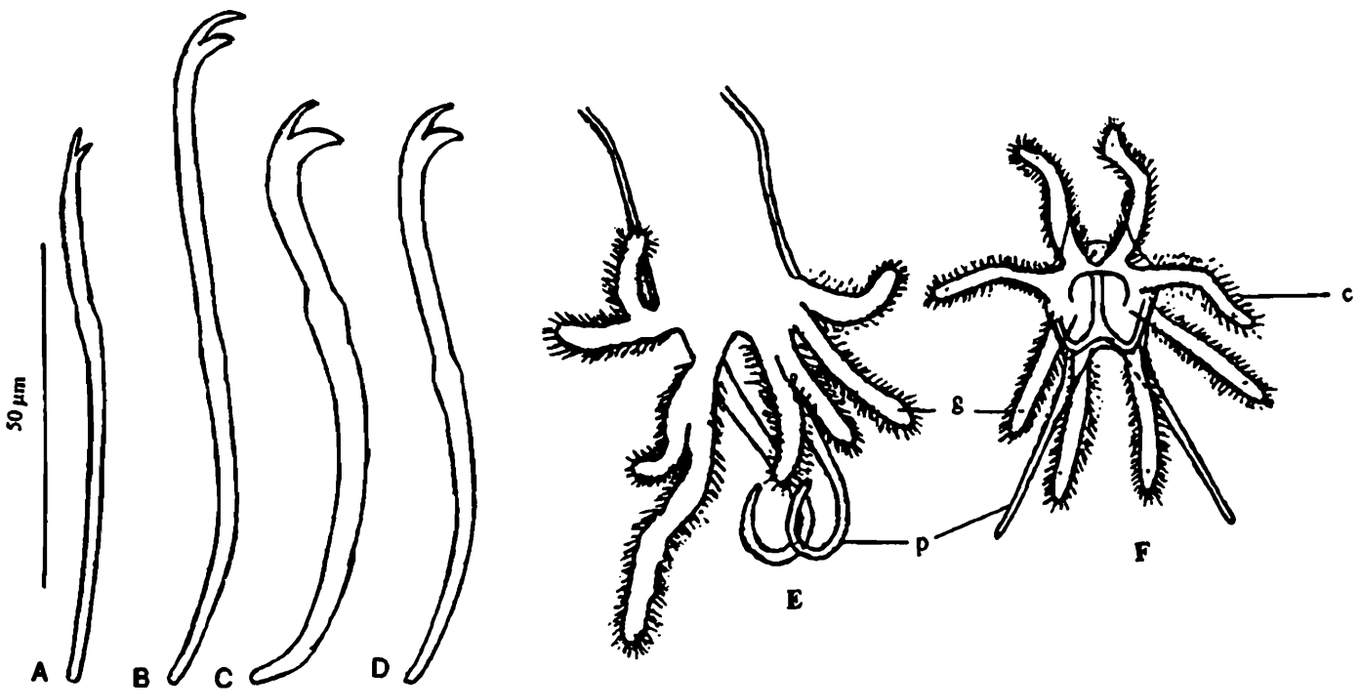

Fig 47 : *Aulophorus michaelseni.* A : Needle seta; B, C, D : Ventral setae of II, middle and posterior segments; E, F : Branchial fossa relaxed. (A-D from Ercolini, 1970). c : cilia; g : gill; p : palp.

Distribution : Trivandrum (Kerala); Chennai, Udhakamandalam (Tamil Nadu); Tirupati, Cuddapah, Gudur, Warangal, Hyderabad (Andhra Pradesh); Bangalore, Bellary (Karnataka); Mumbai, Bandra, Nagpur (Maharastra); Chandigarh; Haryana; Punjab.; Kandy (Sri Lanka).

World distribution : South and East Asia; Somalia (Africa).

Aulophorus moghei Naidu & Srivastava, 1980
(Fig. 48)

Aulophorus moghei Naidu & Srivastava, 1980 : 267.

Type locality : Nagpur, Maharastra, India.

l(p.) = 5-6 mm; d(p.) = 0.35 mm; s = 46 + undifferentiated region and branchial fossa.

Description : Worm of medium size. Prostomium triangular. Dorsal setae from V, each bundle with 1 bayonet-shaped hair seta of 140-180 μm long, and 1 sickle-shaped bifid needle setae (Fig. 48 A), 60-63 μm long, with nodulus about a third from distal

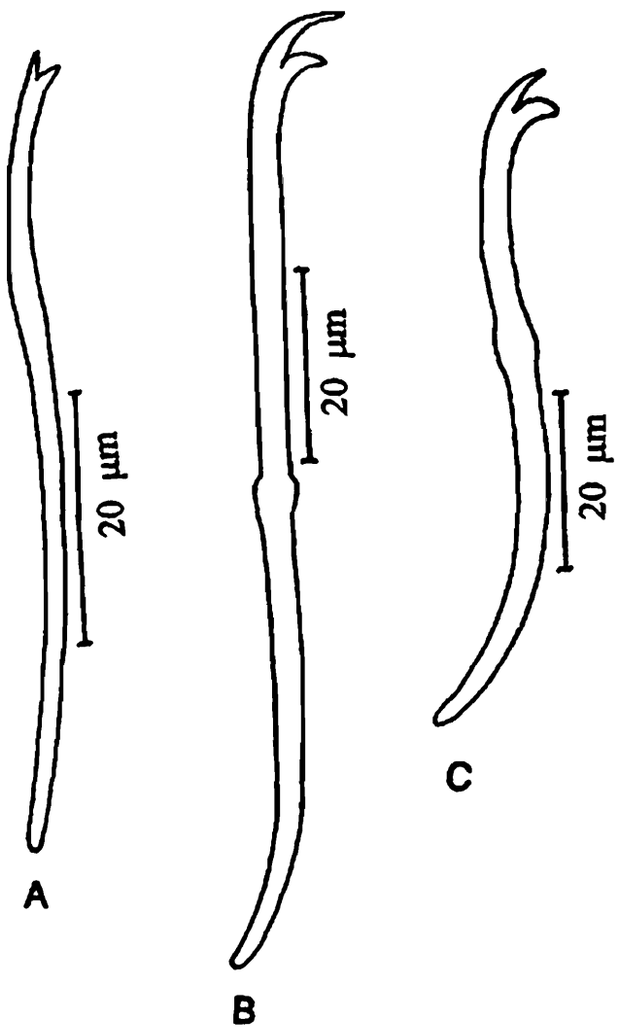

Fig 48 : *Aulophorus moghe.* A : Needle seta; B, C : Ventral setae of II and middle segment.

end, distal tooth longer and thinner than proximal. Ventral setae (Fig. 48 B, C) 4-5 per bundle decreasing to 2 and 1 in hind segments; in II-V slender, 90-100 μm long, with proximal nodulus (D : P :: 5 : 4), distal tooth 1½-2 times as long as and more hooked than proximal. In rest thick, 70-75 μm long, with distal nodulus (D : P :: 5 : 6), distal tooth thinner and slightly longer than proximal. Branchial fossa with 2 slender palps, 0.3 mm long, with 4 pairs of slender digitiform gills of 0.4 mm long, 0.16 mm wide.

Pharynx in II-V, fusiform and thick-walled. Oesophagus from VI, narrow and wavy and continuing impercetibly into intestine; stomach absent. Chloragocytes start in VI. Coelomocytes absent. Dorsal vessel contractile, laterally attached to left of gut from hind end to VI, and mid-dorsal anteriorly. Lateral contractile vessels 2 pairs in VI and VII, connecting dorsal and ventral vessels.

Sex organs not known. Fission zones not observed.

Distribution : Known only from the type locality.

Aulophorus tonkinensis (Vejdovsky, 1894)
(Fig. 49)

Dero tonkinensis Vejdovsky, 1894b: 244.

Aulophorus tonkinensis (Vejdovsky), Michaelsen, 1909a : 132; 1910 : 7; Stephenson, 1911 : 212; 1913a : 738; 1923 : 91; Aiyer, 1925 : 35; Mendis & Fernando, 1962 : 45; Naidu, 1963a : 911; 1966 : 216.Vasisht & Gandhi, 1972 : 99.

Dero (*Aulophorus*) *tonkinensis* Vejdovsky. Ali & Issque, 1975 : 58.

Aulophorus tonkinensis. Sureshkumar & Ramasarma, 1979 : 347; Arunachalam et al., 1980 : 509; Naidu, Kalpana & Sureshkumar, 1981 : 108; Sobhana & Nair, 1983a : 104.

Dero (*Aulophorus*) *tonkinensis*, Mukhopadhyay, 1998 : 105.

Type locality : Tonkin, China.

l(p.) = 1.7-2.0 mm; d(p.) = 0.16-0.22 mm; s = 20-45 + undifferentiated region and branchial organ; n = 13-18.

Description : Worms minute pale white and transparent. In preserved worm head end swells. Prostomium bluntly triangular with stiff sensory cilia on margin. Dorsal setae begin in VI, 1-2 hair and 1-2 needle setae per bundle. Hair setae bayonet-shaped, smooth, 96-160 μm long, shorter than diameter of body. Needle setae (Fig. 49 A) palmate, nearly straight, 63-80 μm long, with distal nodulus (D : P :: 7 : 11) and with long teeth of about 12-13 μm long, and webbing 6-8 μm wide at tip, without ribs, resembling oars. Ventral setae (Fig. 49 B, C, D) of II-V, 3-9 per bundle, long, less curved, thin, 80-120 μm long, with proximal nodules (D : P :: 17 : 10 or 8 : 5), distal tooth thinner and much longer than proximal. In others 4-7 per bundle, curved, thick, 50-80 μm long, with distal nodules (D : P :: 2 : 3), distal tooth shorter and thinner

than proximal. Bronchial fossa (Fig. 49 E) cup-shaped opening posteriorly with 2 non-contractile palps of 200-280 μm long, with stiff sensory cilia and 2 pairs of short, digitiform gills shorter than palps, 1 pair dorsal and 1 pair ventral both short.

Pharynx in II-V, large, wide, with a dorsal diverticulum, its roof eversible through mouth in form of a disc-like sucker for feeding, locomotion and construction of tubes. Oesophagus in VI-VIII. Stomach in IX, wide. Intestine narrow in X-XI, wide from XII. Chloragocytes from VI, grayish. Coelomocytes spherical and granular. Brain incised

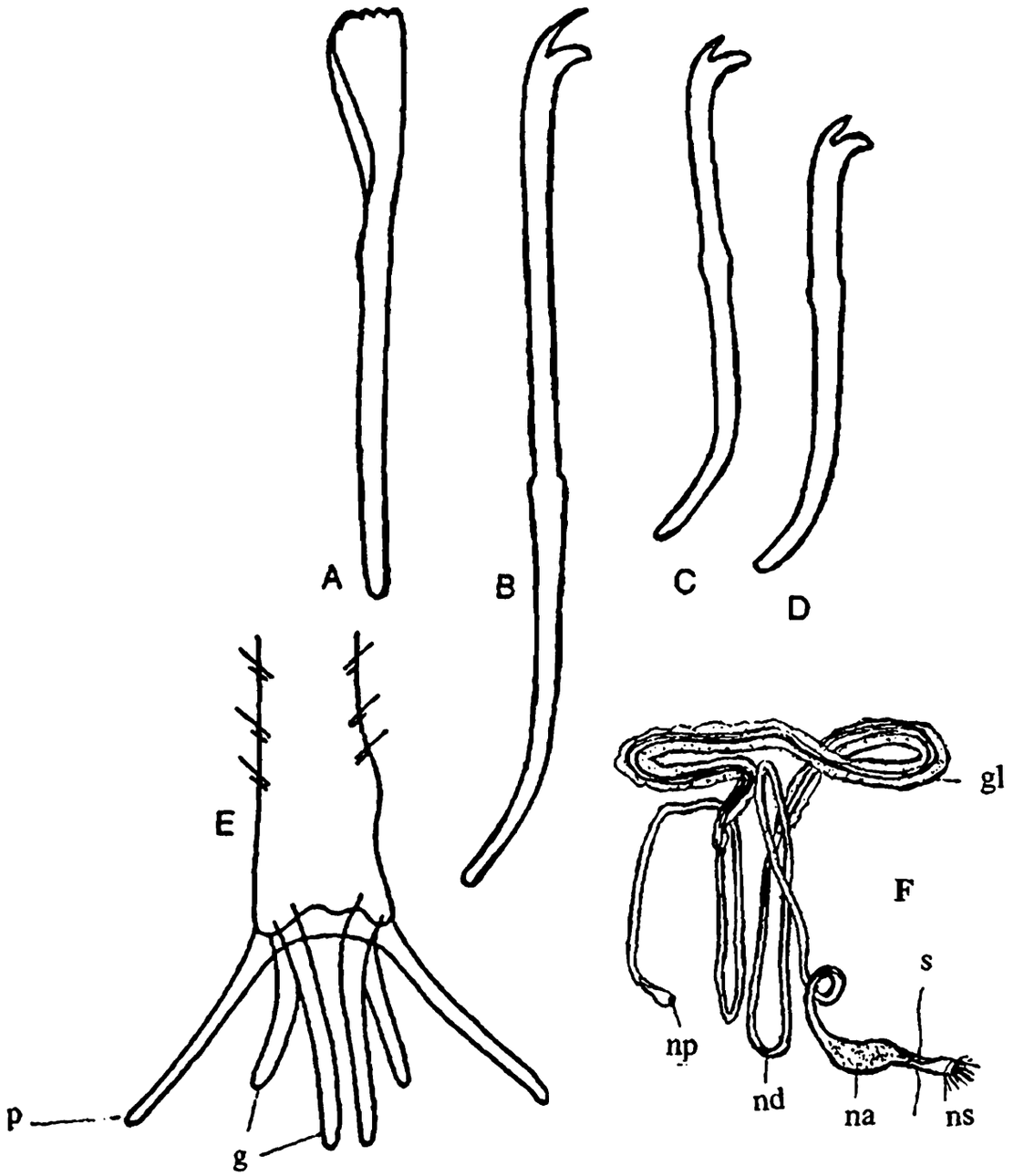

Fig 49 : *Aulophorus tonkinensis.* A : Palmate needle seta; B, C, D : Ventral setae of II and posterior segments; E : Relaxed branchial fossa; F : Nephridium; g : gills; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; p : palp; s : septum.

in front and with a faint dorso-median groove behind. Blood pale red. Dorsal vessel contractile located ventro-laterally to left attached to gut from hind end to X, lateral in IX and mid-dorsal in front. Simple contractile vessels 2 pairs in VII and VIII, connecting dorsal and ventral vessels. Nephridia (Fig. 49 F) from VII, one per segment, pre-septal funnel with nephrostome (Fig. 49 F-ns) in anterior segment and post-septal part with nephridial ampulla (Fig. 49 F-na) and nephridial duct (Fig. 49 F-nd), partly enclosed in gland mass (Fig. 49 F-gl) ending in nephropore (Fig. 49 F-np) in next segment.

Clitellum from V-½VIII (3½ segments), weak or absent between male pores ventrally. Gonads disappear in sexually mature worms. Sperm-sac single with developing sperms and single ovi-sac with a large ovum extend to IX and XIII respectively, former within latter. Male funnels and female funnels on anterior face of septa 5/6 and 6/7 respectively. Atria elongated and club-shaped extend to VIII when full. Male pores at position of ventral setae of VI. Penial setae absent. Female pores in groove between VI and VII ventro-laterally. Spermathecae absent. Asexual reproduction by paratomy, budding zone producing prostomium and five head segments to posterior zooid and several segments to anterior zooid.

Habits : Worms build tubes with help of eversible disc-like sucker of pharynx, mainly of free statoblasts of polyzoan *Plumatella* species, small seeds, sponge gemmules and statoblasts of sponges with mucous secreted by its body-wall. Tubes hang down with one end attached. Worms move freely within tubes and can turn around interchanging anterior end and branchial fossa. While resting, head end and branchial fossa are protruded out of tube. Extending anterior part of body some distance in front of tube, it everts its pharyngeal sucker and fixes it to substratum, fixes anterior ventral setae and contracts the body, dragging tube along. Swims with brisk horizontal undulation when out of tubes.

Distribution : India : Veli Lake, Trivandrum, Palghat, Malapuza (Kerala); Coimbatore (Tamil Nadu); Chittoor, Kambakkam, Mamandur, Srikalahasti, Pullalamadugu, Cuddapah, Gudur, Nayudupeta, Morappu near Guntur, Kakinada Vizianagaram, Hyderabad (Andhra Pradesh); Bangalore (Karnataka); Ujjain (Madhya Pradesh); Varanasi, Lucknow (Uttar Pradesh); Bhim Tal (Uttaranchal); Chandigarh; Punjab; Haryana; Burdwan, Bardhaman, Kolkata (West Bengal); Lahore, North West Frontier province (Pakistan); Dhaka (Bangladesh); Gallee (Sri Lanka).

World distribution : South and East Asia; Abyssinia, Madagascar, Kenya (Africa); Italy (Europe); West Indies, Costa Rica (Central America); Argentina (South America); Queensland (Australia).

Genus ***Allonais*** Sperber, 1948.

Allonais Sperber, 1948 : 200; Naidu, 1963a : 915; Brinkhurst, 1964 : 216; Brinkhurst & Jamieson, 1971 : 384; Persia, 1980 : 95; Mukhopadhyay, 1998 : 101.

Diagnosis : Eyes absent. Ventral setae of II-V only slightly different from those of following segments; dorsal setae normally from VI, hairs and bifid or pectinate needle setae. Septal glands absent. Stomachal dilatation present or absent. Usually a plexus in II-V, and simple lateral vessels in some following segments. Coelomocytes present. Vasa deferentia joining atria above atrial duct; prostate gland cells absent; penial setae present or absent. Fragmentation, budding absent. Cosmopolitan.

Type species : *Allonais inaequalis* (Stephenson, 1911).

Key to Indian species of *Allonais*

1. Needle setae pectinate 2
– Needle setae not pectinate 3
2 Needle setae bifid with equally long or distal tooth longer than proximal with 1-5 intermediate teeth ..... *Allonais pectinata*
– Needle setae with unequal teeth with 1-4 intermediate teeth, or upper tooth appearing as multiple ..... *Allonais inaequalis*
3. Needle setae with distal tooth rudimentary or shorter than proximal or bifid ..... *Allonais paraguayensi paraguayensis*
– Needle setae simply bifid with distinct teeth 4
4. Needle setae with equally thick teeth, distal slightly longer than proximal ..... *Allonais gwaliorensis*
– Needle setae with diverging teeth, proximal twice as long and thick as distal ..... *Allonais rayalaseemensis*

Allonais gwaliorensis (Stephenson, 1920)
(Fig. 50)

Nais gwaliorensis Stephenson, 1920 : 198; Stephenson, 1923 : 59.

Allonais gwaliorensis, Sperber, 1948 : 205; Naidu, 1963a : 919; 1966 : 216; Vasisht & Gandhi, 1972 : 100; Sureshkumar & Ramasarma, 1979 : 347; Naidu & Srivastava, 1980 : 268; Naidu, Kalpana & Sureshkumar, 1981 : 108; Naidu & Naidu, 1981a : 533; Mukhopadhyay, 1998 : 101.

Type locality : Gwalior, Madhya Pradesh, India.

l(p.) = 2.5-3.5 mm; d(p.) = 0.20-0.25 mm; s = 29-86 + undifferentiated region.

Description : Worms small, delicate, slender, pale white. Prostomium bluntly triangular, slightly longer than broad, with stiff cilia. Dorsal setae from VI, each bundle with 1-2 hair and 1-2 needle setae. Hairs setae 140-250 μm long, simple and smooth. Needle setae (Fig. 50 A) 45-68 μm long, 2.15 μm thick, with weak distal nodulus (D : P :: 2 : 3), bifid with equally thick teeth, distal slightly longer than

proximal. Ventral setae (Fig. 50 B, C) of II-V 50-80 μm long, 2 μm thick, thinner, straighter than other setae, with median nodulus, distal tooth nearly twice as long as and thinner than proximal. In rest 4-6 per bundle, 45-60 μm long, 2.5 μm thick, with distal nodulus (D : P :: 3 : 5), distal tooth thinner and slightly longer than proximal.

Pharynx in II-V, wide, with an eversible dorsal diverticulum in form of a bulb through mouth. Oesophagus in VI-VIII, narrow. Stomach in IX-X, weak. Intestine narrow in XI-XII, wide and sacculated from XIII. Oesophageal and pharyngeal glands absent. Chloragogen cells from VI, greenish in life. Coelomocytes spherical 10-14 μm in diameter, whitish. Septal glands absent. Anus postero-dorsal. Brain (Fig. 50 D) incised deeply behind and less deeply in front. Blood yellowish. Dorsal vessel ventral to left of gut from hind end to VI and mid-dorsal in anterior segments. Contractile vessels 3 pairs in VI-VIII and 4 pairs of non-contractile vessels in II-V. First nephridium (Fig. 50 E) in VII with its nephrostome (Fig. 50 D-ns) in VI, enters VII and widens into an ampulla (Fig. 50 D-na) and continues as nephridial duct (Fig. 50 D-nd) enters glandular mass (Fig. 50 D-gl) and end in nephropore (Fig. 50 D-np) ventrally.

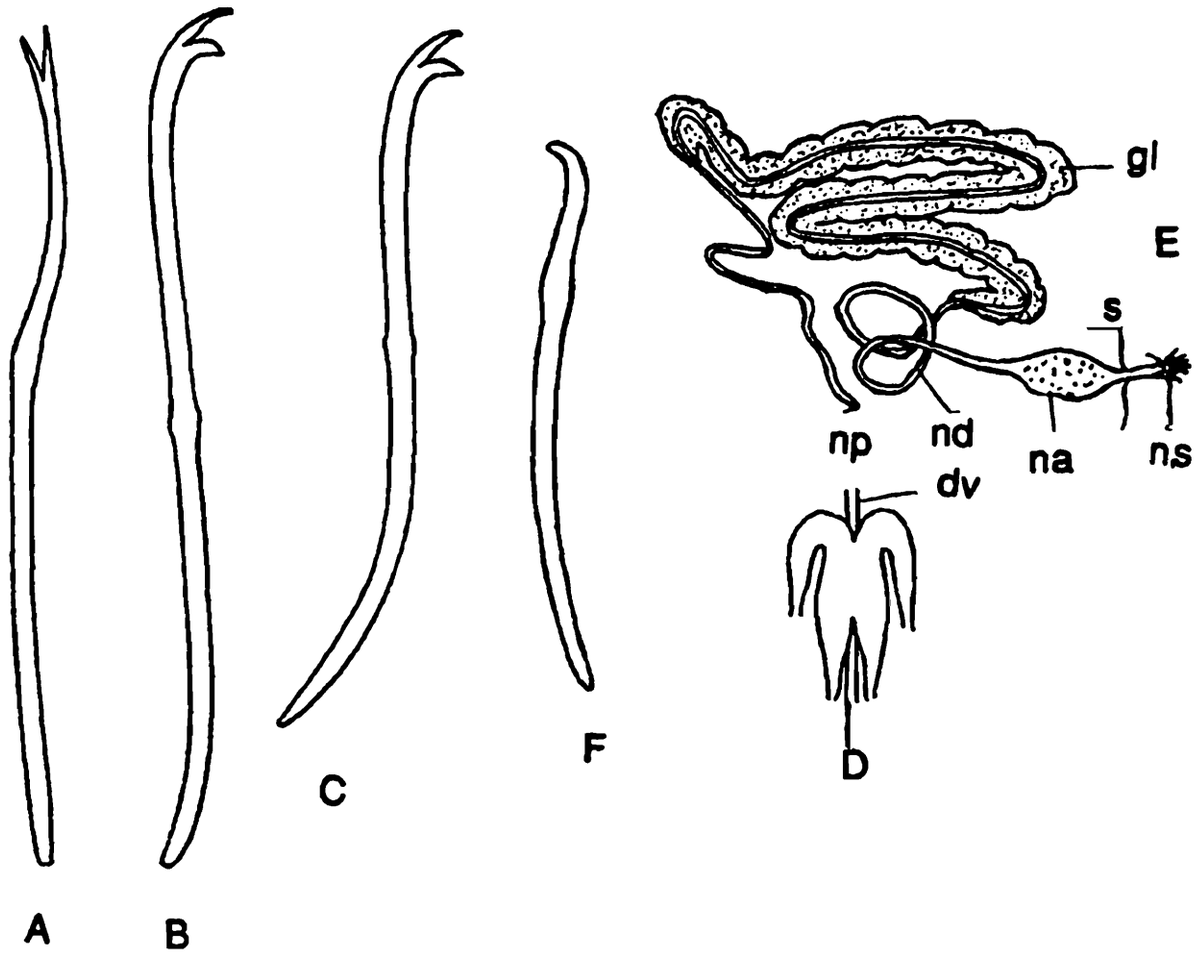

Fig 50 : *Allonais gwaliorensis.* A : Needle seta; B, C : Ventral setae of anterior and posterior segment; D : Brain; E : Nephridium; F : Penial seta. dv : dorsal vessel; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

Clitellum from ½V-VIII (3½ segments). Sperm-sac and ovi-sac extend to XII and XIII respectively. Male funnels cup-shaped, vasa deferentia 93 μm long, 12 μm wide enters atrium anteriorly. Atrial ampulla ovoid 70 μm long, 33 μm wide. Ejaculatory duct short 27 μm long and 19 μm wide, opening ventro-laterally in a shallow depression near bundles of penial setae in VI. Penial setae (Fig. 50 F) modified ventral setae, 3-5 per bundle, 65-78 μm long with distal nodulus and simple distal hook. Spermathecae in V, ovoid, 55 μm long, 21 μm wide, thin-walled, with thick ducts opening in front of ventral bundles of V. Budding absent. Fragmentation occurs. After fragmentation, anterior fragment regenerates several hind segments and posterior fragment regenerates prostomium and 5 anterior segments.

Habits : Worms live among algae and aquatic plants, in fresh water and not tube-dwelling. Swim by transverse undulations.

Commensals : A number of sessile vorlicellids (Protozoa) were found attached to body wall and setae of worms from Nagpur (Naidu & Srivastava, 1980).

Parasites : Holotrichoms astomatous ciliates akin to *Juxtaradiophrya* sp. are seen in gut of some worms (Naidu, 1965a).

Distribution : India : Palghat, Malapuza, Calicut (Kerala); Thanjavur (Tamil Nadu); Chittoor, Chandragiri, Tirupati, Tirumala, Horsley Hills, Kambakkam, Srikalahasti, Gudur, Nayudupeta, Cuddapah, Anantapur, Kurnool, Kakinada, Visakhapatnam, Vizianagaram, Hyderabad (Andhra Pradesh); Bellary, Mysore (Karnataka), Powai Lake, Mumbai, Bandra, Thane, Nagpur (Maharastra); Gwalior, Pachmarhi (Madhya Pradesh); Delhi; Chandigarh; Punjab; Haryana; Bankura, Bishnupur (West Bengal).

World distribution : South-East Asia; Madagascar, Somalia (Africa).

Allonais inaequalis (Stephenson, 1911)
(Fig. 51)

Nais pectinata var. *inaequalis* Stephenson, 1911 : 208; Mehra, 1920 : 458; Stephenson, 1923 : 64; Aiyer, 1929a : 21.

Allonais inaequalis, Naidu, 1963a : 915; 1966 : 217; Costa, 1967 : 46; Vasisht & Gandhi : 1972 : 100; Mukhopadhyay, 1998 : 102.

Type locality : Kolkata, West Bengal, India.

l = 8-20 mm; l(p.) = 7-10 mm; d = 0.6 mm; d(p.) = 0.25-0.3 mm; s = 40-110 + undifferentiated egion; n = 40 (on Fragmentation).

Description : Worms light reddish brown, large. Prostomium bluntly conical. Dorsal setae begin in VI, 1-2 hair and 1-2 needle setae per bundle. Hair setae 160-364 μm long, smooth, nearly straight. Needle setae (Fig. 51 A, B, C) 67-112 μm long, slightly sickle-shaped, pectinate with 1-4 fine intermediate teeth connected by a web, proximal tooth nearly twice as thick and twice as long as distal, with a slight indication of

distal nodulus (D : P :: 1 : 2 or 2 : 3). Intermediate teeth slightly shorter and thinner than distal tooth. Ventral setae (Fig. 51 D, E) 4-6 per bundle, in II-V 97-105 μm long, straighter and thinner than rest, with a slightly proximal nodulus (D : P :: 9 : 8), distal tooth longer than proximal; in rest 60-93 μm long, with distal nodulus (D : P :: 7 : 10), teeth equally long; in both distal thinner than proximal.

Pharynx in III-V, ciliated, diffusely covered with small amount of chloragogen pigment extending to prostomium, with dorsal diverticulum. Rest of gut not distinctly differentiated into oesophagus, stomach and intestine; broad in VI-VIII, then narrow upto XIV, after which it continues as a broad tube, with ciliated epithelium causing strong ciliary movements and anti-peristalsis in posterior gut. Anus dorsal. Coelomocytes rounded, brownish, some colourless filled with refractile granules. Chloragocytes from VI brownish. Blood yellowish without corpuscles. Dorsal vessel

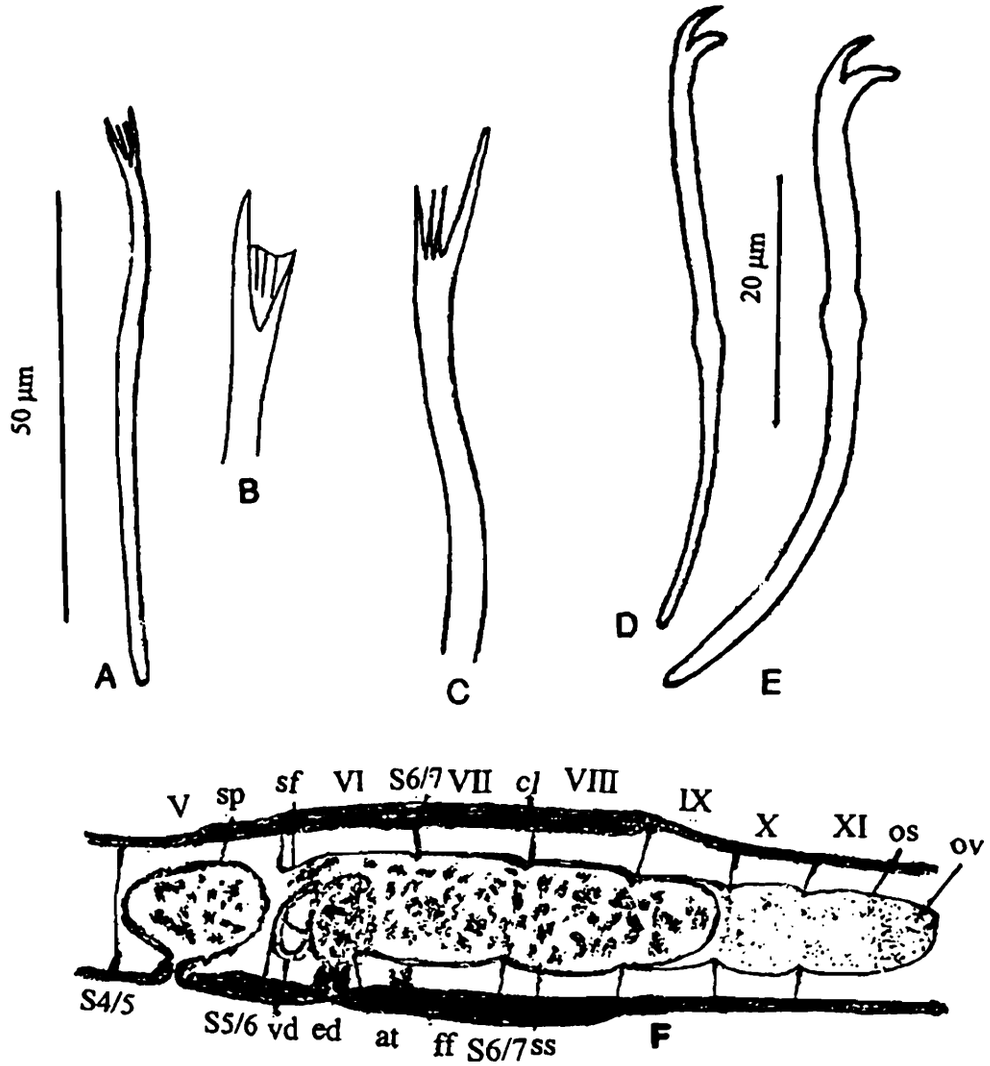

Fig 51 : *Allonais inaequalis.* A, B, C : Pectinate needle setae; D, E : Ventral setae of anterior and posterior segments; F : Genital organs. (A from Ercolini, 1970, B, C from Aiyer, 1929a, F from Mehra, 1922). at : atrium; cl : clitellum; ed : ejaculatory duct; ff : female funnel; os : ovi-sac; ov : ovum; sf : male funnel; sp : spermatheca; ss : sperm-sac; vd : vas deferens; S4/5, S5/6, S6/7, S7/8 : septa 4/5, 5/6, 6/7, 7/8.

contractile, ventro-lateral to left of gut from hind end to septum 5/6 and mid-dorsal in 5 anterior segments, and bifurcates near anterior end, turning ventrally, unite to form non-contractile ventral vessel, which runs mid-ventrally. Four pairs of commissural vessels in II-V form a plexus, and from VI-XVI a pair of transverse vessels in each segment on anterior face of each segment. Brain deeply incised in front and behind. Ventral nerve cord irregularly lobulated. First nephridium in VII, 1 per segment, brown, with its preseptal on anterior face of septum 6/7.

Clitellum (Fig. 51 F-cl) in ½V-VIII, absent between male pores and spermathecal pores. Gonads appear first and disappear before rest of genital apparatus reach its full development. Testes and ovaries, ovoid, a pair each, on the anterior face of septa 4/5 and 5/6 respectively. Sperm-sac (Fig. 51 F-ss) and ovi-sac (Fig. 51 F-os) formed by back-pouching of septa 5/6 and 6/7, former within latter extend upto XII and XVI respectively. Male funnels (Fig. 51 F-sf) large, cup-shaped with everted ciliated lips, 45 μm wide with short, thick, vasa deferentia (Fig. 51 F-vd), short, with a single bend, 15 μm thick and narrowing distally to 9 μm thick, passes downwards and enter atria on their anterior face close to ejaculatory duct. Atrial ampulla (Fig. 51 F-at) ovoid, 80-90 μm high, 45-50 μm wide, ejaculatory duct (Fig. F-ed) short about 30 μm long, opening to exterior in a short tubular depression of ventral body wall. Prostate cells absent. Female funnels (Fig. 51 F-ff) on anterior face of septum 6/7 near ventral body wall, opening on ventral surface at about level of septum 6/7. Spermathecae (Fig. 51 F-sp) in V, their ampullae large, spherical, 105 μm high, their duct start ventrally, 45 μm long and open at anterior edge of clitellum immediately behind septum 4/5. Penial setae modified ventral setae of VI, 4-6 per bundle 98-105 μm long, slightly swollen near tip and usually with a simple hook. Alimentary canal undergoes great degeneration in sexually mature worms, anterior 8 segments with genital organs separate off as a sort of cocoon, while rest of animal ultimately dies. Asexual reproduction by architomy, after fragmentation, anterior fragment develops several hind segments, and posterior fragment develops prostomium and 5 anterior segments.

Habits : Lives among aquatic vegetation and decaying vegetable matter in fresh water, also in colonies of sponges, *Spongilla carteri.* Swims by active wriggling movement.

Distribution : India : Bheemnagar, Trivandrum (Kerala); Cuddapah (Andhra Pradesh); Agra (Uttar Pradesh); Chandigarh; Punjab; Haryana; Katwa, Mourigram, Howrah, Janai, Kolkata, Hooghly, West Dinapur, 24 Paraganas district (West Bengal). Maha Oya, Peradeniya (Sri Lanka).

World distribution : Asia; Africa; Spain (Europe); South America; Queensland (Australia).

Allonais paraguayensis paraguayensis (Michaelsen, 1905) (Fig. 52)

Nais paraguayensis Michaelsen, 1905 : 354; 1909a : 131; Stephenson, 1909b : 263; Michaelsen, 1910 : 7; Stephenson, 1920 : 197.

Nais paraguayensis var. *aequalis* Stephenson, 1920 : 197.

Nais paraguayensis, Stephenson, 1921 : 750.

Nais paraquayensis var. *barkudensis* Stephenson, 1921 : 751; 1923 : 63.

Nais paraguayensis, Stephenson, 1923 : 61.

Nais parguayensis var. aequalis, Stephenson, 1923 : 62; 1924a : 321.

Nais paraguayensis, Aiyer, 1924 : 615.

Nais paraguayensis var. aequalis, Stephenson, 1924a : 321.

Nais paraguayensis, Weerakonn & Samarasinghe, 1958 : 160.

Allonais paraguayensis paraguayensis, Sperber, 1948 : 203; Naidu, 1966 : 217.

Allonais paraguayensis, Julka, Senapati & Paliwal, 1989 : 86; Mukhopadhyay, 1998 : 102.

Type locality : Paraguay, South America.

l(p.) = 5-20 mm; d(p.) = 0.23-0.26 mm; s = 150-200 + undifferentiated region; n = 24-46 (on fragmentation).

Description : Worms moderately large with anterior 6 segments reddish in colour. Prostomium bluntly triangular, length and breadth equal. Dorsal setae from VI, with 1-3 hair and 1-3 needle setae per bundle. Hair setae simple, straight 200-500 μm long, needles setae (Fig. 52 A, B) bifid, slightly sickle-shaped, 52-192 μm long and 2.5 μm thick, with nodulus a third from distal end (D : P :: 1 : 2), and proximal tooth twice as long as and much thicker than distal, which may be bifid rarely. Ventral setae (Fig. 52 C, D) 5-8 per bundle, 52-123 μm long, 3 μm thick, teeth about equal in length, with distal thinner than proximal. Nodulus median to distal (D : P :: 5 : 4) in II-V and distal in rest (D : P :: 3 : 5).

Pharynx in II-V, wide, ciliated. Oesophagus in VI-VII, narrow and sinuous. Stomach absent. Intestine narrow in VIII-IX and wide, and sacculated from X. Pharyngeal and oesophageal glands absent. Septa well developed, but septal glands absent. Coelomic corpuscles spherical, varying in size from 12-16 μm in diameter with a central nucleus. Brain incised in front and behind. Blood reddish. Dorsal vessel contractile and ventro-lateral to left of gut from hind end to VI and mid-dorsal anteriorly. Lateral vascular vessels form a plexus in anterior segments. First nephridium in VII, with its nephrostome in VI.

Clitellum (Fig. 52 F-c) from ½V-VIII (3½ segments), absent between male pores. Testes and ovaries (Fig. 52 F-t, v) on posterior face of septa 4/5 and 5/6 laterally. Sperm-sac (Fig. 52 F-e) and ovi-sac (Fig. 52 F-i) back-pouching of septa 5/6 and 6/7, extend upto IX and XI respectively, former within latter. Male funnels (Fig. 52 F-d) on anterior face of septum 5/6 laterally. Vasa deferentia about 110 μm long and 17 μm wide, open into atria near ejaculatory ducts on anterior face. Atrial ampulla (Fig. 52 F-a) spherical, 85-100 μm in diameter, its duct well defined, 70 μm long and

26 μm wide opening to outside by male pore (Fig. 52 F-p) on a projection ventrally in VI. Penial setae (Fig. 52 E) modified ventral setae of VI, 3-11 per bundle, 140-180 μm long, 3 μm thick, with a simple hook distally and distal nodulus (D : P :: 1 : 2). Spermathecal ampulla (Fig. 52 F-s) ovoid, 175 μm long, and 100 μm wide; its duct fairly short, opening ventro-laterally in V Both sexually mature and asexual worms develop epidermal glands in pregenital segments (Marcus, 1943). Oviducts apparently unable to deposit eggs. Cocoons not formed. Anterior 8 segments with fully mature eggs were cast off and such eggs did not develop. Hinder part of worm after casting anterior 8 segments regenerates lost segments (Marcus, 1943). Asexual reproduction by fragmentation. Fragments developing required head segments to posterior fragment and several posterior segments to anterior fragment.

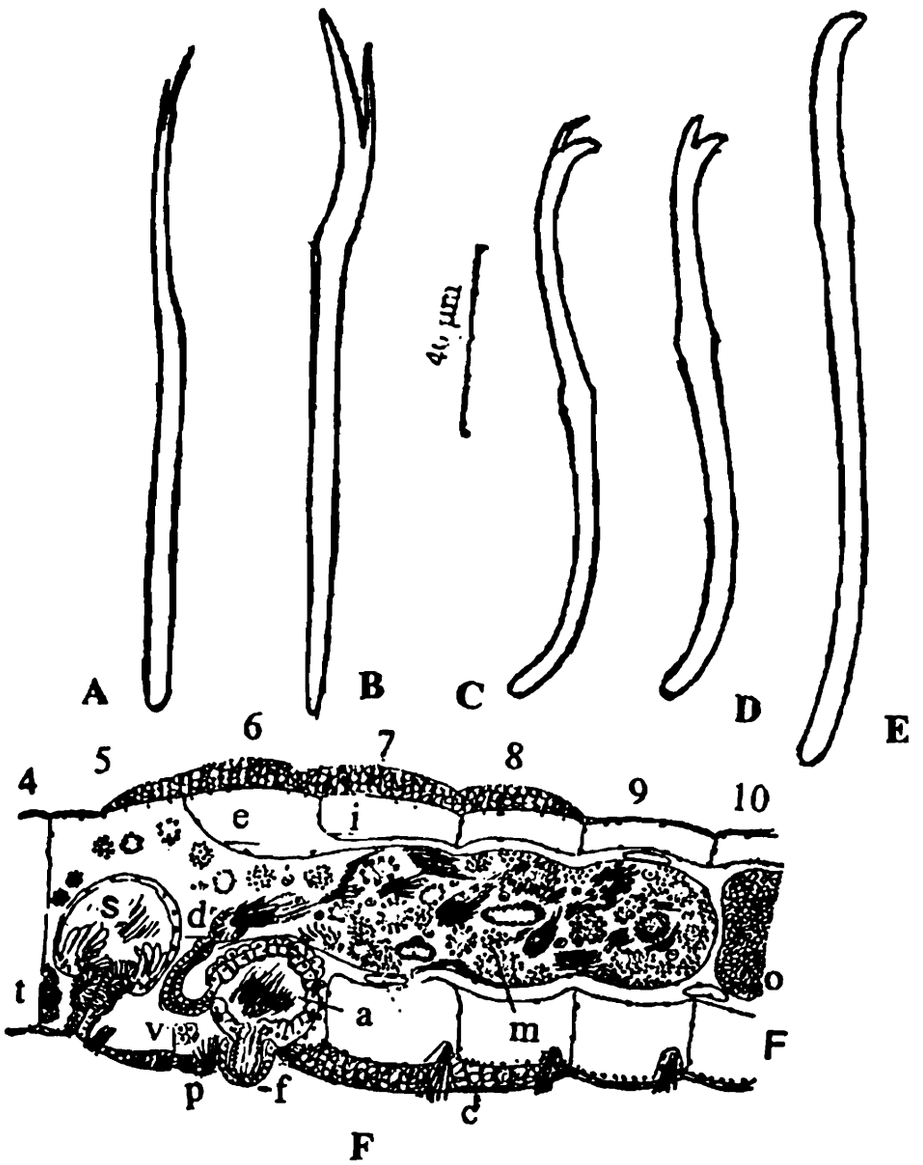

Fig 52 : *Allonais paraguayensis paraguyensis.* A, B : Needle seta; C, D : Ventral setae of anterior and posterior segment; E : Penial seta; F : Genital organs. (all from Marcus, 1943). a : atrium; c : clitellum; d : male funnel; e : sperm-sac; f : male pore; i : ovi-sac; m : spermatocyte; o : ovum; p : penial setae; s : spermatheca; t : testis; v : ovary.

Habits : Live among roots of aquatic angiosperm, *Eichhornia crassipes* in Brazil. Worms swim with transverse movements rotating around their axes in fresh water.

Distribution : India : Trivadrum (Kerala); Mumbai (Maharastra); Barkuda Island, Chilka Lake (Orissa); Gwalior, Sagar, Pachmarhi (Madhya Pradesh); Sirsah (Bihar); Bamongola, Kolkata (West Bengal). Lahore, Peshawar (Pakistan); Meegoda near Colombo (Sri Lanka).

World distribution : Asia; Africa; Italy (Europe); North America; Nicaragua (Central America); South America; Queensland (Australia).

Allonais pectinata (Stephenson, 1910)
(Fig. 53)

Nais pectinata Stephenson, 1910b : 236; 1920 : 198; 1923 : 63; Aiyer, 1929a : 19; *Allonais pectinata,* Sperber, 1948 : 206; Naidu, 1966 : 217; Costa, 1967 : 46; Naidu & Naidu, 1979a : 325.

Nais pectinata, Singh, 1989 : 274.

Type locality : Bheemanagar, Kerala, India.

l(p.) = 6-7 mm; d(p.) = 0.3 mm; s = 40-95 + undifferentiated region; n = 20-35 (on fragmentation).

Description : Worms of medium size, slender, delicate and reddish brown in life. Prostomium bluntly triangular. Dorsal setae from VI, each bundle with 1-2 hair and 1-2 needle setae. Hair setae 160-220 μm long, simple, smooth. Needle setae (Fig. 53 A, B, C) pectinate, slightly sickle-shaped with 1-4 intermediate teeth between main teeth, 42-68 μm long, with weak nodulus about 1/3 length from distal end (D : P :: 1 : 2). Ventral setae (Fig. 53 D, E, F), of II-V 3-7 per bundle, thinner, less curved than rest, with proximal nodulus (D : P :: 4 : 3), distal tooth slightly thinner and longer than proximal. In rest 2-7 per bundle, thicker and more curved than anterior setae, 50-56 μm long, with distal nodulus (D : P :: 2 : 3 or 3 : 4), distal tooth thinner and as long as proximal.

Pharynx in II-V, wide, with protrusible roof through mouth. Oesophagus in VI-IX, narrow. Stomach weak in X-XII. Intestine narrow in XIII, wide and sacculated from XIV. Anus postero-dorsal resembling a minute branchial fossa. Chloragocytes from VI. Coelomocytes numerous, spherical, about 10 μm in diameter. Septal glands absent. Brain deeply incised in front and behind. Blood reddish. Dorsal vessel mid-dorsal in II-V and ventro-laterally placed to left of gut from VI. Four pairs of commissural vessels in II-V, second pair being shorter than others. First pair of nephridia in VIII, with their preseptal nephrostomes on septum 7/8 in VII.

Clitellum from ½V-½VIII (3 segments). Sperm-sac and ovi-sac extend to X and XII respectively, former within latter. Male funnels laterally on anterior face of septum 5/6 with vasa deferentia 80 μm long and 21 μm thick, convoluted, enter atria on their

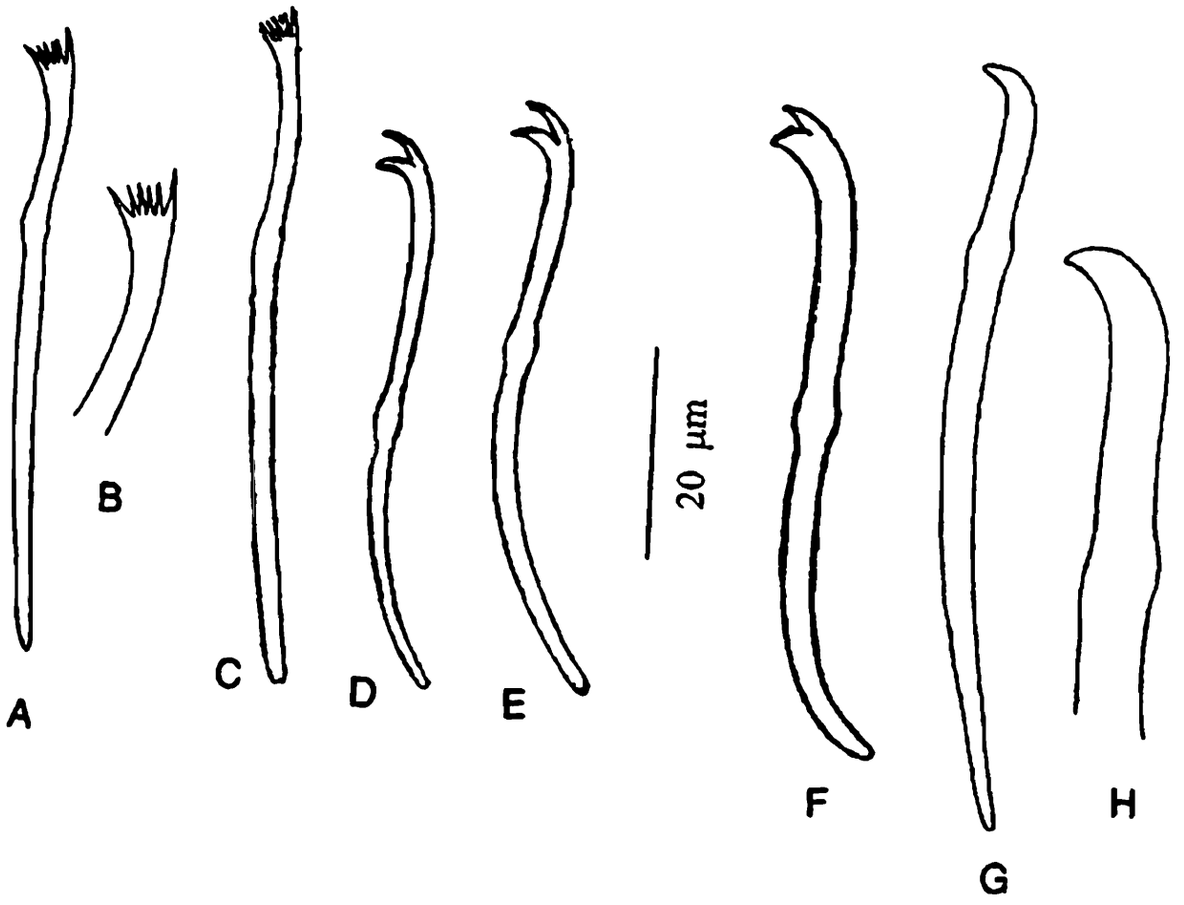

Fig 53 : *Allonais pectinata.* A, B, C : Pectinate needle setae; D, E, F : Ventral setae of II, VI and posterior segment, G, H : Penial setae (A, B, G, H from Chekanovskaya, 1962; C, D, E from Stephenson, 1910a).

anterior face. Atrial ampullae subspherical 80 µm long and 55 µm wide, with short thick ejaculatory ducts covered with prostate gland, opening to exterior by transverse slits, postero-lateral to ventral bundles of VI. Ventral setae of VI modified into penial setae (Fig. 53 G, H), 4-5 per bundle, 55-70 µm long, with weak distal nodulus (D : P :: 1 : 2) and a simple distal hook, occassionally with a vestigeal distal tooth. Spermathecae ovoid, 96 µm long and 55 µm wide, with ducts of 42 µm long and 28 µm wide in V, opening close to inter-segmental furrow of 4/5. Both sexually mature and asexual worms develop epidermal glands in pregenital segments (Marcus, 1943). Cocoons not formed. Anterior 8 segments with a fully developed eggs cast off and such eggs did not develop. Oviducts apparently unable to deposit eggs. Hinder part of worm regenerates lost segments (Marcus, 1943). Asexual reproduction by architomy, worms fragmenting into 2, and later develop five anterior segments and postomium to posterior fragment and some posterior segments to anterior fragment.

Habits : Worms live among filamentous algae, aquatic plants and in sponge colonies of *Spongilla carteri,* etc. in fresh water. Move by active wriggling.

Commensals : Epizoic vorticellids (Protozoa) were found attached to setae of worms.

Distribution : India : Kottayam, Bheemanagar (Kerala); Chittoor (Andhra Pradesh); Gwalior (Madhya Pradesh); Agra (Uttar Pradesh).

World distribution : China, Sumatra (Asia); Africa; Peru, Paraguay, (South America); Queensland (Australia).

Allonais rayalaseemensis Naidu, 1963
(Fig. 54)

Allonais rayalaseemensis Naidu, 1963a : 917; 1966 : 217; Costa, 1967 : 46; Naidu & Srivastava, 1980 : 268;. Naidu, Kalpana & Sureshkumar, 1981 : 109 : Naidu & Naidu, 1981a : 534.

Type locality : Cuddapah, Andhra Pradesh, India.

l(p.) = 10-13 mm; d(p.) = 0.4 mm; s = 93-118 + undifferentiated region; n = 48-54.

Description : Worms large, yellowish brown, with orange red patches in head segments. Prostomium bluntly triangular, longer than broad, enclosing coelomic fluid with corpuscles with stiff cilia on margin. Dorsal bundle from VI, each with 1-2 hair and 1-2 needle setae. Hair setae simple, smooth, straight 238-366 μm long. Needle setae (Fig. 54A) sickle-shaped, bifid, 80-105 μm long, with a distal nodulus (D : P :: 11 : 18), teeth diverging, proximal tooth twice as long and as thick as distal. Ventral setae (Fig. 54 B, C) 4-7 per bundle, in II-V with median nodulus (D : P :: 13 : 12); in others with distal nodulus (D : P :: 11 : 15), in II upto 91 μm long, distal tooth longer and thinner than paroximal, gradually decreasing to 84 μm in succeeding segments, where distal tooth thinner and slightly longer than proximal.

Pharynx in II-V, wide, ciliated, partly eversible through mouth for feeding. Oesophagus in VI-X, thin, sinuous. Pharyngeal and oesophageal glands absent. Stomach in XI-XII, fusiform. Intestine narrow in XIII, and wide in following segments, ascending ciliary action and anti-peristalsis occur. Anus dorsal, extends from side to side, its anterior margin incised medianally, resembling a miniature fossa with inner surface ciliated. Chloragocytes from VI, greenish brown. Coelomocytes granular, spherical, 14-17 μm in diameter. Septa well developed, septal glands absent. Brain (Fig. 54 E) incised deeply behind and less deeply in front. Blood orange red. Dorsal vessel contractile, attached to left wall of gut from hind end to VI, mid-dorsal in I-V anteriorly dividing into 2 in prostomium, branches uniting to form non-contactile ventral vessel in II. Anterior 5 segments have a plexus of blood vessels formed of lateral vessels; contractile lateral vessels 6 pairs in VI-XI. First nephridium (Fig. 54 F) in VII with its nephrostome (Fig. 54 F-ns) in VI, connected by a neck passing through septa to post-septal, consisting of an anterior fusiform, granular ampulla (Fig. 54 F-na) and a long coiled nephridial duct (Fig. 54 F-nd), middle part passing through gland tissue (Fig. 54 F-gl) and ectal part forming a vesicle before opening to exterior in a nephropore (Fig. 54 F-np) ventro-laterally.

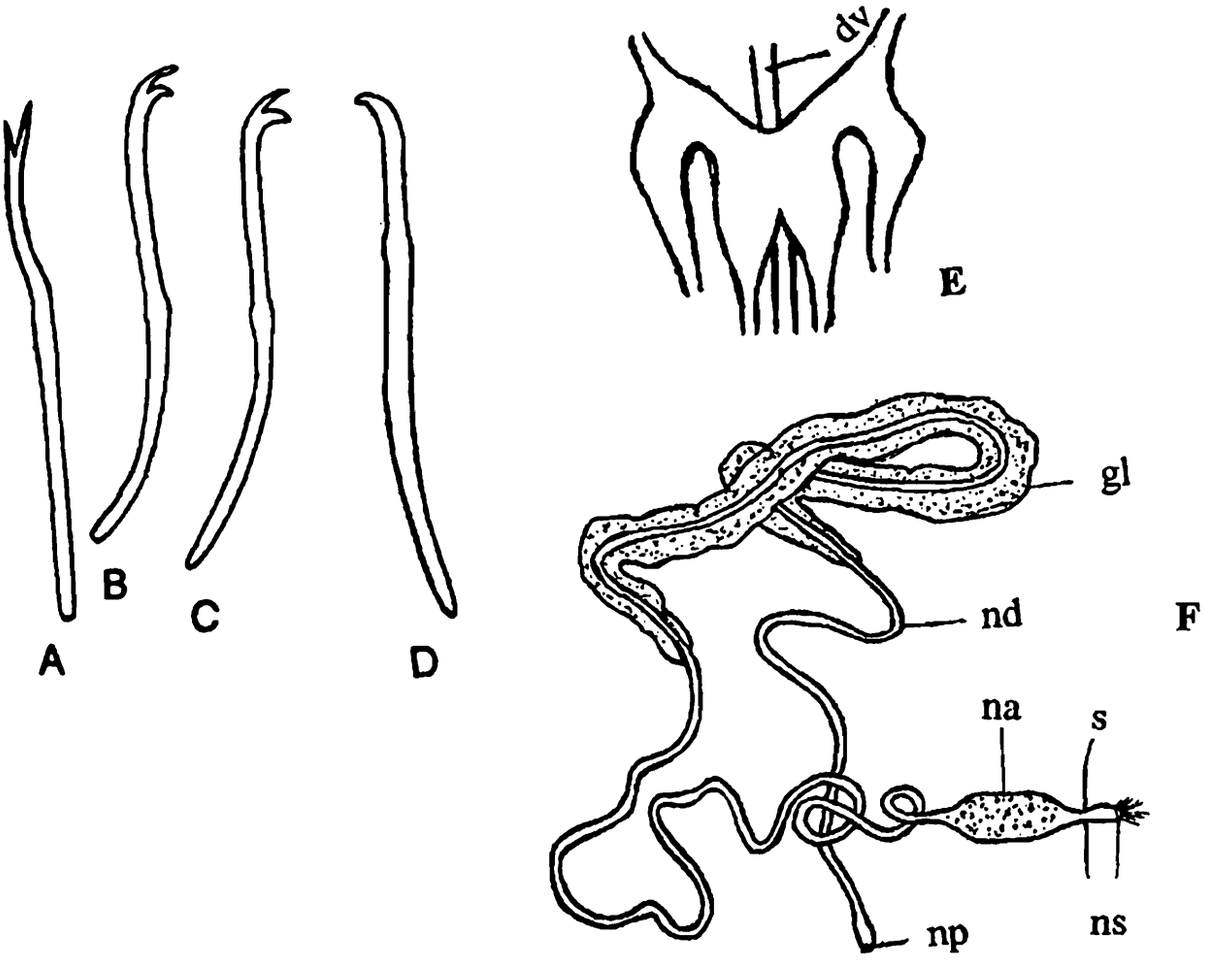

Fig 54 : *Allonais rayalaseemensis.* A : Needle seta; B, C : Ventral setae of II and X; D : Penial seta; E : Brain; F : Nephridium. dv : dorsal vessel; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

Clitellum opaque white from ½V-½VIII (3 segments). In worms with clitellum gonads absent, evidently absorbed after production of sexual cells. Male and female funnels not observed owing to opacity of clitellum. Atria with ovoid ampullae and short ejaculatory ducts opening near ventral bundles of VI. Penial setae (Fig. 54 D) 4-5 per bundle, 119 μm long, with simple hook distally. Sperm- and ovi-sacs, back-pouchings of septa 5/6 and 6/7, extending to X and XIII respectively, former within latter. Spermathecal ampullae ovoid and open by pores in front of ventral bundles of V. Budding absent; fragmentation occurs. Posterior fragment regenerates prostomium and 5 head segments and anterior fragment regenerates several hind segments.

Habits : Worms live among filamentous algae and decaying vegetable matter feeding on them in fresh water. When they are left in a vessel of water (without any aquatic plants), they entangle themselves with one another and form knotty masses, and on removal to a slide with some water, disentangle themselves and move away in all directions. They swim by slow transverse movements.

Distribution : India : Calicut, Malapuza, Palghat (Kerala); Thanjavur (Tamil Nadu); Cuddapah, Chittoor, Tirupati, Tirumala, Chandragiri, Mamandur, Horsley Hills, Nayudupeta, Kakinada, Visakhapatnam, Vizianagaram, Hyderabad (Andhra Pradesh); Bellary, Mysore (Karnataka); Powai Lake, Mumbai, Thane, Nagpur (Maharastra); Ujjain (Madhya Pradesh); Delhi. Ibbagamuwa Tank near Karunegala (Sri Lanka).

World distribution : South-east Asia.

Subfamily STEPHENSONIANINAE Naidu, 1963.

Stephensoniananinae Naidu, 1963b : 201; Naidu, 1966 : 217.

Diagnosis : Eyes absent. Prostomium simple. Dorsal setal bundles begin in II, consisting of hair and needle setae. Ventral setae of two types. Pharynx with a dorsal diverticulum. Coelomocytes absent. Nephridia present. Testes and spermathecae in IV, ovaries and atria in V. Penial setae present. Four anterior segments formed by budding zone.

Type genus : *Stephensoniana* Cernosvitov, 1938.

Genus ***Stephensoniana*** Cernosvitov, 1938.

Stephensonia Aiyer, 1929a : 27; Stephenson, 1930 : 735.

Stephensoniana Cernosvitov, 1938 : 538; Sperber, 1948 : 208; Naidu, 1963b : 201; Brinkhurst & Jamieson, 1971 : 388.

Diagnosis : Eyes absent. Prostomium simple. Dorsal setae from II, with hairs and straight, simple-pointed needles. Ventral setae two types. Pharynx with a dorsal diverticulum. Coelomocytes absent. Nephridia present. Testes and spermathecae in IV, ovaries and atria in V Atria provided with prostate gland cells. Penial setae present. Four anterior segments formed by budding. Cosmopolitan.

Type genus : *Stephensoniana trivandrana (*Aiyer, 1926).

Stephensoniana trivandrana (Aiyer, 1926)
(Fig. 55)

Naidium (?) *trivandranum* Aiyer, 1926 : 139.

Stephensonia trivandrana, Aiyer, 1929a : 27.

Stephensoniana trivandrana, Sperber, 1948 : 208; Naidu, 1963b : 201; 1966 : 217; Vasisht & Gandhi, 1972 : 100; Sobhana & Nair, 1983a : 105.

Type locality : Trivandrum, Kerala, India.

l = 2-6 mm; d = 0.2 mm; s = 21- 43 + undifferentiated region; n = 12-20.

Description : Worms (Fig. 55 A) small, filiform and reddish brown in life. Body-wall with cutaneous glands, anterior ½ to 2/3 of body covered with mucous sheath to which foreign matter adheres. Prostomium bluntly triangular. Dorsal and ventral setae begin II. Dorsal bundles with 3-5 hair and 3-5 needle setae per bundle, decreasing to 2 each and 1 each posteriorly. Hair setae (Fig. 55 B) bayonet-shaped, 115-175 μm long, smooth. Needle setae (Fig. 55 C) simple, straight, suddenly tapering to a point and slightly curving towards distal end, 38-52 μm long, without nodulus. Ventral setae (Fig. 55 D, E) 3-5 per bundle, decreasing to 2 and 1 posteriorly; in II-IV 70-93 μm long, with a slightly proximal nodulus (D : P :: 7 : 6), less curved, teeth equally thick, distal longer than proximal; in rest 67-91 μm long with proximal nodulus (D : P :: 8 : 5), with equally thick distal tooth thinner and longer than proximal.

Pharynx in II-III, wide with a dorsal diverticulum. Oesophagus ½III-V, narrow and sinuous, later half of oesophagus covered outside by minute oil droplets. Stomach absent. Intestine starts in VI, wide throughout with particles of reddish orange pigment, scattered throughout intestine which accumulate prominently at posterior end. Coelomocytes absent. Chloragocytes brown and cover gut from VI. Blood orange red. Dorsal vessel attached to left of gut from hind end to V and mid-dorsal in I-IV Ventral vessel mid-ventral lying above ventral nerve cord. Contractile vascular loops, a pair in IV. First nephridium in VI with its pre-septal funnel on anterior face of septum 5/6, its tube passes through septum and dilates into a pear-shaped vesicle, after which it continues as thin tube, thrown into 3 or 4 coils and opens to exterior in nephropore.

Clitellum (fig. 55 F-c) in ½IV-½VI, conspicuous and whitish. Testes a pair in IV. Sperm-sac (Fig. 55 F-ss) single back-pouching of septum 4/5 and occupies V and VI, containing sperms in indifferent stages of development. Male funnels (Fig. 55 F-m) on anterior face of septum 4/5, ciliated, 27 μm long and 18 μm wide at mouth. Vas deferens (Fig. 55 F-v) 9 μm wide behind septum 4/5, passes downwards towards body wall and opens into atrium apically. Atrium (Fig. 55 F-a) small, ovoid or pear-shaped in V with thick glandular epithelium, about 54 μm long and 36 μm wide at broad ental end and 27 μm wide at narrow ectal end, its upper 2/3 covered with a mass of pear-shaped prostate (Fig. 55 F-p) gland cells, opening directly in male pores (Fig. 55 H-mp) ventrally. Ejaculatory duct absent. Penial setae (Fig. 55 G, H) 4-5 per bundle about 81 μm long with a distinct distal nodulus, shaft beyond nodules has a slight sickle-shaped curve, ending in two blunt teeth. Ovaries a pair in V attached to posterior face septum 4/5. Ovi-sac (Fig. 55 F-o) single back-pouching of septum 5/6, extend to VII containing single ovum of 315 μm long and 112 μm wide. Female funnels not observed. Spermathecae (Fig. 55 F-s) in VI small, its ampulla oval (72 μm long) or spherical (65 μm long) with short duct 27 μm in height and 21 μm wide distinctly marked off from it by a constriction. Asexual reproduction by paratomy, by development of budding zones, one at a time. Prostomium and 4 anterior segments budded off to posterior individual, and some posterior segments to anterior individual.

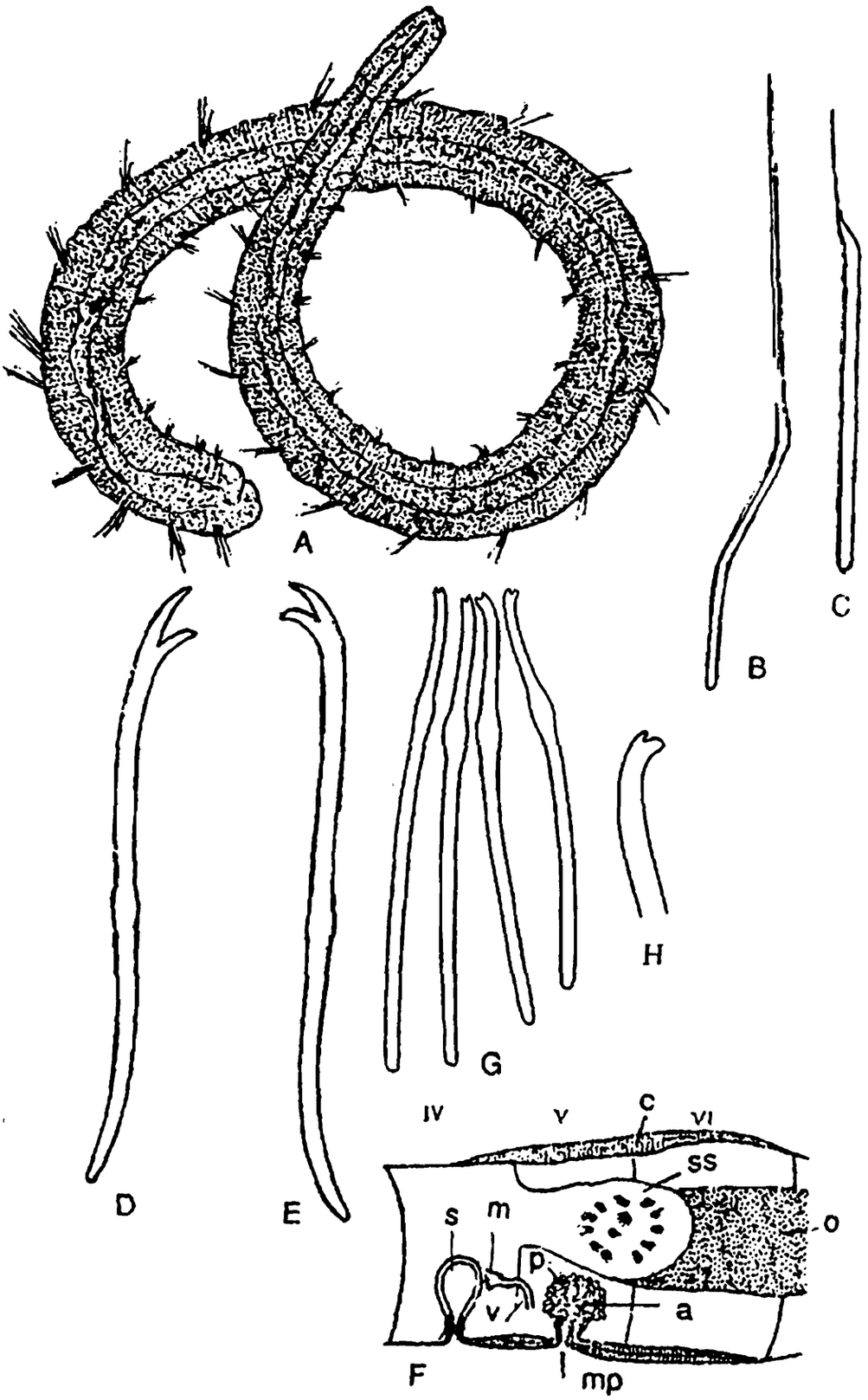

Fig 55 : *Stephensoniana trivandrana.* A : General view of entire worm; B : Hair seta; C : Needle seta; D, E : Ventral setae of II and V; F : Genital organs; G, H : Penial setae. (F, G, H from Aiyer, 1926, 1929a). a : atrium; c : clitellum; m : male funnel; mp : male pore; o : ovi-sac; p : prostate; s : spermatheca; ss : sperm-sac; v : vas deferens.

Habits : Lives in fresh water, in soft mud, moves very slowly on substratum, and when disturbed coils into a flat spiral like a millipede or screws itself up into an irregular spiral like *Aulodrilus*. Swims with brisk wriggling movements.

Parasites : Large holotrichous astomatus ciliates were found in the gut of several worms (Aiyer, 1929a, Naidu, 1963b).

Distribution : India : Trivandrum, Veli Lake (Kerala); Cuddapah, Gudur (Andhra Pradesh); Bellary (Karnataka); Chandigarh; Punjab; Haryana.

World distribution : Asia; Africa; Louisiana, Columbia, Mississippi (North America); Surinam, Argentina (South America).

Subfamily PRISTININAE Lastockin, 1924.

Pritininae Lastockin. Sperber, 1948 : 209; Chekanovskaya, 1962 : 210; Brinkhurst, 1964 : 216; Brinkhurst & Jamieson, 1971 : 389; Brinkhurst, 1985; 472; Mukhopadhyay, 1998 : 110.

Diagnosis : Prostomium with or without a proboscis. Eyes absent. Dorsal setae usually beginning in II, consisting of hairs and needles. Pharyngeal and septal glands present, stomach of special structure, with intra-cellular canals. Commissural vessels mostly in pre-ovarial segments. Coelomocytes present. Nephridia sometimes invested with bladder-like peritoneal cells. Testes and spermathecae in VII, ovaries and atria in VIII. Seven anterior segments formed by posterior zooid by budding.

Type genus : *Pristina* Ehrenberg, 1828.

Key to genera of subfamily PRISTININAE

Prostomium with proboscis ..... ***Pristina***

Prostomium without proboscis ..... ***Pristinella***

Genus ***Pristina*** Ehrenberg, 1828

Pristina Ehrenberg, 1828 : 209; Beddard, 1895 : 289; Stephenson, 1923 : 69; 1930 : 739; Sperber, 1948 : 209; Naidu, 1963b : 204; Chekanovskaya, 1962 : 210; Brinkhurst, 1964 : 217; Brinkhurst & Jamieson, 1971 : 389; Brinkhurst, 1985 : 472; Persia, 1980 : 96; Mukhopadhyay, 1998 : 110.

Diagnosis : Proboscis present. Eyes absent. Dorsal bundles begin in II with hairs and simple, bifid or trifid needles, with or without nodulus. Ventral setae progressively differ from anterior to posterior bundles. Septal glands present in some segments from III-VI. Dorsal vessel mid-dorsal; commissural vessels simple, anastomosing or forming a plexus. Stomach beginning in VII, or VIII with intra-cellular canals. Chloragocytes beginning in IV or V. Testes and spermathecae in VII, ovaries and

atria in VIII, genital setae on V, VI and VIII or VII and VIII with glands. Prostates on vasa deferentia. Atria without prostate, most often weak, tubular; genital setae of various shapes, often accompanied by special glands. Spermathecae present. Cosmopolitan.

Type species : *Pristina longiseta* Ehrenberg, 1828.

Species included are : *Pristina aequiseta* Bourne, 1891; *P. breviseta* Bourne, 1891; *P. evelinae* Marcus, 1943; *P. foreli* (Piguet, 1906); *P. longiseta* Ehrenberg, 1828; *P. macrochaeta* Stephenson, 1931; *P. proboscidea* Beddard, 1896; *P. sperberae* Naidu, 1963, *P. synclites* Stephenson, 1925, *P. americana* Cernosvitov, 1937, *P. biserrata* Chen, 1940; *P. leidyi* Smith, 1896; *P. peruviana* Cernosvitov, 1939; *P. plumaseta* Turner, 1935. Of these first nine species occur in Indian subcontinent.

Key to Indian species of genus *Pristina*

1. Dorsal setae begin in III or IV ..... *Pristina macrochaeta*
– Dorsal setae begin in II 2
2. Needle setae simple pointed 3
– Needle setae bifid, with at least a minute distal tooth 4
3. Elongate hair setae absent ..... *Pristina proboscidea*
– Elongate setae present in III ..... *Pristina longiseta longiseta*
4. Teeth of needle setae fine, equal 5
– Teeth of needle setae long, equal or unequal in length 8
5. Giant ventral setae absent 6
– Giant ventral setae in IV or V or both 7
6. Hair setae finely serrated, dorsal bundles with 1-4 hairs, 1-4 needles; needle teeth equally thick, distal shorter than proximal ..... *Pristina foreli*
– Hair setae smooth, dorsal bundles with 1 hair and 1 needle; needle teeth fine, equal ..... *Pristina sperberae*
7. Giant ventral setae in IV or V or both, distal tooth twice as long as proximal, or proximal absent; genital setae unknown ..... *Pristina aequiseta*
– Giant ventral setae single pointed in V, enlarged genital setae in VII in some ..... *Pristina evelinae*
8. Teeth of needle setae unequal in length ..... *Pristina synclites*
– Teeth of needle setae equal, diverging ..... *Pristina breviseta*

Pristina aequiseta Bourne, 1891
(Fig. 56)

Pristina aequiseta Bourne, 1891 : 352; Michaelsen, 1909a : 135; Stephenson, 1909b : 269; Michaelsen, 1910 : 8; Stephenson, 1913a : 739; 1915b : 786; 1916 : 304; 1922a : 253; 1923 : 71; Aiyer, 1929a : 25; Sperber, 1960 : 158; Naidu, 1963b : 212; 1966 : 218; Vasisht & Gandhi, 1972 : 100; Naidu & Srivastava,1980 : 269; Naidu & Naidu, 1981b : 116; Naidu, Kalpana & Sureshkumar, 1981 : 109; Mukhopadhyay, 1998 : 111.

Type locality : England.

l = 1.5-3.0 mm; d = 0.15-0.20 mm; s = 18-27 + undifferentiated region; n = 12-23.

Description : Worms small, slender, delicate and pale white. Prostomium bluntly triangular, longer than broad with median fairly long, about 100 μm long, mobile proboscis with stiff, short cilia on margin. Dorsal setae 1-2 hair and 1-2 needle setae per bundle. Hair setae 85-240 μm long, simple, finely serrated on convex border. Needle setae (Fig. 56 A) 30-54 μm long, bifid, without nodulus, distally curved, with short, fine teeth. Ventral setae (Fig. 56 B, C) 3-10 per bundle, in II 52-66 μm long, 1.3 μm thick, longer, thinner than rest, with teeth equally thick, distal twice as long as proximal and slightly proximal nodulus (D : P :: 9 : 7); in III 44-48 μm long, 1.5 μm thick, thicker, with slightly distal nodulus (D : P :: 6 : 7), teeth equally thick, distal longer than proximal. In IV giant setae (Fig. 56 D) 1-2 per bundle, 60-70 μm long, 3 μm thick, with distal nodulus (D : P :: 8 : 11), and very thick distal tooth about 7 μm long, strongly hooked and a rudimentary proximal tooth of 3 μm long. In rest 45-50 μm long, 1.4-1.6 μm thick, with distal nodulus (D : P :: 6 : 8), teeth equally thick, distal slightly longer decreasing to equal or slightly shorter than proximal towards posterior end.

Pharynx in II-III, wide. Oesophagus in IV-VII, narrow. Stomach in VIII, pear-shaped occupying anterior half of segment, with intra-cellular canals on wall. Intestine narrow in VIII-IX, wide from X. Chloragocytes from VI, greenish brown in life. Coelomocytes numerous, spherical, morula-like with central nucleus and granules, 8-14 μm in diameter. Septal glands in III-V. Brain incised anteriorly and posteriorly. Blood pale red. Dorsal vessel mid-dorsal and contractile. Six pairs contractile lateral vessels in II-VII connecting dorsal and ventral vessels. First pair of nephridia in IX, with their pre-septal nephrostomes in VIII.

Sex organs not known. Paratomy occurs, producing normally a single rarely two budding zones, second budding zone always forming a segment in front of first zone. Prostomium, proboscis and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off before separation.

Habits : Worms live among filamentous algae and sponge, *Spongilla carteri*, etc. in fresh water. Swimming absent, but move by creeping.

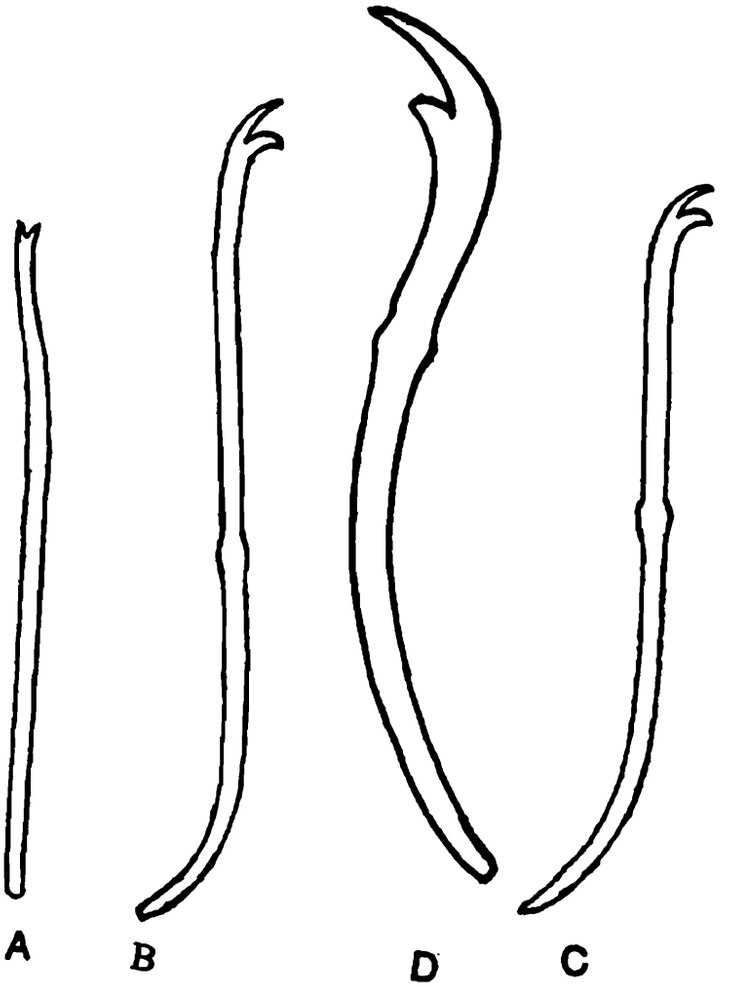

Fig 56 : *Pristina aequiseta.* A : Needle seta; B, C : Ventral setae of II and XX; D : Giant ventral seta. (D from Ercolini, 1969).

Chromosomes : 2n = 12 (Mc Gee & French, 1977).

Distribution : India : Vellayani, Trivandrum (Kerala); Udhakamandalam (Tamil Nadu); Chittoor, Cuddapah, Warangal, Vijayawada, Kakinada, Visakhapatnam, Vizianagaram (Andhra Pradesh); Bellary, Mysore (Karnataka); Mumbai, Nagpur (Maharastra); Allahabad (Uttar Pradesh); Chandigarh; Punjab; Haryana; Kolkata (West Bengal). Lahore (Pakistan); Sri Lanka; Kouh-Bibtchchin, Farah, Baram (Afghanistan).

World distribution : Cosmopolitan.

Pristina breviseta Bourne, 1891
(Fig. 57)

Pristina breviseta Bourne, 1891 : 353; Michaelsen, 1910 : 8.

Naidium breviseta, Stephenson, 1923 : 67; Aiyer, 1925 : 32; Stephenson, 1926a : 291; Aiyer, 1929a : 23; Weerakonn & Samarasinghe, 1958 : 160.

Pristina breviseta, Mendis & Fernando, 1962 : 45; Naidu, 1966 : 218; Khatoon & Ali, 1993 : 532.

Type locality : Chennai (Madras), Tamil Nadu, India.

l = 8-20 mm; d = 0.2-0.25 mm; s = 35-120 + undifferentiated region; n = 18-26.

Description : Worms of medium size, delicate, flesh coloured. Prostomium bluntly triangular, longer than broad, with a short, mobile proboscis. Dorsal setae begin in II, 1 hair and 1 needle seta, rarely 2 of each per bundle. Hair setae 140-290 μm long, straight, non-serrate. Needle setae (Fig. 57 C) 45-95 μm long, bifid, slightly bayonet-shaped, with weak nodulus, curved above nodulus and with long diverging equally

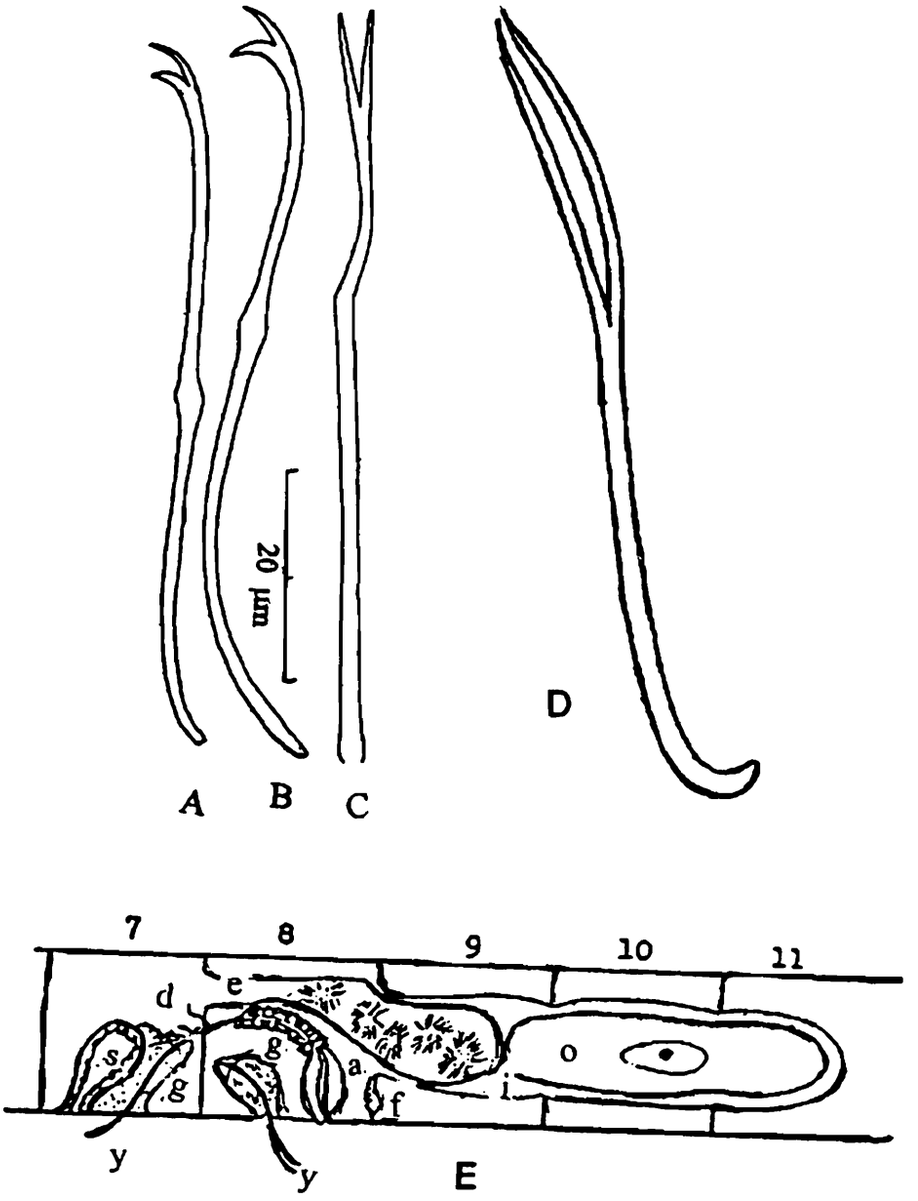

Fig 57 : *Pristina breviseta.* A, B : Ventral setae of II and XX; C : Needle seta; D : Spermathecal seta; E : Genital organs. (A-C, E from Marcus, 1943; D from Stephenson, 1930). a : atrium; d : male funnel; e : sperm-sac; f : female funnel; g : genital gland; i : ovi-sac; o : ovum; s : spermatheca; y : spermathecal seta; 7, 8, 10, 11, 12 : segments VII-XI.

long and thick teeth. Ventral setae (Fig. 57 A, B) 3-5 per bundle, 62-95 μm long, increasing in length backwards in anterior segments, in II straighter with median nodulus, distal tooth thinner and longer than proximal. In posterior segments setae curved, with distal nodulus, proximal tooth longer and slightly thicker than distal.

Pharynx in II-III, wide. Oesophagus in IV-VI, narrow and straight. Stomach in VII-VIII, pear-shaped, with intra-cellular canals on wall. Intestine from IX, wide and sacculated. Chloragocytes from V or VI. Coelomocytes numerous spherical. Dorsal vessel slightly to left on gut, contractile, dividing into right and left branches in II, descend downwards, run backwards below pharynx and unite in middle of VI to form non-contractile ventral vessel. Three pairs of non-contractile lateral vessels in II-IV and 3 pairs of short contractile lateral vessels in V-VII connect dorsal and ventral vessels. First nephridium in IX with its pre-septal funnel-shaped nephrostome in VIII.

Clitellum in ½VII-IX (2½ segments), weak or absent mid-ventrally. Sperm-sac (Fig. 57 E-e) and ovi-sac (Fig. 57 E-i) back-pouching of septa 7/8 and 8/9 extending to IX and XI respectively when full. Male funnels (Fig. 57 E-d) cup-shaped on anterior face of septum 7/8. Vasa deferentia narrow, surrounded by prostate gland cells, opening into atria dorsally. Atrial ampulla (Fig. 57 E-a) ovoid, fairly high, with a narrow lumen. Ejaculatory ducts short, narrow, thin-walled, both opening in common into a median pit. Spermathecae (Fig. 57 E-s) in VII, ovoid, small, thick-walled, ducts narrow, both opening into a pit, in common or separately. One spermathecal setae (Fig. 57 D, E-y) to right of spermatheca in VII, and another hind most in VII or VIII on left side, both strongly curved proximally with two enormous converging teeth, united by a membrane, and both enclosed within genital glands (Fig. 57 E-g). Asexual reproduction by paratomy, one budding zone develops at a time. Prostomium with a short proboscis, and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off before separation.

Distribution : India : Kovilam, Chirayinkil, Trivandrum (Kerala); Chennai (Tamil Nadu). Meegoda near Colombo (Sri Lanka).

World distribution : South-East Asia; Yugoslavia, Switzerland (Europe); North and South America.

Pristina evelinae Marcus, 1943
(Fig. 58)

Pristina evelinae Marcus, 1943 : 112; Naidu, 1963b : 214; 1966 : 218; Costa, 1967 : 48; Naidu & Naidu, 1981a : 534.

Type locality : Sao Paulo, Brazil, South America.

l(p.) = 1.1-1.5 mm; d(p.) = 0.1-0.14 mm; s = 13-22 + undifferentiated region; n = 13-14.

Description : Worms minute, delicate and brownish in life. Prostomium bluntly

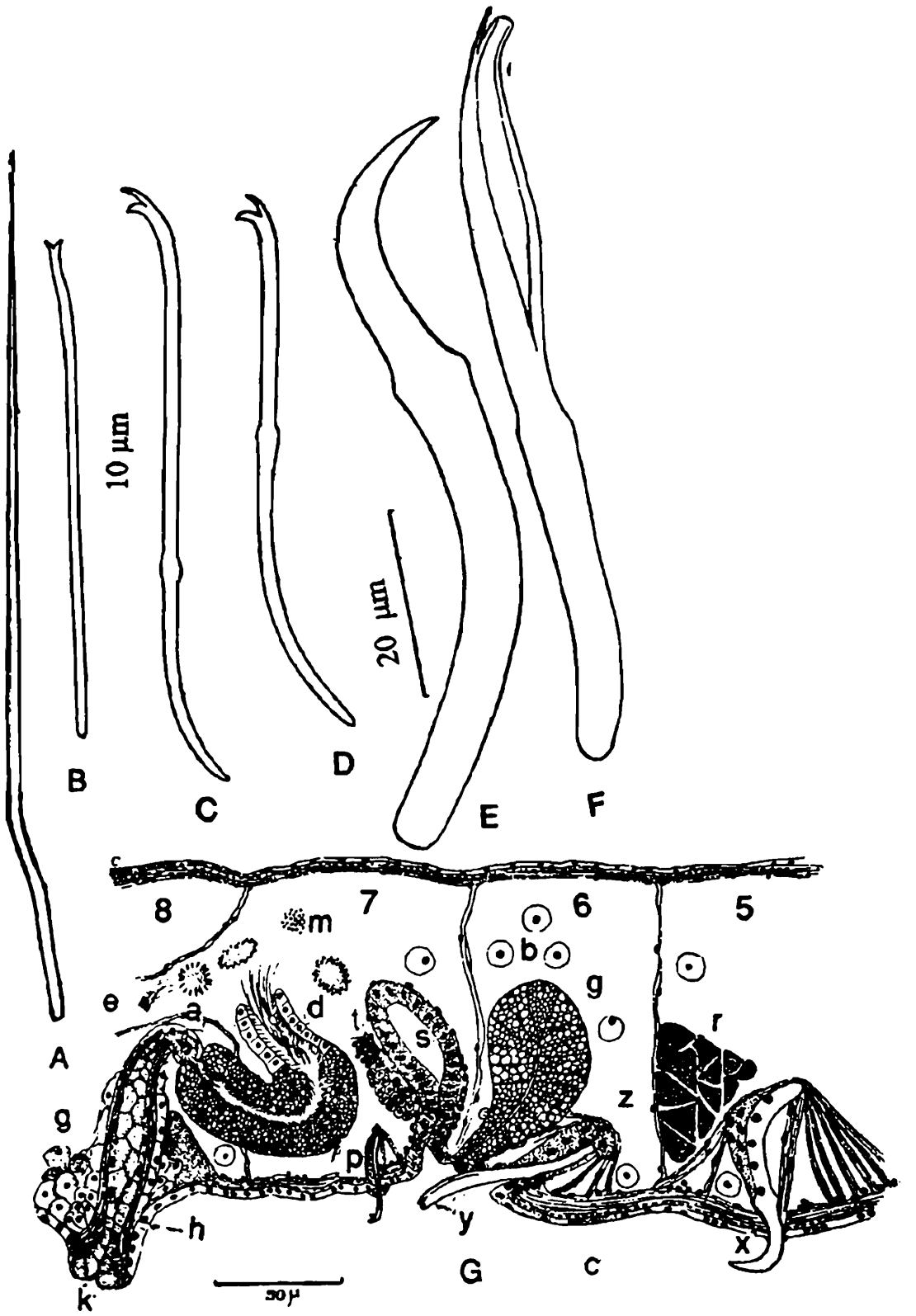

Fig 58 : *Pristina evelinae.* A : Hair seta; B : Needle seta; C, D : Ventral setae of II and posterior segment; E : Giant ventral seta; F : Spermathecal seta; G : Genital organs. (E-G from Marcus, 1943). a : atrium; b : coelomocyte; c : clitellum; d : male funnel; e : sperm-sac; g : gland; r : septal gland; s : spermatheca; t : testis; x : giant ventral seta; y : spermathecal seta; z : setal follicle.

triangular, with a median proboscis longer than prostomium, both with stiff short cilia. Dorsal setae begin in II, 1 hair and 1 needle seta per bundle. Hair setae (Fig. 58 A) 91-175 μm long, simple, finely serrated on convex border. Needle setae (Fig. 58 B) 30-42 μm long, bifid, with weak nodulus 1/3 from distal end (D : P :: 1 : 2), slightly curved distal to nodulus, teeth fine, short, diverging. Ventral setae (Fig. 58 C, D) 4-7 per bundle, more in middle segments, in II 49-55 μm long, longest; in III and IV shortest, 33-42 μm long; in VI one giant seta (Fig. 58 E) per bundle, 70-80 μm long, and in rest 39-46 μm long. Nodulus slightly proximal in II (D : P :: 8 : 7); slightly distal (D : P :: 5 : 6) in III; distal (D : P :: 5 : 7) in IV, distal in giant seta (D : P :: 2 : 3) and distal (D : P :: 5 : 8) in all other segments. Distal tooth longer and thinner than proximal in II, and thinner and about equal or shorter than proximal in other segments.

Pharynx in II-III, wide, with an eversible roof for feeding. Oesophagus in IV-VII, narrow. Stomach in VIII, pear-shaped, with intra-cellular canals on wall. Intestine from IX, wide and sacculated. Chloragocytes from VI, cover gut and dorsal vessel. Coelomocytes (Fig. 58 G-b) about 9 μm in diameter, round with granular protoplasm and a few oil-drop like bodies. Septal glands (Fig. 58 G-r) in III-V. Brain incised in front and behind. Blood pale red. Dorsal vessel mid-dorsal all its length, dividing into a right and a left branches anteriorly, discend downwards, run backwards below pharynx to unite into a non-contractile ventral vessel. Four pairs of contractile lateral vessels in V-VIII and three pairs of non-contractile or slightly contractile lateral vessels in II-IV connect dorsal and ventral vessels. First nephridium in IX situated to left, with its preseptal nephrostome in VIII.

Clitellum (Fig. 58 G-c) in VIII-IX (2 segments) absent ventrally in VIII. Testes (Fig. 58 G-t) a pair on posterior face of septum 6/7 laterally in VII. Ovaries a pair on posterior face of septum 7/8 laterally in VIII. Testes active for a long time. Before copulation sex organs degenerate. Sperm-sac (Fig. 58 G-e) simple back-pouching of septum 7/8 extend to X. Ovi-sac single back-pouching of septum 8/9 extend to XI when filled with ova. Male funnels (Fig. 58 G-d) large tubular ciliated, enter into sperm-sac and face backwards. Vasa deferentia (Fig. 58 G-p) very thick and glandular entering atria on top. Atrial ampulla (Fig. 58 G-a) pear-shaped, very small with very long ejaculatory ducts curved, with narrow lumina. Strongly enlarged genital setae (Fig. 58 F, G-y) 1 per bundle, 80 μm long and 6 μm thick, in VI and sometimes in VII with proximal nodulus and 2 very long teeth starting a little distal to nodulus, distal tooth thick and bifid at tip, and uniformly thin elongated proximal tooth. A pair of genital glands (Fig. 58 G-g) behind setae of VI and a single gland medially in VIII behind male pores and an unpaired glandular mass. Spermathecae (Fig. 58 G-s) a pair, club-shaped in VIII. In VI two enormous accessory glands (Fig. 58 G-g) and in VIII single median one developed. Asexual reproduction by paratomy, one budding zone developed at a time. Prostomium with proboscis and 7 anterior segments to anterior individual and several posterior segments to anterior individual budded of by budding zone, before separation.

Habits : Lives among aquatic plants and algae in fresh water. This species and *P. longiseta* creep by stretching forward 8-10 segments by contraction of circular muscles and attach itself with their setae, then contract longitudinal muscles, pulls forward rest of body (Marcus, 1943). This species is often found together with *Aulophorus carteri* (Marcus, 1943).

Distribution : India : Trivandrum, Vellayani Lake, Bheemanagar (Kerala); Udhakamandalam (Tamil Nadu); Cuddapah, Mamandur, Vizianagaram, Warangal, Hyderabad. Peradeniya, Ratmalana (Sri Lanka).

World distribution : South Asia; Germany (Europe); Argentina; Brazil (South America).

Pristina foreli Piguet, (1906)
(Fig. 59)

Naidium foreli Piguet, 1906 : 222.

Pristina foreli, Sperber, 1958 : 52; Ali & Issaque, 1975 : 59.

Type locality : Switzerland.

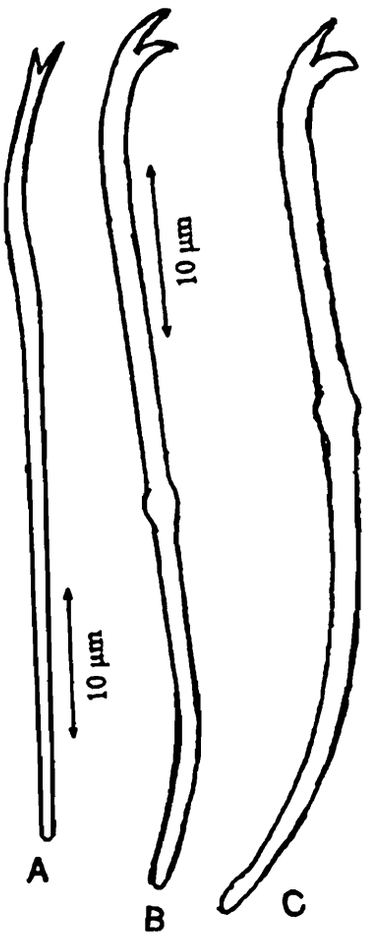

Fig 59 : *Pristina foreli.* A : Needle seta; B, C : Ventral setae of II and VII.

l(p.) = 1.4-3.0 mm; d(p.) = 0.1-0.12 mm; s = 25-29 + undifferentiated region; n = 13-19.

Description : Worms minute, delicate, slender and transparent. Prostomium bluntly triangular with a median proboscis, 84-88 μm long, with stiff short cilia. Dorsal setae from II, 1-4 hair and 1-4 needle setae per bundle. Hair setae 120-270 μm long, nearly straight with very fine serrations on convex border. Needle setae (Fig. 59A) thinner than hair setae with weak nodulus, slightly curved distal to nodulus, 45-72 μm long, 0.8-1.1 μm thick, teeth fine, equally long, proximal tooth slightly thicker and longer than distal. Ventral setae (Fig. 59 B, C) 2-8 per bundle, in II-VII markedly different from rest, in II 47-60 μm long, 1.4 μm thick, in III 47-54 mm long, 1.4 μm thick, in IV-VI 47-51 μm long, 1.5 μm thick, in VII 54-70 μm long, 1.5 μm thick, in rest 48-53 μm long, 1.6 μm thick. Nodulus proximal in II and distal in rest. In II-VII distal tooth longer than proximal; in rest teeth equally thick, distal slightly longer becoming shorter posteriorly.

Pharynx in II-III, wide and ciliated, with an eversible roof. Oesophagus in IV-VII narrow and wavy. Stomach in VIII abruptly widening, pear-shaped with intra-cellular canals on its wall. Intestine narrow and sinuous in IX-X and wide and sacculated from XI. Chloragogues from VI. Coelomocytes present. Brain incised deeply behind and less deeply in front. Blood pale yellow. Dorsal vessel in mid-dorsal and contractile. Lateral commissural vessels in II-VII, occasionally those of II-III anastomosing. Nephridia from IX, one per segment with preseptal nephrostome in previous segment.

Genital organs not known. Asexual reproduction by paratomy, developing only one budding zone at a time. Prostomium, proboscis and 7 anterior segments to posterior individual and several anterior segments to posterior individual budded before separation.

Habits : Live in fresh water. Movement by forward and backward creeping. Swimming absent.

Distribution : India : Courtallam (Tamil Nadu); Chittoor (Andhra Pradesh); Bangalore Mysore, (Karnataka). Dhaka (Bangladesh).

World distribution : Asia; Europe; Africa; Georgia (North America); Costa Rica (Central America); Queensland (Australia).

Pristina longiseta longiseta Ehrenberg, 1828
(Fig. 60)

Pristina longiseta Ehrenberg, 1828: 112 (Footnote); Michaelsen, 1909a : 135; Stephenson, 1909b : 264; 1910b : 235.

Pristina longiseta f. *typica* Michaelsen, 1910 : 8.

Pristina longiseta, Stephenson, 1913a : 739; 1916 : 304; 1920 : 199; Mehra, 1920 : 457.

Pristina longiseta f. *typica*, Stephenson, 1923 : 70; Aiyer, 1929a : 24.

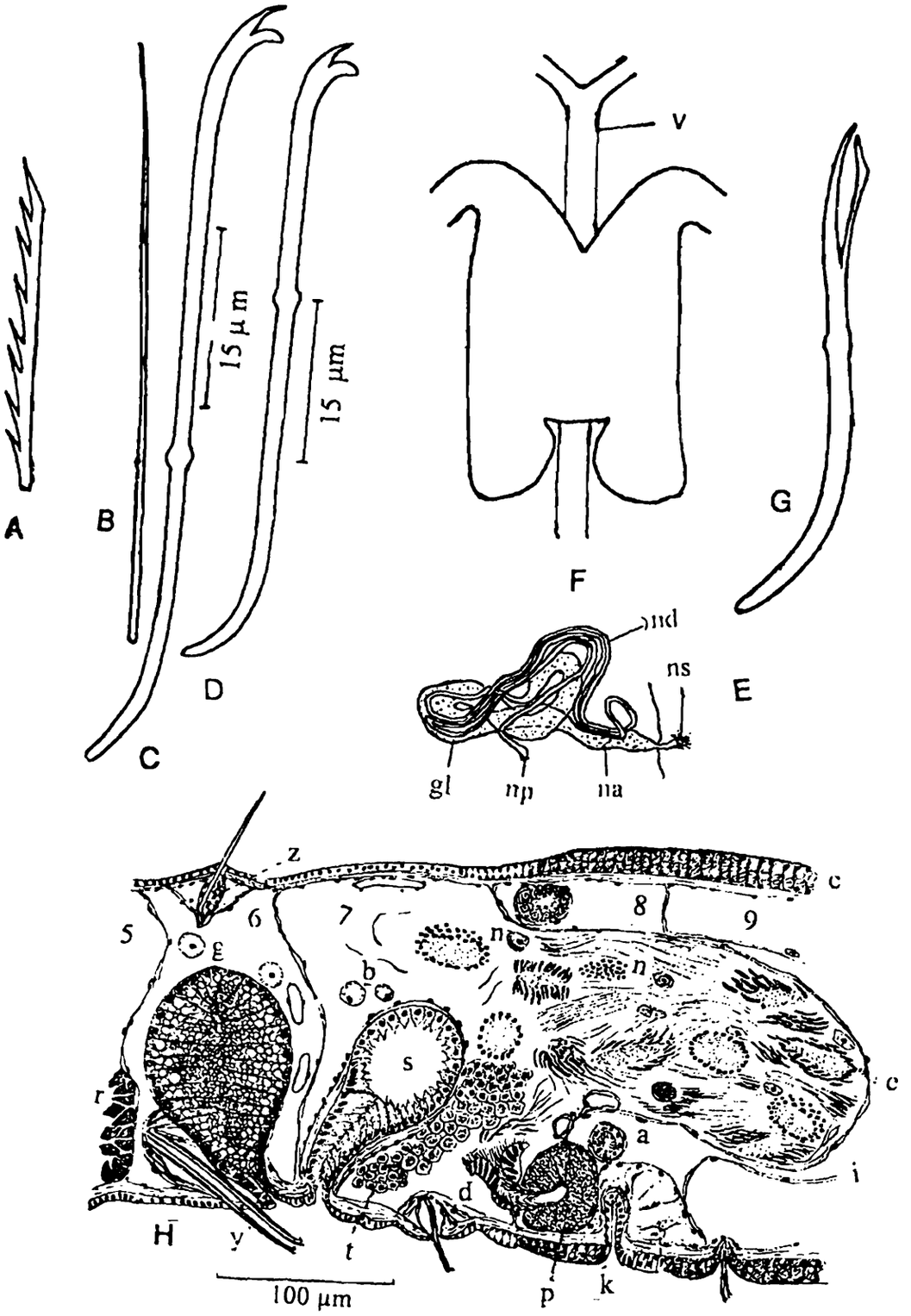

Fig 60 : *Pristina longiseta longiseta.* A : Part of hair seta showing serrations; B : Needle seta; C, D : Ventral setae of II and posterior segment; E : Nephridium; F : Brain G : Spermathecal seta; H : Genital organs. (A from Aiyer, 1929a; H from Marcus, 1943). a : atrium; b : coelomocyte; c : clitellum; d : male funnel; e : sperm-sac; g : genital gland; i : ovi-sac; k : atrial pore; n : spermatocyte; p : prostate gland; s : spermatheca; t : testis; v : dorsal vessel; y : spermathecal seta; z : setal follicle.

Pristina longiseta longiseta, Sperber, 1948 : 236.

Pristina longiseta, Sperber, 1958 : 52.

Pristina longiseta longiseta, Naidu, 1963a : 216; 1966 : 218.

Pristina longiseta, Costa, 1967 : 47.

Pristina longiseta longiseta, Vasisht & Gandhi, 1972 : 100; Naidu & Naidu, 1979b : 416.

Pristina longiseta, Sureshkumar & Ramasarma, 1979 : 347; Arunachalm et al., 1980 : 509.

Pristina longiseta longiseta, Naidu & Srivastava, 1980 : 269; Naidu & Naidu, 1981a : 534; 1981b : 115; Naidu, Kalpana & Sureshkumar, 1981 : 110; Sobhana & Nair, 1983a : 104; Mukhopadhyay, 1998 : 110.

Pristina longiseta, Khatoon & Ali, 1993 : 532.

Type locality : Unassigned, Germany.

l = 2-3 mm (single); 4-5 mm (chain); d = 0.10-0.12 μm; s = 20-30 + undifferentiated region; n = 13-18.

Description : Worms small, slender, delicate and pale yellow in life. Prostomium bluntly triangular, longer than broad, with a median long proboscis, longer than prostomium, both with stiff, short cilia. During forward movement, proboscis curved upwards and backwards. Dorsal setae from II, 1-3 hair and 1-3 needle setae per bundle. Hair setae (Fig. 60 A) nearly straight, of III specially elongated, non-serrated, 600-800 μm long, those of II and other segments 120-285 μm long, with serrations 3 μm apart on convex border. Needle setae (Fig. 60 B) fine, straight with a distal end slightly curved and simple-pointed without nodulus, 40-60 μm long. Ventral setae (Fig. 60 C, D) 3-9 per bundle, in II longest, thinner than rest, 57-75 μm long, 1.4-1.5 μm thick, in III slightly longer and thicker than in following segments, 57-70 μm long, 2 μm thick, teeth equally thick, distal twice as long as proximal in II and III; in rest 50-58 μm long, 1.6-1.8 μm thick, distal tooth thinner and equal or shorter than proximal. Nodulus proximal (D : P :: 11 : 7) in II, slightly distal (D : P :: 8 : 7) in III, median (D : P :: 1 : 1) in IV and slightly distal (D : P :: 8 : 7) in rest.

Buccal cavity in I. Pharynx in II-III, ovoid, ciliated with a protrusible dorsal diverticulum. Stomach in VIII, abrupt and pear-shaped, thick-walled with intra-cellular canals on its wall. Chyle cells in stomach wall, part single cells and part blocks of 2-3 cells. Intestine narrow in IX and wide from X opening by anus posteriorly in a notch between two lobes with short, stiff sensory cilia. Chloragocytes from VI. Septal glands connected with pharynx by muscle strands on septa 4/5, 5/6 and 6/7. Coelomocytes (Fig. 60 H-b) colourless, spherical with grayish granules, 10 μm in diameter. Brain (Fig. 60 F) incised narrowly in front and widely behind. Blood yellowish. Dorsal vessel contractile and mid-dorsal. Six pairs of lateral vessels in II-VII, in II non-contractile, in rest contractile, later pairs longer and more contractile. First pair of nephridia in IX, with pre-septal nephrostome (Fig. 60 E-ns) in VIII, continued by a neck to post-

septal consisting of fusiform ampulla (Fig. 60 E-na) followed by a coiled, ciliated duct (Fig. 60 E-nd), partly free and partly enclosed in gland tissue (Fig. 60 E-gl) and opening ventro-laterally by nephropore (Fig. 60 E-np).

Clitellum in 1½VII-½IX (2 segments). A pair of ovoid, white testes (Fig. 60 H-t) and a pair of ovaries attached to posterior face of septa 6/7 and 7/8 respectively laterally. Testes remain active for a long time. Before copulation sex organs degenerate. Sperm-sac (Fig. 60 H-e) and ovi-sac (Fig. 60 H-I) back-pouchings of septa 7/8 and 8/9 extending to XI and XII respectively when full. Male funnels (Fig. 60 H-d) wide, ciliated on posterior face of septum 7/8. Vasa deferentia short and wide, slightly bent on themselves covered with prostate gland cells and opening into atria dorsally. Atrial ampullae (Fig. 60 H-a) ovoid and glandular with short, thick, ejaculatory ducts opening ventro-laterally by atrial pore (Fig. 60 H-k) in VIII. Spermathecal ampullae (Fig. 60 H-s) long, ovoid with short ducts opening ventro-laterally in VII. Ventral setae of VI replaced by a pair of spermathecal setae (Fig. 60 G, H-y) 1 per bundle, not enclosed in genital glands, 80 μm long with 2 long teeth converging distally. Genital glands (Fig. 60 H-g) one larger in VI and one smaller in VIII present. Paratomy occurs; one budding zone common, two zones rare; second budding zone always develops in anterior individual 3-4 segments in front of first. Prostomium, proboscis and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off before separation. As in *Stylaria fossularis,* worms develop sex organs while going through asexual reproduction repeatedly producing budding zones until sexual maturity.

Habits : Worms live among filamentous algae, sponges *Spongilla crassissima, S. carteri* and Polyzoans *Plumatella fruticosa, P. emarginata*, etc., in fresh water. Swimming absent. Move by forward and backward creeping. movements. During creeping movement, it holds its proboscis upwards. When met with a *Chaetogaster*, nematode, copepod or a mite, it jerks backwards, but not so when accosts with other species of *Pristina* (Marcus, 1943).

Commensals : Protozoans belonging to *Spirochona* sp. and Vorticellids were found attached to setae and body-wall of head and in smaller numbers to other parts of body.

Parasites : Sporocysts of an actinomyxid protozoan parasite, *Triachinomyxan* sp. (Naidu, 1959b) were found infecting gut wall of this worm from Cuddapah in Andhra Pradesh. Sporocysts of microsporid sporozoan, *Mrazekia caudata* Leger & Hesse (Naidu, 1959a) were found in coelom of two worms.

Distribution : India : Veli Lake, Trivandrum, Bheemanagar (Kerala); Udhakamandalam, Thanjavur, Tandikoudi, Ouralpatti (Tamil Nadu); Chittoor, Mamandur, Chandragiri, Tirupati, Kambakkam, Balapalle, Cuddapah, Gudur, Vizianagaram, Hyderabad, Warangal, (Andhra Pradesh); Bangalore, Mysore, Bellary (Karnataka); Vehar Lake, Mumbai, Bandra, Nagpur (Maharastra); Gwalior (Madhya

Pradesh); Agra (Uttar Pradesh); Delhi; Chandigarh; Punjab; Haryana; Srinagar (Jammu & Kashmir); Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Mahakanda near Peradeniya, Peradeniya, Parakrama Samudra near Polannuruwa (Sri Lanka).

World distribution : Cosmopolitan.

Pristina macrochaeta Stephenson, 1936
(Fig. 61)

Pristina macrochaeta Stephenson, 1931b : 299; Sperber, 1960 : 158.

Type locality : Lagoon near Makthlawaiya, Paraguay, South America.

l(p.) = 3.8-7.0 mm; d(p.) = 0.12-0.20 μm; s = 19-25 + undifferentiated region; n = 10-16.

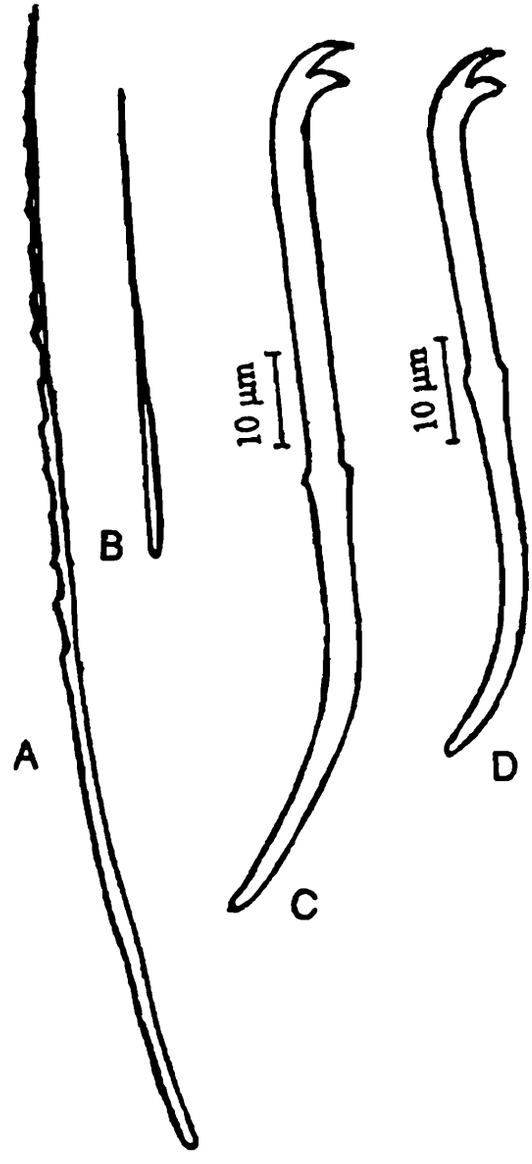

Fig 61 : *Pristina macrochaeta.* A : Hair seta; B : Needle seta; C, D : Ventral setae of II and posterior segment.

Description : Worms of medium size. Prostomium with a long median cylindrical proboscis, 600-800 μm long. Dorsal setae from III or IV, with 1-4 hair and 1-4 needle setae per bundle. Hair setae (Fig. 61 A) 476-630 μm long, 3-4 μm thick, nearly straight, with serrations 12 μm apart on convex border. Needle setae (Fig. 61 B) simple pointed 45-60 μm long, without nodulus. Ventral setae (Fig. 61 C, D) from II, 5-10 per bundle, all of same type, with teeth about equal in thickness and distal longer than proximal; in II longer than rest, 108-112 μm long, in III 87-105 μm long, in IV 70-84 μm long, in V 70-80 μm long, in VI 70-75 μm long and in VII and following segments about 70 μm long. Nodulus proximal in setae of II and III (D : P :: 7 : 5) and distal in setae of other segments.

Pharynx in II-III, wide. Oesophagus in IV-VI, narrow and straight. Stomach in VII and VIII, pear-shaped, its epithelial cells having intra-cellular canals openings into lumen of stomach. Intestine from IX wide, sacculated. Septal glands in III-V or IV-VI. Chloragocytes from IV or V Coelomocytes present. Dorsal vessel mid-dorsal throughout its length. Lateral commissural vessels short in VI-VII.

In a worm in early stage of sexuality testes in VII and ovaries in VIII are noticed. Asexual reproduction by the formation of budding zone, one at a time. Prostomium with proboscis and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off by budding zone before separation.

Habits : Live in fresh water, Proboscis is held upwards while creeping.

Distribution : Afghanistan : Dalkhab.

World distribution : Afghanistan (Asia); Paraguay, Brazil, Peru (South America).

Pristina proboscidea Beddard, 1896
(Fig. 62)

Pristina proboscidea Beddard, 1896 : 4.

Pristina proboscidea f. *typica* Michaelsen, 1909a : 133.

Pristina proboscidea var. *paraguayensis,* Michaelsen, 1909a : 134.

Pristina proboscidea f. *typica*, Michaelsen, 1910 : 8.

Pristina proboscidea var. *paraguayensis,* Michaelsen, 1910 : 8.

Pristina proboscidea f. *typica,* Stephenson, 1911 : 211; 1923 : 73; Aiyer, 1929a : 26.

Pristina proboscidea, Weerakonn & Samarasinghe, 1958 : 160; Mendis & Fernando, 1962 : 145; Naidu, 1966 : 219; Ali & Issaque, 1975 : 59; Ali & Rashid-u-Zaman, 1975 : 91; Naidu & Srivastava, 1980 : 269; Naidu & Naidu, 1981a : 535; Sobhana & Nair, 1983a : 104; Nair et al., 1984 : 477; Mukhopadhyay, 1998 : 111.

Type locality : Chile, South America.

l = 3-5 mm; d = 0.2-0.25 mm; s = 30-46 + undifferentiated region; n = 16-24.

Description : Worms small, slender, delicate and pale white. Prostomium bluntly triangular with a median proboscis varying in length from as long as to nearly 3 times length of prostomium. Dorsal setae from II, with 1-4 hair and 1-4 needle setae per bundle. Hair setae (Fig. 62 A) 175-520 μm long, none specially elongated, with serrations 6.5-7.7 μm apart on convex border. Needle setae (Fig. 62 B) simple pointed, straight and fine, without nodulus, 50-54 μm long. Ventral setae (Fig. 62 C, D) 4-6 per bundle in anterior segments, 7-9 per bundle in posterior segments, all setae of one type, in II 78-108 μm long, 3 μm thick, in III-XII 68-81 μm long, 2 μm thick; in rest 58-80 μm long; 1.5-2.0 μm thick, with distal tooth longer and thinner than proximal, and in II longer and thinner than in rest.

Pharynx in II-IV, wide. Oesophagus in V-VII, narrow. Stomach in VIII, pyriform with intra-cellular canals in its wall. Intestine narrow in IX, wide and sacculated from X. Chloragocytes from VI, cover gut and dorsal vessel. Septal glands 3 pairs in III-V. Coelomocytes numerous, spherical, 10 μm in diameter. Dorsal vessel contractile

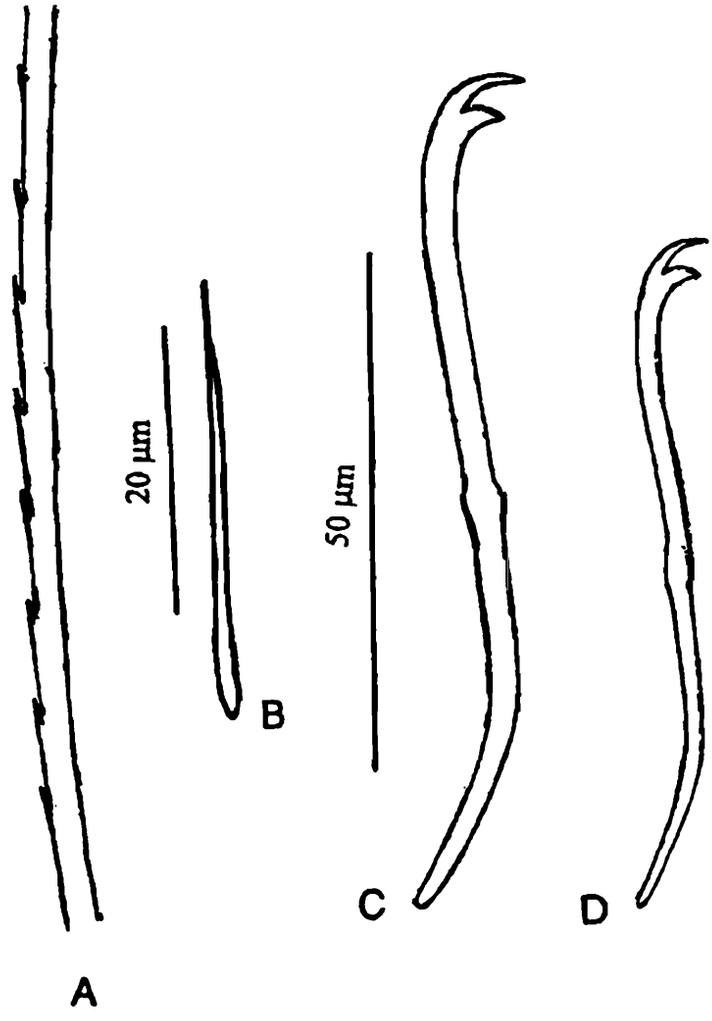

Fig 62 : *Pristina proboscidea.* A : Part of hair seta; B : Needle seta; C, D : Ventral setae of II and IV. (A, C, D from Ercolini, 1970).

and mid-dorsal. Non-contractile lateral vessels 4 pairs in II-V and contractile lateral vessels 2 pairs in VI-VII, those of VII stout. First nephridium in IX, one each in succeeding segments, with preseptal nephrostome in anterior segment.

Sex organs not known. Paratomy occurs, one budding zone common, occasionally upto 3 budding zones formed, first zone behind XVI, second zone one segment in front of first and third zone behind XXIX. Prostomium with proboscis and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off, before separation.

Habits : Worms live in sponges *Spongilla carteri*, *S. crassissima* and in Polyzoan colonies of *Plumatella emarginata* and *P. fruticose* in fresh water. Swimming absent. Move by forward and backward by creeping.

Distribution : India : Veli Lake, Trivandrum, Kadinamkulam (Kerala); Horsley Hills, Hyderabad, (Andhra Pradesh); Vehar Lake, Powai Lake, Mumbai, Nagpur (Maharastra); Delhi; Bishnupur, Kolkata (West Bengal). Dhaka (Bangladesh); Lahore (Pakistan); Meegoda near Colombo, Peradeniya, Ratmalana (Sri Lanka).

World distribution : South-East Asia; Zanzibar, Egypt, Somalia (Africa); Russia, Rumania, Spain (Europe); Ohio (North America); South America; Queensland (Australia).

Pristina sperberae Naidu, 1963
(Fig. 63)

Pristina sperberae Naidu, 1963b : 219; 1966 : 219; Mukhopadhyay, 1998 : 111.

Type locality : Cuddapah, Andhra Pradesh, India.

l = 1.5-2.0 mm; d = 0.12 mm; s = 20 + undifferentiated region; n = 14-15.

Description : Worms minute, slender, pale white. Prostomium with proboscis, latter slightly longer than former and does not break. Both prostomium and proboscis bear fine cilia. Dorsal setae from II, each bundle with 1 hair and 1 needle seta. Hair setae smooth, nearly straight, 98-190 μm long, in III not specially elongated, but slightly longer than those of II and slightly shorter than those of IV. Needle setae (Fig. 63 A) bifid, 28-35 μm long, with weak distal nodulus (D : P :: 1 : 4), shaft gently curved above nodulus ending in fine diverging teeth, distal slightly thicker than proximal. Ventral setae (Fig. 63 B, C) 7-8 per bundle in anterior 7 or 8 segments, gradually decreasing to 4 posteriorly; in II 44-46 μm long with proximal nodulus (D : P :: 8 : 5); in III shortest 35-37 μm long with median nodulus (D : P :: 5 : 5.5); in others 39-46 μm long with distal nodulus (D : P :: 5 : 7). Teeth about equal in thickness, distal longer than proximal in anterior 7 segments, and in rest, distal thinner and slightly longer than proximal.

Pharynx in II-III, wide. Oesophagus in V-VII, narrow. Stomach in VIII, pear-

shaped, with intra-cellular canals, on its wall. Intestine narrow, sinuous upto X, wide and sacculated from XI. Chloragocytes start in VI, geenish gray. Coelomocytes spherical, morula-like with gray granules. Septa well developed, with septal glands on septa 4/5, 5/6 and 6/7. Brain incised deeply behind and less deeply in front. Blood yellowish. Dorsal vessel mid-dorsal on gut, contractile, covered partially with chloragocytes. Lateral commissural vessels in II-VII. Ventral vessel mid-ventral and non-contractile. First pair of nephridia (Fig. 63 D) in IX, one in each of succeeding segments. Each nephridium with pre-septal funnel with ciliated nephrostome (Fig. 63 D-ns) and post-septal fusiform ampulla (Fig. 63 D-na) followed by a long, coiled, ciliated duct (Fig. 63 D-nd) partly passing through gland tissue (Fig. 63 D-gl) and partly free, ending in a nephropore (Fig. 63 D-np) opening ventro-laterally.

Sex organs not known. Asexual reproduction by paratomy, only one budding zone developing at a time, producing 7 head segments with prostomium and proboscis for posterior zooid and several segments for anterior zooid.

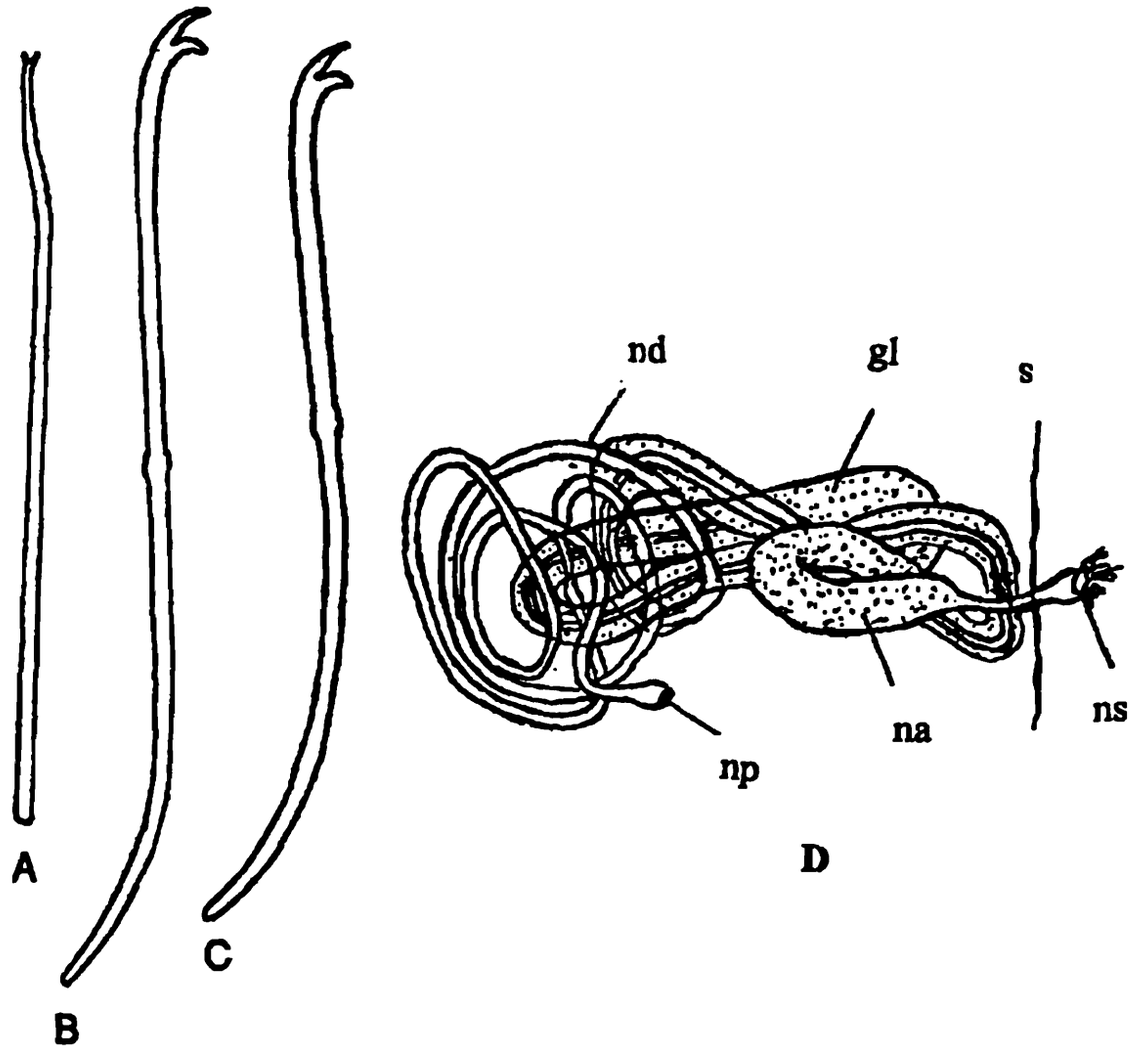

Fig 63 : *Pristina sperberae.* A : Needle seta; B, C : Ventral setae of II and VIII; D : Nephridium; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

Habits : Worms live in fresh-water among water plants and filamentous algae. Swimming absent. Move by creeping forwards and backwards.

Remarks : Naidu (1963b) described a new species, *Pristina sperberae* on the basis of having smooth hair setae, smaller sized needle setae, with minute and unequal needle teeth distinct from others. But Brinkhurst & Jamieson (1971) did not recognize this species and placed it in *P. foreli* stating that it is very difficult to resolve fine serrations of hair setae with most optical equipment. *P. sperberae* however differs in following characters from *P. foreli*.

	P. sperberae	***P. foreli***
D. Bs.	with 1 hair + 1 needle	1-4 hairs + 1-4 needles
Hairs :	smooth	finely serrated
Needle teeth :	teeth fine diverging, distal slightly thicker than proximal	unequal, proximal thinner and longer than distal
Ventrals in II	44-46 μm	47-72 μm
Ventrals of III :	shortest, 35-37 μm.	shortest, 47-54 μm

In view of the above differences between these closely related species *P. sperberae* is revalidated as a distinct species here.

Distribution : Cuddapah (Andhra Pradesh); Bardhaman, Kolkata (West Bengal).

Pristina synclites Stephenson, 1925
(Fig. 64)

Pristina synclites Stephenson, 1925b : 45; Naidu, 1963b : 208; 1966 : 219; Naidu & Naidu, 1981a : 535.

Type locality : Bangalore, Karnataka, India.

l(p.) = 5-7 mm; d(p.) = 0.25-0.35 mm in anterior half diminishing to 0.14-0.17 mm towards posterior end; s = 42-63 + undifferentiated region; n = 18-23.

Description : Worms largest among *Pristina*, pale red in life, with posterior half of body, slender and highly vascularised, decreasing gradually in diameter to a blunt hind end. Prostomium triangular with a slender, delicate proboscis with stiff short cilia, frequently breaking off partly or wholly. Proboscis shorter than prostomium. Dorsal setae from II, 1-2 hair and 1-2 needle setae per bundle. Hair setae of III not specially elongated. Hairs slightly bayonet-shaped, non-serrate, 175-350 μm long. Needle setae (Fig. 64 A) bifid, bayonet-shaped, 70-104 μm long, with weak distal nodulus (D : P :: 1 : 2), teeth separated by an acute angle, 7-8 μm long, proximal tooth longer and thinner than distal. Ventral stae (Fig. 64 B, C) 4 per bundle decreasing to 3 in middle segments and to 2 posteriorly, 63-84 μm long, length increasing from 63-84 μm from II-VI, decreasing to 77 μm in VII and VIII and further decreasing to

74 μm in IX onwards; distal tooth longer, thinner than proximal. Nodulus median (D : P :: 1 : 1) in II-III and distal from IV onwards (D : P :: 5 : 6 or 3 : 4).

Pharynx in II-IV, wide. Oesophagus in ½IV-½VII narrow and straight. Stomach in ½VII-VIII, gradual and fusiform without intra-cellular canals. Intestine narrow and wavy in IX-XI, and wide and sacculated from XII, opening by anus in a notch at hind end. Chloragocytes cover gut and dorsal vessel from VI. Septal glands in IV-V Coelomocytes spherical, gray, granular, largest measuring 17.5 μm in diameter. Brain incised deeply in front and less deeply behind. Blood orange red. Dorsal vessel contractile, laterally attached to left of gut upto XII, unattached in IX-VIII, again attached in VII-VI, mid-dorsal in anterior 5 segments. Contractile lateral vessels 4 pairs, first 2 pairs in middle of IV and V, non-contractile lateral vessels in II-III. Dorsal vessel thicker in slender hinder part of body and gives off several non-contractile vessels to body-wall, one pair per segment to form a vascular plexus. No such vascular plexus occurs in anterior half of body. First nephridium (Fig. 64 D) in IX with its short pre-septal funnel with nephrostome (Fig. 64 D-ns) in VIII, post-septal part with a long cylindrical granular ampulla (Fig. 64 D-na) followed by a long coiled duct (Fig. 64 D-nd), partly passing through gland tissue (Fig. 64 D-gl) before opening by a nephropore (Fig. 64 D-np) ventro-laterally.

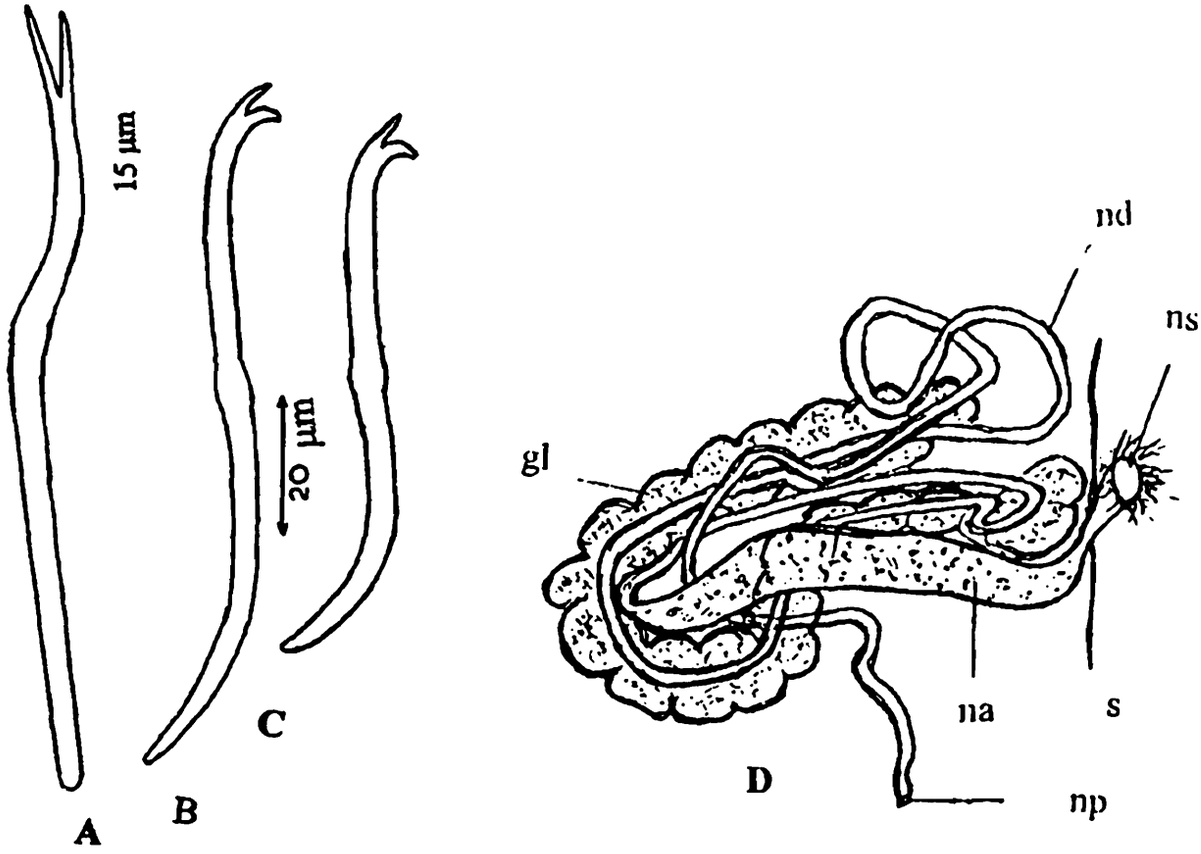

Fig 64 : *Pristina synclites.* A : Needle seta; B, C : Ventral setae of II and posterior segments; D : Nephridium; gl : glandular part; na : nephridial ampulla; nd : nephridial duct; np : nephropore; ns : nephrostome; s : septum.

Sex organs not known. Asexual reproduction by paratomy, single budding zone common, 2 zones rare. Budding zone buds off proboscis, prostomium and 7 anterior segments to posterior individual and several posterior segments to anterior individual before separation. After production of hind part of anterior individual, budding of anterior part to posterior individual takes place.

Habits : Worms live in fresh-water freely in soft mud along with *Dero dorsalis*, *Aulophorus michaelseni* and *Limnodrilus hoffmeisteri* and also as commensal in Polyzoa. Worms coil into flat spirals when disturbed. Swimming absent but move by creeping.

Distribution : India : Chittoor, Tirupati, Horsley Hills, Cuddapah, Hyderabad, Vijayawada, Vizianagaram (Andhra Pradesh), Mysore, Bangalore, Bellary (Karnataka); Powai Lake, Mumbai (Maharastra).

World distribution : South Asia; Africa; Virginia, Texas (North America); Argentina (South America).

Genus ***Pristinella*** Brinkhurst, 1985

Naidium O. Sch. Vejdovsky, 1884a : 25; Stephenson, 1923 : 66.

Pristinella Brinkhurst, 1985 : 472.

Diagnosis : Prostomium without proboscis. Dorsal setae from II, hair setae present, ventral setae progressively differ from anterior to posterior bundles. Septal glands in some segment from III-VI. Stomach in VI, VII or VIII, with intra-cellular canals. Testes and spermathecae in VII, ovaries and atria in VIII. Genital setae absent, or present in VIII in one species. Spermathecae absent. Prostate glands absent. Male pores median in one species. Cosmopolitan.

Type species : *Pristinella bilobata* (Bretscher, 1903).

Species included are : *Pristinella acuminata* (Liang, 1958); *P. jenkinae* (Stephenson, 1931); *P. menoni* (Aiyer, 1930); *P. minuta* (Stephenson, 1914); *P. amphibiotica* (Lastockin, 1927); *P. bilobata* (Bretscher, 1903); *P. idrensis* (Sperber, 1948); *P longidentata* (Harman, 1965); *P. longisoma* (Harman, 1997); *P. notopora* (Cernosvitov, 1937); *P. osborni* (Walton, 1906); *P. rosea* (Piguet, 1906); *P. sima* (Marcus, 1943); *P. arcaliae* (Pop, 1977). Of these first four species occur in the Indian subcontinent.

Key to Indian species of *Pristinella*

1. Needle setae almost simple-pointed, distal tooth very fine.....*Pristinella menoni.*

   Needle setae bifid 2

2. Needle teeth diverge with wide angle; ..... *Pristinella minuta*

   Needle teeth diverge at acute angle; 3

3. Distal tooth of needle setae shorter than proximal .....*Pristinella jenkinie*

   Distal tooth of needle setae longer than proximal ..... *Pristinella acuminata*

Pristinella acuminata (Liang, 1958)
(Fig. 65)

Pristina acuminata Liang, 1958 : 42.

Pristinella acuminata, Brinkhurst, 1985 : 396; Battish & Sharma, 1997 : 82.

Type locality : Nanking, China.

l(p): 3.3-5 mm; d(p) : 0.2 mm; s: 20-53.

Description : Worms small creamy white. Prostomium triangular with pointed apex but without proboscis. Dorsal setae (Fig. 65 C) begin in II, each with 1-5 bayonet shaped, finely serrate, 79-144 μm long hair setae and 5 bifid, 43-62 μm needles setae, with teeth narrowly diverging, distal tooth longer and thinner than proximal. Ventral setae (Fig. 65 A, B) with 3-6 bifid, 49-70 μm long setae, distal tooth thinner and longer than proximal.

	China	N. America	Peru
Hairs	79-144 μm	99-127 μm	?-154 μm
Needles	43-62 μm	35-50 μm	36-43 μm
Ventrals	49-70 μm	32-53 μm	57-60 μm

Septa distinct; septal glands present in III and IV. Coelomocytes present. Stomach in VII-VIII, not distinctly dilated, with intra-cellular canals. Dorsal blood vessel on left side with winding commissural vessels in II-VII. Nephridia paired, begin in IX, single or absent posteriorly.

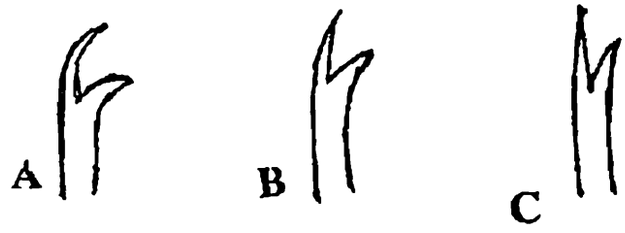

Fig 65 : *Pristinella acuminata.* A, B : Ventral seta; C : Needle seta (from Brinkhurst & Jamieson, 1971).

Sex organs unknown. Asexual reproduction by paratomy.

Distribution : India : Suraj Kund, Kurishetra (Haryana).

World distribution : Asia; North America; Peru (South America).

Pristinella jenkinae (Stephenson, 1931)
(Fig. 66)

Naidium jenkinae Stephenson, 1931a : 39.

Pristina jenkinae, Sperber, 1948 : 224; 1958 : 51; Naidu, 1963b : 210; 1966 : 218.

Type locality : Lake Naivasha, Kenya, Africa.

l(p.) = 2.5-3.0 mm; d(p.) = 0.2 mm; s = 22-26 + undifferentiated region; n = 15-20.

Description : Worms small with chalk-white colour. Prostomium bluntly triangular without proboscis. Dorsal setae begin in II, each bundle with 1-2 hair and 1-2 needle setae. Hair setae smooth, straight, 108-284 μm long, in II nearly half, in III three-fourth as long as in following segments. Needle setae (Fig. 66 A) bifid, bayonet-shaped with distal nodulus, 38-72 μm long, 2 μm thick, teeth faintly diverging, large, unequal and blunt, distal tooth 3.8 μm long, proximal tooth 7.8 μm long, proximal twice as thick as distal, nodulus distal (D : P :: 6 : 7). Ventral setae (Fig. 66 B) all of one type, 4-5 decreasing to 2-3 per bundle posteriorly, with about median nodulus (D : P : : 6 : 7) in anterior segments and slightly distal (D : P :: 6 : 8) in rest; shortest in II-III 44-46 μm long, 2 μm thick, abruptly increasing to 53 μm in IV and decreasing in middle segments, with distal tooth longer and thinner than proximal in anterior segments, becoming shorter in later segments.

Pharynx in II-IV, wide; oesophagus in V-VI, narrow and sinuous; stomach in VII-VIII, gradual and fusiform; intestine narrow in IX, wide from X, opening in a notch

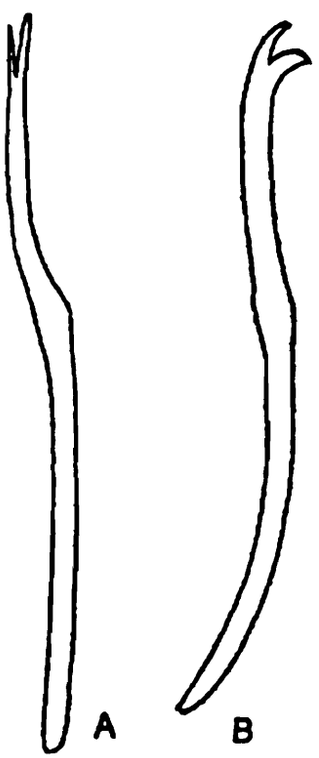

Fig 66 : *Pristinella jenkinae*. A : Needle seta; B : Ventral seta of anterior segment.

at hind end dorsally. Septa delicate and complete. Coelomocytes spherical, granular, largest 12 μm in diameter. Chloragocytes cover gut from VI, brownish. Blood pale red. Dorsal vessel mid-dorsal and contractile. Six pairs of lateral vascular loops, 2 pairs non-contractile in II-III, 4 pairs contractile in IV-VII. First nephridium in IX with its pre-septal nephrostome in VIII and post-septal coiled duct opening by nephropore ventro-laterally.

Sexual worms not known. Asexual reproduction by paratomy, by development of budding zone occurs; budding zone buds off 7 anterior segments and prostomium to posterior zooid and an unspecified number of segments to anterior zooid.

Habits : Worms live in fresh-water, swimming absent, but move by creeping forwards and backwards.

Distribution : India : Tirupati, Visakhapatnam, Hyderabad (Andhra Pradesh); Bellary (Karnataka).

World distribution : Asia; Africa; Europe; North America; Costa Rica (Central America); South America; New Zealand.

Pristinella menoni (Aiyer, 1929)
(Fig. 67)

Naidium menoni Aiyer, 1929a : 21.

Pristina menoni, Sperber, 1958 : 50; Naidu, 1966 : 218, 223.

Type locality : Cherayinkil, Trivandrum, Kerala, India.

l(p.) = 1.0-3.2 mm; d(p.) = 0.1-0.2 mm; s = 16-30 + undifferentiated region; n = 13-28.

Description : Worms small, slender, delicate, whitish and semi-transparent. Prostomium bluntly triangular slightly longer than broad without proboscis and marginal cilia. Dorsal setae from II, 1-2 hair and 1-2 needle setae per bundle. Hair setae almost straight not serrate, 192-225 μm long 1.3 μm thick. Needle setae (Fig. 67 A, B) stout, 39-79 μm long, 1.7 μm thick generally simple-pointed occasionally with a rudimentary minute distal tooth, when bifid proximal tooth much thicker and much longer than minute distal tooth, with nodulus a third from distal end (D : P :: 13 : 27), part above nodulus strongly curved. Ventral setae (Fig. 67 C, D) in II-VII 4-5 per bundle, and from VIII backwards 2-3 per bundle, 1.4 μm thick in all segments; in II 39-50 μm long with median nodulus (D : P :: 1 : 1), in III 45-54 μm long with slightly distal nodulus (D : P :: 4 : 5), from IV onwards 46-61 μm long with distal nodulus (D : P :: 2 : 3); in anterior segments distal tooth thinner and longer than proximal, in posterior segments teeth equally thick, distal tooth longer than proximal.

Pharynx in II-III, wide with a dorsal diverticulum in III. Oesophagus in IV-VI, narrow and straight. Stomach in VII-VIII widening gradually, with intra-cellular canals in its wall. Intestine from IX, wider than stomach. Chloragocytes begin in V

and cover gut and dorsal vessel. Septal glands 3 pairs in III-V. Coelomocytes numerous spherical 7-8 μm in diameter. Brain widely incised both in front and behind. Dorsal vessel on gut a little to left of median line on its whole length, connected with mid-ventral vessel by unbranched paired lateral vessels in III-VII and branched pair of lateral vessels in II. Lateral vessels of V-VII contractile and those of VI and VII shorter and more contractile, while those of II-IV non-contractile. Dorsal vessel runs forward below brain, emerges at its anterior end and divides into right and left branches, which pass ventrally, run backwards and unite in median line at level of setae of V to form ventral vessel, unattached to gut and situated above ventral nerve cord. First nephridium unpaired in IX on right side, with its funnel attached to anterior face of septum 8/9 at low level opening to exterior immediately in front of right ventral setal bundle, but before opening it dilated to form a small end bladder.

Sexual organs unknown. Asexual reproduction by paratomy. Single budding zone develops at a time. Prostomium and 7 anterior segments to posterior individual and several posterior segments to anterior individual budded off before separation.

Habits : Worms live in fresh water among aquatic vegetation. Swimming absent. Move by forward and backward creeping.

Distribution : India : Trivandrum, Chirayinkil (Kerala) : Yercaud (Tamil Nadu); Ujjain (Madhya Pradesh).

World distribution : Asia; Africa; Europe; North and Central America; Argentina, Venezuela (South America); New South Wales (Australia);

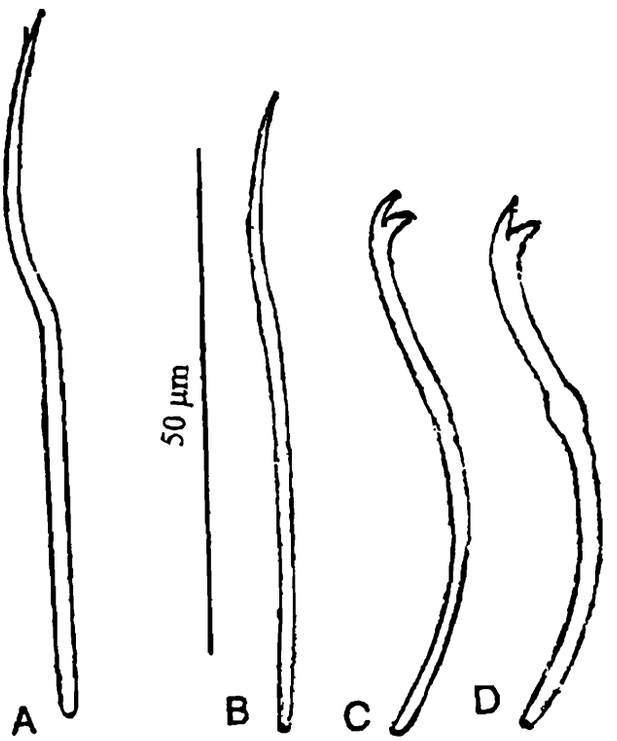

Fig 67 : *Pristinella menoni.* A, B : Bifid and single pointed needle setae; C, D : Ventral setae of anterior and posterior segments. (A from Aiyer, 1929a, B from Ercolini, 1970).

Pristinella minuta (Stephenson, 1914)
(Fig. 68)

Naidium minutum Stephenson, 1914b : 327; 1915b : 786; 1923 : 68; Weerakonn & Samarasinghe, 1958 : 156.

Pristina minuta, Sperber, 1948 : 222; Naidu, 1963b : 206; 1966 : 218; Costa, 1967 : 48.

Type locality : Ravi River, Lahore, Pakistan.

l = 1.5-1.85 mm; d = 0.10-0.13 mm; s = 15-16 + undifferentiated region; n = 12.

Description : Worms minute, slender, delicate and pale white. Prostomium bluntly triangular, longer than broad without proboscis. Anterior 7 segments shorter than succeeding segments in all adult worms. Dorsal setae begin in II, 1 hair and 1 needle seta per bundle. Hair setae 80-145 μm long nearly straight, and non-serrate. Needle setae (Fig. 68 A) 30-50 μm long, more than 1 μm thick, bifid, teeth short, equally long and thick, separated by a wide angle, with distal nodulus (D : P :: 3 : 7). Ventral setae (Fig. 68 B, C) 3-5 per bundle, decreasing to 2 posteriorly, in II 32 μm long, shortest, finer than in rest, with distal tooth longer and thinner than proximal and with proximal nodulus (D : P :: 5 : 4). In succeeding segments 35-40 μm long, 1.25 μm thick, with distal tooth thinner and longer than proximal gradually decreasing in length to became equally long in posterior segments, and with median or slightly distal nodulus (D : P :: 1 : 1, 5.5 : 5.0).

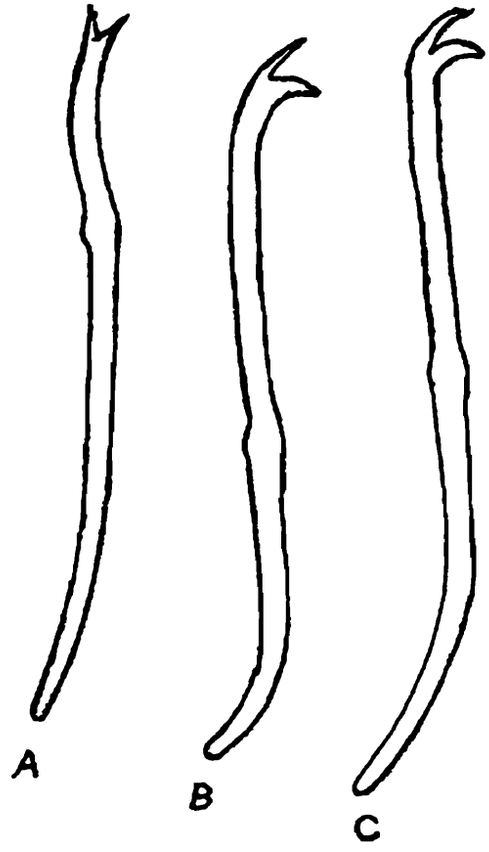

Fig 68 : *Pristinella minuta.* A : Needle seta; B, C : Ventral setae of II and middle segments.

Pharynx in II-IV, wide. Oesophagus in V-VII, narrow. Stomach in VIII, suddenly dilating, pear-shaped with intra-cellular canals in its wall. Intestine narrow and flexed on itself in IX, and wide from X. Anus in a notch bounded by a lobe on each side. Chloragocytes from V cover gut and dorsal vessel, yellowish brown in life. Coelomocytes numerous with a nucleus and aggregation of minute oil-droplet like granules, circular, 6-14 μm in diameter. Septal glands 3 pairs on septa 4/5, 5/6 and 6/7. Brain slightly bifid behind and with a concave border in front. Blood pale red. Dorsal vessel contractile and mid-dorsal. First nephridium in IX, with its funnel shaped nephrostome in VIII. Subsequent two segments have a nephridium each.

Sex organs unknown. Asexual reproduction by paratomy, only one budding zone developing at a time. Prostomium and anterior 7 segments to posterior individual and several posterior segments to anterior individual budded off before separation.

Habits : Worms live in fresh-water. Swimming absent, move by creeping forward and backward.

Commensals : Protozoan epistylid ciliate, *Rhabdostyla pristinis* Righi, 1973 is epizoic in this species in Brazil (Righi, 1973).

Distribution : India : Cuddapah (Andhra Pradesh). Lahore (Pakistan); Peradeniya, Meegoda near Colombo (Sri Lanka).

World distribution : Asia; Africa; Iberian Peninsula (Europe); North America; Costa Rica (Central America); Argentina; Brazil (South America); New South Wales (Australia).

Family TUBIFICIDAE Beddard, 1895

Tubificidae Beddard, 1895 : 226; Stephenson, 1923 : 95; 1930: 740; Chekanovskaya, 1962 : 219; Brinkhurst & Cook, 1966 : 13; Brinkhurst & Jamieson, 1971 : 444; Mukhopadhyay, 1998 : 112.

Diagnosis : Prostomium without proboscis. Eyes absent. Dorsal setae from II, hair setae present or absent; otherwise bifid setae or with any number of intermediate teeth forming obscurely to completely pectinate setae or rarely palmate setae, even simple-pointed setae but these mostly in posterior bundles. Ventral setae in indefinite number per bundle, beginning in II, bifid or rarely simple-pointed. Clitellum in a few segments in region of gonads. Testes and ovaries a pair each, in X and XI, spermathecae paired in X, or single or absent, spermatophores or free sperm masses in spermathecae. Male funnels in testes segment, atrium and male pores in succeeding segment together with female funnels. Female pores in furrow behind segment bearing male pores. All reproductive organs may be shifted from one to several segments forward. Sperm-sac and ovi-sac usually present, unpaired. Spermathecal or penial setae or both modified or absent in mature specimens. Asexual reproduction by fragmentation. Cosmopolitan.

Type genus : *Tubifex* Lamarck, 1816.

This family is subdivided into 8 sub-families : 1. Tubificinae Eisen, 1879; 2. Rhyacodrilinae Hrabe, 1963; 3. Telmatodrilinae Eisen, 1879; 4. Branchiurinae; 5. Aulodrilinae Brinkhurst & Jamieson, 1971; 6. Phallodrilinae Brinkhurst & Jamieson, 1971; 7. Clitellinae Brinkhurst & Jamieson, 1971; 8. Limnodriloidinae Brinkhurst, Of the eight subfamilies, first five occur in the Indian sub-continent.

Key to Indian subfamilies of Family TUBIFICIDAE

1. Gills present ..... BRANCHIRUINAE
– Gills absent 2
2. Coelomocytes abundant ..... RHYACODRILINAE
– Coelomocytes sparse or absent 2
3. Atria with solid prostate attached by narrow stalk, spermatophores in spermathecae ..... TUBIFICINAE.
– Atria with prostates not as above, spermatophores absent 3
4. Atrial wall penetrated by prostate glands at several points ..... TELMATODRILINAE
– Prostates attached to atria by broad bases ..... AULODRILINAE

Subfamily TUBIFICINAE Eisen, 1879

Tubificinae Eisen, 1897 : 7; Chekanovskaya, 1962 : 219; Hrabe, 1966 : 70; Brinkhurst & Jamieson, 1971 : 445; Chekanovskaya, 1980 : 24.

Diagnosis : Prostate solid, stalked and attached to atria when present. Sperm and spermatophores within spermathecae. Coelomocytes absent, rarely present.

Type genus : *Tubifex* Lamarck, 1816.

Subfamily Tubificinae has 16 genera : 1. *Tubifex* Lamarck, 1816, 2. *Limnodrilus* Claparède, 1862, 3. *Isochaeta* Pointner, 1911, 4. *Peloscolex* Leidy, 1851, 5. *Potamothrix* Vejdovsky & Mrazek, 1902, 6. *Psammoryctides* Hrabe, 1964, 7. *Ilyodrilus* Eisen, 1879, 8. *Antipodrilus* Brinkhurst, 1971, 9. *Isochaetoides* Hrabe, 1966, 10. *Adelodriloides* Cook, 1971, 11. *Tubificidarum* Karman, 1973, 12. *Quistadrilus* Brinkhurst, 1981, 13. *Baikalodrilus* Holmquist, 1978, 14. *Haber* Holmquist, 1978, 15. *Varichaetadrilus* Brinkhurst & Kathman, 1983, 16. *Arctidrilus* Brinkhurst & Kathman, 1983. Of these *Tubifex* and *Limnodrilus* occur in Indian subcontinent.

Key to Indian genera of subfamily TUBIFICINAE

1. Thick-walled, cylindrical, cuticular penis sheath usually much longer than broad, covered by spiral muscles ..... ***Limnodrilus***

2. Penis sheath tub or thimble shaped, occasionally cylindrical but not thick-walled, not covered with spiral muscles ..... ***Tubifex***

Genus *Tubifex* Lamarck, 1816

Tubifex Lamarck, 1816 : 225; Beddard, 1895 : 242; Stephenson, 1923 : 105; 1930 : 745; Chekanovskaya, 1962 : 271; Brinkhurst, 1963 : 19; 1966 : 450; Chekanovskaya, 1980 : 16; Persia, 1980 : 99; Mukhopadhyay, 1998 : 115.

Diagnosis : Dorsal setal bundles with bifid setae and atleast in anterior part of body, of hair setae and pectinate setae. Ventral setae all bifid. Form of dorsal and ventral setae differ. Large coelomocytes absent. Male efferent ducts with vasa deferentia at least as long as pear-shaped or cylindrical atria often turned over apically, otherwise standing vertically in IX. Ejaculatory ducts not distinct. Prostate glands large, closely connected to atria sub-apically on anterior face. Penes present, with tub-shaped or conical to elongate chitinous penis sheaths. Spermathecae present, rarely absent. Spermatophores present when spermathecae are absent. Genital setae absent. Cosmopolitan.

Type species : *Tubifex tubifex* (Müller, 1774).

Tubifex tubifex (Müller, 1774)
(Fig. 69)

Lumbricus tubifex Müller, 1774 : 227 (in part).

Tubifex (*Tubifex*) *tubifex*, Stephenson, 1921 : 753; 1923 : 106; Naidu, 1965a : 464; 1966 : 219.

Tubifex tubifex, Naidu, 1966 : 219; Naidu & Naidu, 1979b : 416; 1981b : 117; Sobhana & Nair, 1983b : 201; Nair, Dharmaraj, Aziz, Arunachalam & Krishnakumar, 1984 : 477; Gupta & Pant, 1986 : 117; Tiwari, Saxena & Kulashrestha, 1988 : 67; Julka, Senapati & Paliwal, 1989 : 86; Cross-Bell, 1990: 221; Khatoon & Ali, 1993 : 533; Mukhopadhyay, 1998 : 115.

Type locality : Unassigned Germany.

l(p.) = 20-30 mm; d(p.) = 0.9 mm; s = upto 135 + undifferentiated region.

Description : Worms (Fig. 69 A) large, cylindrical, reddish brown in anterior third and bright orange red in posterior half of body. Posterior half of worm gradually tapering to a blunt point. Prostomium bluntly conical. Dorsal bundles from II with hair and bifid needle setae in anterior 60-70 segments, needles only in rest, except last 6-10 segments, achaetous, in front of undifferentiated region. Hair setae (Fig. 69 B) 1-4 or 6 per bundle, bayonet-shaped, with short feather-like barbs on either side,

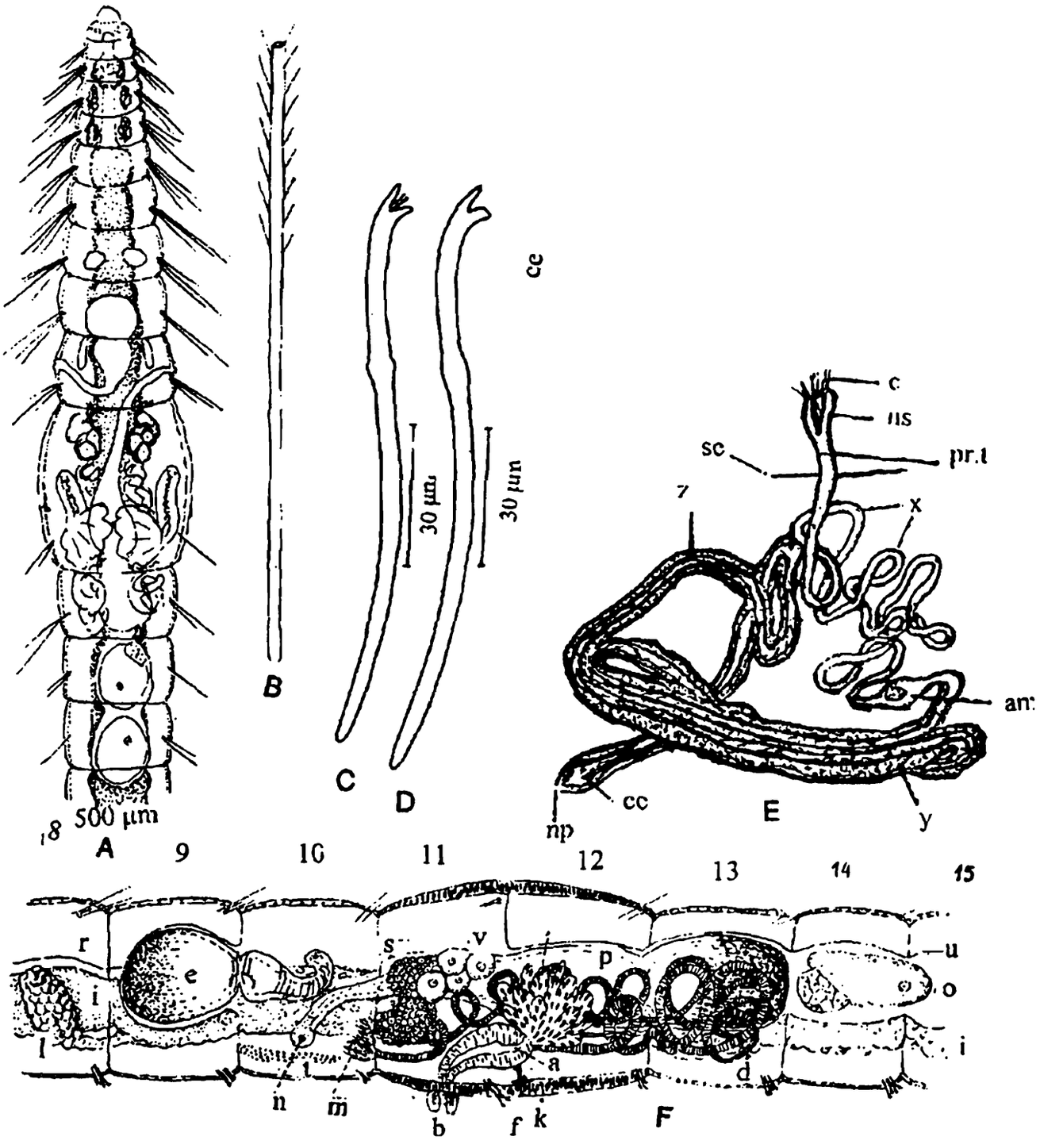

Fig 69 : *Tubifex tubifex.* A : Anterior part of worm; B : Basal part of hair seta; C : Pectinate dorsal seta; D : Bifid ventral seta; E : Nephridium; F : Genital organs. (A, B, F from Marcus, 1942; E from Dixon, 1915). am : ampulla; b : male pore; c : cilia of nephrostome; cc ; contratile part of nephridial duct; d : vas deferens; e : spermatheca; f : female funnel; i : intestine; k : clitellum; l : lateral contratile vessel; m : male funnel; n : spermathecal pore; np : nephropore; ns : nephrostome; o : ovum; p : prostate; pr.t : preseptal part of nephridial duct; sc : septum; u : ovi-sac; v : ovary; x : thin-walled coiled part of nephridial duct; y : wider part of nephridial duct; z : thick-walled part of nephridial duct leading to exterior; 7-14 : segments VII-XIV.

115-125 μm long. Needle setae (Fig. 69 C) 3-5 per bundle, 80-140 μm long, with distal nodulus (D : P :: 3 : 7), distal tooth thinner and longer than proximal, simply bifid in II and in hind segments, and in rest with pectinate outgrowth in between teeth, 1-2 outgrowths in III, 2-3 in IV-V and 4 from VI onwards. Pre-clitellar segments have 3-4 hair and 4-5 needle setae, and others have less. Ventral setae (Fig. 69 D) 2-10 anteriorly decreasing to 2 per bundle posteriorly, 87-140 μm long, with distal nodulus (D : P :: 13 : 27), distal tooth slightly thinner and longer or equal to proximal, becoming shorter in posterior segments.

Pharynx in II-III, wide. Oesophagus in IV-V, narrow. Stomach absent. Intestine begins in VI, narrow upto IX and wide from X. Chloragocytes start in VI, dark brown and cover intestine and dorsal vessel. Coelomocytes pale brown, spherical and variously shaped. Septal sacs mid-ventral in anterior segments. Blood reddish. Dorsal vessel lateral to left of gut from hind end to VII and mid-dorsal in anterior segments. Lateral contractile vessels, 3 pairs in VIII-X, first pair large and connect supra-intestinal and ventral vessels. Body-wall of anterior 5-6 segments and posterior two-thirds highly vascularised with plexuses. Brain squarish in I-II. Nephridia paired in VII and VIII and unpaired from XIII placed laterally. Each nephridium (Fig. 69 E) consists of pre-septal (Fig. 69 F-pr.t) funnel with nephrostome (Fig. 69 E-ns) in one segment and post-septal consisting of thin-walled coiled nephrodial duct (Fig. 69 F-x) with ampulla (Fig. 69 E-am), wider part (Fig. 69 E-y) ending in contractile tube (Fig. 69 E-cc) before opening by nephropore (Fig. 69 E-np) in next segment.

Clitellum (Fig. 69 F-k) opaque white, barrel-shaped in ½X-XII (2½ segments). Before development of clitellum in early sexuality, one pair of whitish testes and one pair of whitish ovaries (Fig. 69 F-v) attached to posterior face of septa 9/10 and 10/11 respectively, situated ventro-laterally. Sperm-sacs (Fig. 69 F-s) a pair, anterior and posterior diverticula of X, anterior sac small extends to IX and posterior sac large extends to XIII. Ovi-sac (Fig. 69 F-u) single back-pouching of septum 11/12, extends to XVI when full. Male funnels (Fig. 69 F-m) a pair on anterior face of septum 10/11 laterally, followed by a long, coiled and thick-walled efferent duct (Fig. 69 F-d), which open into pear-shaped atria (Fig. 69 F-a). A large prostate gland (Fig. 68 F-p) opens into atrium by a short duct very close to vas deferens. Terminal part of atrium modified into a muscular short penis supported by a chitinous sheath into which it retracts in contraction. Male pores (Fig. 69 F-b) ventro-lateral in XI. Ventral setae of XI and penial setae absent. Female funnels and ducts not observed. Spermathecae (Fig. 69 F-e) a pair of long and club-shaped with ampullae 2-3 times as broad as its ectal part, opening laterally half way between dorsal and ventral bundles of setae of X.

Habits : Anterior half of body buried in mud waving posterior half of body in water, withdrawing it completely into mud when disturbed. Waving action vigorous when worms are crowded. Worms cleared from mud form tangled masses in water, when disturbed or on pouring water on them or stirred with a rod, they separate and each coils into a close spiral. This species and *Limnodrilus hoffmeisteri* are used as food for fish in aquaria.

Parasites : Protozoan cnidosporidian *Raabeia garlicensis* Janiszewski, 1952, from body cavity, *Hexactinomyxon helvegi* Janiszewski, 1952 from gut, and *Echinoactinomyxon radiatum* Janiszewski, 1952 from gut of this species are reported from Poland. (Janiszewski, 1952); *Triactinomyxon ignotum* Stolc, 1899, *T legeri* Mackinnon & Adams, 1924, *T dubium* Granata, 1925 and *T mrazeki* Mackinnon & Adams, 1924 parasitic in gut are reported from this species. (Stolc, 1888, Lom & Dykova, 1992, Granata, 1925).

Distribution : India : Kadinamkulam near Trivandrum (Kerala); Udhakamandalam, Coonoor, Kanyakumari district (Tamil Nadu); Bangalore (Karnataka); Bhopal, Ujjain (Madhya Pradesh); Delhi; Chandigarh; Naini Tal (Uttaranchal); Batote, Srinagar, Pahalgam (Jammu & Kashmir); Ranchi (Bihar); Kaliachawk (West Bengal).

World distribution : Cosmopolitan.

Genus ***Limnodrilus*** Claparède, 1862

Limnodrilus Claparède, 1862 : 248; Beddard, 1895 : 248; Stephenson, 1923 : 96; 1930 : 747; Chekanovskaya, 1962 : 246; Brinkhurst, 1963 : 33; Brinkhurst & Cook, 1966 : 14; Kennedy, 1965 : 26; Chekanovskaya, 1980 : 21; Mukhopadhyay, 1998 : 114.

Diagnosis : Dorsal and ventral setae bifid, both identical in shape; hair setae, single-pointed and pectinate setae absent. Coelomocytes absent. Lateral hearts in segments VIII and IX; perietal vascular plexus in posterior part of body. Testes and ovaries, a pair each in X and XI respectively. Male efferent ducts with long vasa deferentia, small bean-shaped atria with large prostates, ejaculatory ducts long, penes elongate with thick cylindrical chitinous sheaths with spiral muscles around penis sheath. Spermathecae paired in testis segment containing spermatozoa. Cosmopolitan.

Type species : *Limnodrilus hoffmeisteri* Claparéde, 1862

Key to Indian species of *Limnodrilus*

1. Penial sheaths short 2
– Penial sheaths cylindrical, long 3
2. Penial sheath broad, spatulate ..... *Limnodrilus silvani*
– Penial sheath upto 4 times as long as broad when fully developed with plate like hood ..... *Limnodrilus udekemianus*
3. Penial sheath upto 43 times as long as broad, with small pear shaped hood, its shaft entering hood centrally ..... *Limnodrilus claparedianus.*
– Penial sheath upto 8 times as long as wide, with plate-like hood at right angles to shaft ..... *Limnodrilus hoffmeisteri*

Limnodrilus claparedianus Ratzel, 1868
(Fig. 70)

Limnodrilus claparedianus Ratzel, 1868 : 590; Khatoon & Ali, 1993 : 533; Battish & Sharma, 1997 : 94.

Type locality : Unassigned, Germany.

l : 30-60 mm; d : 1.0 mm; s : 50-120.

Description : Worms large. Prostomium bluntly conical. Dorsal and ventral setae (Fig. 70 A-D) bifid 6-9 per bundle anteriorly, decreasing to 3-4 in middle segments and 1-2 in hind segments. Setae similar to those of *Limnodrilus hoffmeisteri*, those of anterior bundles often with distal tooth much longer than proximal, in rest with distal tooth thinner slightly longer than proximal.

Pharynx in II-III, wide. Oesophagus narrow in IV-VII. Stomach absent. Intestine from VIII, sacculated. Septal glands two pairs on 6/7 and 7/8. Chloragocytes from VI. Blood red. Dorsal vessel contractile, to left of gut from hind end to VII and mid-dorsal anteriorly, branch into two, descend down to form non-contractile ventral vessel. Lateral contractile vessels in VIII and IX Paired nephridia from VII laterally in each segment and single in posterior segments.

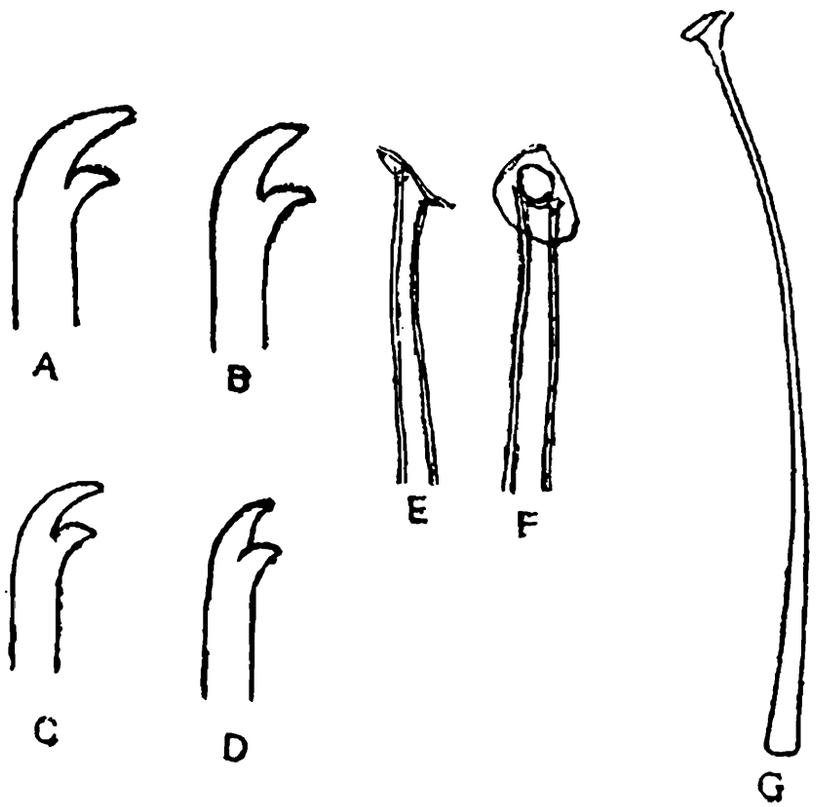

Fig 70 : *Limnodrilus claparedianus.* A, B : Setae of anterior bundle, C, D : Setae of middle bundles; E, F : Distal end of penial sheath lateral and front view, G. Chitinous penial sheath. (E, F, from Brinkhurst & Cook, 1966; G from Chekanoskaya, 1962).

Clitellum in XI-XII. Testes and ovaries paired attached to posterior face of 9/10 and 10/11 respectively. Sperm-sacs paired, anterior sac extends forwards into IX and posterior sac extends backwards through several segments. Male funnels, a pair on anterior face of 10/11, continue into long vasa deferentia opening into small, spindle-shaped atria, with large prostates. Ejaculatory ducts leading to very long penis enclosed in very long, straight, thin walled, chitinour sheath (Fig. 70 E-G) upto 43 times as long as wide at base, their distal ends expand abruptly to form pear-shaped hood, with thin end drawn out to a point. Hood set at right angles to shaft when viewed latarally. Penial setae absent. Spermathecae a pair in X, club-shaped and ampulla tapering ectally and opening by transverse apertures in front of ventral bundles X.

Distribution : Kurukshetra (Haryana); Punjab; Pakistan.

World distribution : Cosmopolitan.

Limnodrilus hoffmeisteri Claparède, 1862
(Fig. 71)

Limnodrilus hoffmeisteri Claparède, 1862 : 248.

Limnodrilus socialis Stephenson, 1912a : 237; 1912b : 294; 1913a : 740; 1913b : 260.

Limnodrilus sp. Stephenson, 1916 : 307.

Limnodrilus socialis, 1923 : 96; 1925b : 48; 1926b : 250; Mendis & Fernando, 1962 : 45.

Linmodrilus hoffmeisteri, Naidu, 1965a : 477; 1966 : 220; Costa, 1967 : 49; Vasisht & Gandhi, 1972: 100; Gates, 1972 : 316; Ali & Issaque, 1975 : 59; Ali & Rashid-u-Zaman, 1976 : 91; Sharma, Handa & Sahi, 1976 : 102; Naidu & Naidu, 1979b : 417; Naidu & Srivastava, 1980 : 269; Naidu & Naidu, 1981a : 536; 1981b : 116; Sobhana & Nair, 1984 : 302; Gupta & Pant, 1986 : 117; Julka, Senapati & Paliwal, 1989 : 86; Khatoon & Ali, 1993 : 533; Battish & Sharma, 1997 : 84; Mukhopadhyay, 1998 : 114.

Type locality : Unassigned, Switzerland.

l(p.) = 20-50 mm; d(p.) = 1.0-1.5 mm; s = 90-150 + undifferentiated region.

Description : Worms large, cylindrical with anterior half reddish and posterior half yellowish in life. Prostomium bluntly conical. Dorsal and ventral setae start in II, all of similar type, composed of 6-7 per bundle anteriorly, 3-5 in middle, and 1-2 in hind segments, bifid (Fig. 71 A, B) 60-80 μm long with distal nodulus (D : P :: 9 : 16, 3 : 5) with distal tooth thinner and equal in length to proximal. Dorsal setae slightly shorter and thinner than ventral setae.

Pharynx in II-IV, wide. Oesophagus in V-VII, narrow. Stomach absent. Intestine begins in VIII wide, and sacculated, anterior part covered with orange red cells. Septal glands 2 pairs on posterior face of septa 7/8 and 8/9 on either side. Chloragogues

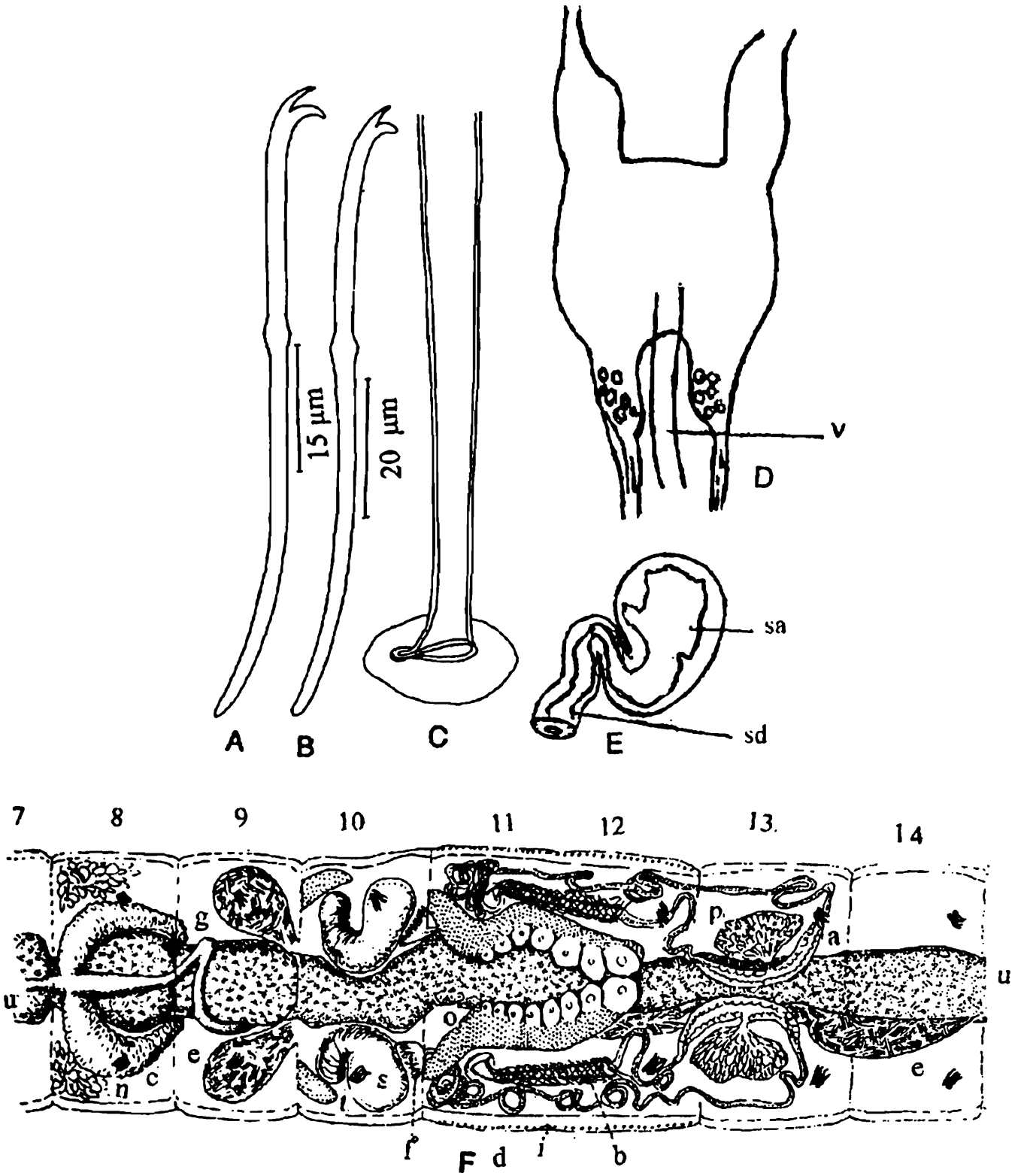

Fig 71 : *Limnodrilus hoffmeisteri.* A : Ventral seta; B : Dorsal seta; C : Chitinous penial sheath; D : Brain; E : Spermatheca; F : Genital organs. (D from Stephenson, 1912b; E from Chekanovskaya, 1962, F from Marcus, 1942). a : atrium; b : chitinous penial sheath; c : contractile vessel; d : vas deferens; e : sperm sac; f : male funnel; g : dorsal vessel; i : clitellum; n : nephridium; o : ovary; p : prostate; s : spermatheca; sa : spermathecal ampulla; sd : spermathecal duct; t : testis; u : intestine; v : dorsal vessel; 7-14 : segments VII-XIV.

from VI, pear-shaped. Paired aggregations of tall chromophil cells attached to anterior septa of VII and VIII. Anti-peristalsis occurs, but ascending ciliary action of gut absent. Blood red. Dorsal vessel (Fig. 71 F-g) to the left of gut from hind end to VII, and mid-dorsal in II-VI, divides into 3 branches, and unite below pharynx to form ventral vessel in IV Lateral contractile vessels (Fig. 71 F-c) 2 pairs in VIII and IX, both arising from supra-intestinal vessel, anterior pair stout, long, inclined backwards; second pair slender and coiled, both pairs opening into ventral vessel, one behind other. Vascular plexuses present in anterior 6 segments and in posterior half of worm. Brain (Fig. 71 D) situated dorsal to mouth in I, almost squarish in shape and hollowed out broadly in front and narrowly behind. Paired nephridia in VII-IX or X, placed on gut. Each nephridium consists of a preseptal funnel with ciliated nephrostome in one segment and post-septal composed of an ampulla, a long coiled, ciliated duct partly passing through glandular mass and ending in a small vesicle before opening by a nephropore in front of ventral setae in succeeding segment.

Clitellum (Fig. 71 F-i) in XI-XII (2 segments), opaque white. In early sexuality a pair of yellowish, ovoid testes (Fig. 71 F-t) and a pair of whitish cylindrical or pear-shaped ovaries (Fig. 71 F-o) attached ventro-laterally to posterior faces of septa 9/10 and 10/11 respectively. In sexually mature worm gonads disappear. Sperm-sacs (Fig. 71 F-e) a pair, anterior sac a forward diverticulum of septum 9/10 extending to IX and posterior sac a backward pouching of septum 10/11 extending to XII partly occupying ovi-sac, latter back-pouching of septum 11/12 extending to XVI or XVII when full with ova. Male funnels (Fig. 71 F-f) a pair in X placed laterally on anterior face of septum 10/11, each funnel continues into long coiled vas deferens (Fig. 71 F-d), which opens into an atrium in XI. Atrial ampulla (Fig. 71 F-a) pear or spindle-shaped, prostate (Fig. 71 F-p) connected to one side, distal end narrows and continues into long coiled ejaculatory duct containing a true penis supported by a chitiuous sheath (Fig. 71 C, F-b), eight times as long as its width at distal end, enclosed in a penial chamber formed by invagination of ventral body wall and opening by evagination of body wall by a large transverse male aperture in position of ventral setae of XI. Ventral setae of XI lost, and penial setae absent. Female funnels wide, opening into coelomic cavity, continuing into ducts which open in inter-segmental groove XI/XII ventro-laterally. Spermathecae (Fig. 71 E, F-s) a pair in X, flatly club-shaped, folded on themselves with an ampulla tapering ectally and opening by large transverse apertures in front of ventral bundles of X.

Habits : Worms bury anterior ½-2/3 of their body in soft mud and wave free portion of body rhythmically in water. These movements are vigorous when crowded and less vigorous when not crowded. They were found living along with *Branchiura sowerbyi*, *Aulodrilus pigueti, Branchiodrilus semperi* and *Dero digitata.*

Parasites : Protozoan cnidosporidians *Aurantiactinomyxon raabei* Janiszewski, 1952, from gut, *Raabeia magna* Janiszewski, 1952 in body cavity, *Maupausella cylindri*

Katashima, 1952 in gut from Japan (Katashima, 1952), and *Ochridanus kozorovi* Puytorac,1959 from gut in Yugoslavia Puytorac (1959).

Predators : This species is preyed upon by chironomid (Diptera) larvae belonging to *Polypedelum* sp., *Chironomus attenuatus*, *Cryptochironomus* sp., and *Ablabesmyia* sp. (Loden, 1974).

Remarks : Most commonly met with tubificid in polluted water sources all over the Indian subcontinent, in great abundance forming tangled masses of several pounds in weight, waving their hind part of body and on interference contract and disappear into mud with extraordinary swiftness, and there may be no sign of life, where a moment ago there was a large animated mass. Stephenson found in Lahore a large proportion of worms without their anterior segments among sexually mature in December and February and opined that disposition of large ova causes so much damage to anterior segments that these are thrown off, as oviducts are too small to enable ova to escape. These worms without their anterior segments live for sometime and whole generation perishes every year. These worms and *Tubifex tubifex* are sold in India and Japan as food for goldfish and other fishes in aquaria and thus these two species are a few oligochaetes that are commercially important.

Chromosomes : 2n = 24 (Sharma, Handa & Sahi, 1976).

Distribution : India : Calicut, Palghat, Malapuza Dam area, Trivandrum (Kerala); Chennai, Coimbatore, Udhakamandalam, Coonoor (Tamil Nadu); Chittoor, Tirupati, Horsley Hills, Kambakkam, Cuddapah, Adoni, Visakhapatnam, Warangal, Hyderabad (Andhra Pradesh); Bangalore, Mysore, Bellary (Karnataka); Mumbai, Nagpur (Maharastra); Bhopal, Ujjain (Madhya Pradesh); Naini Tal, (Uttaranchal); Delhi; Chandigarh; Pinjore, Kapurthala, Ludhiana (Punjab); Haryana; Pahalgam, Sonasar Lake (Jammu & Kashmir); Ranchi (Bihar); Katwa, Dinhata, Mathabhanga, Alipurduar, Domjur, Kaliachawk, Midnapur, Paraz, Bagmundi, Sahib Bandh, Purulia, Belgatchia, Kolkata, South and North 24 Paraganas districts (West Bengal); Gauhati (Assam). Lahore (Pakistan); Dhaka (Bangladesh); Rangoon, Indawagyi Lake (Burma); Kandy, Peradeniya, Parakrama Samudra near Polannaruwa (Sri Lanka).

World distribution : Cosmopolitan.

Limnodrilus silvani Eisen, 1879
(Fig. 72)

Limnodrilus silvani Eisen, 1879 : 19.

Limnodrilus sp. Stephenson, 1929 : 227.

Limnodrilus grandisetosus Nomura, 1932 : 511; Naidu, 1966 : 219.

Type locality : Unknown.

l(p) = 20-30 mm; d(p) = 0.4-0.6 mm; s = 80-120 + undifferentiated region.

Description : Worms large, reddish brown in life, filiform, remarkaby slender, hinder part extremely thin and thread-like. Prostomium bluntly conical. Segments I-V biannulate, posterior annulus larger. Dorsal and ventral setae (Fig. 72 A, B) begin in II, both of same type, bifid, weakly sigmoid, with distal nodulus (D : P :: 1 : 2), 3-4 per bundle anteriorly, gradually decreasing to 1 in posterior segments, with distal tooth, longer and thicker than proximal Ventral setae of IV-X disproportionately larger than corresponding dorsal setae; in VII largest ventral seta about 1½ times as long and 3 times as thick as longest dorsal seta.

Pharynx II-III, wide Pharyngeal gland cells attached to wall of horse-shoe-shaped dorsal inlet of pharynx separately or forming masses. Oesophagusin IV-V, narrow. Stomach absent. Intestine begins in VI, wide and sacculated from VIII. Chloragocytes

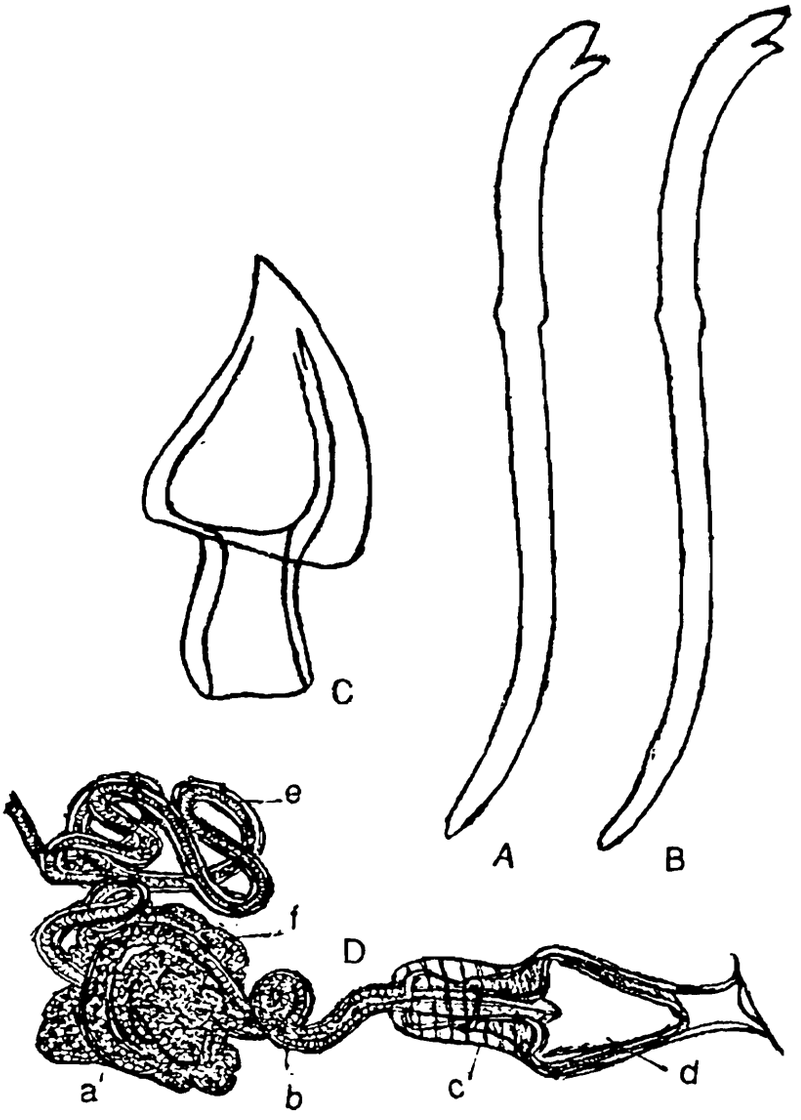

Fig 72 : *Limnodrilus silvani.* A, B : Setae; C : Chitinous penial sheath; D : Male efferent duct (A, B, D from Brinkhurst & Jamieson, 1971; C from Stephenson, 1929). a : atrium; b : ejaculatory duct; c : chitinous penial sheath; d : penis; e : vas deferens; f : prostate gland.

from VI, cover gut and dorsal blood vessel. Septal sacs 2 pairs attached to posterior face of septa 6/7 and 7/8 on ventral surface of intestine in sexually mature worms. Coelomocytes absent. Blood red. Dorsal vessel mid-dorsal in I-VI and lateral to left of gut from VII. In segments, I-VI and IX-X with complicated parietal vascular loops. Brain squarish, slightly concave in front and behind, with a median nerve ending in prostomium. Nephridia begin in VII or VIII, one in each segment on left of body.

Clitellum in XI-XII (2 segments), ring-shaped. In early sexual maturity, when clitellum not yet formed, a pair of testes in X and a pair of ovaries in XI, attached ventro-laterally on posterior face of 9/10 and 10/11 respectively. Sperm-sacs two, anterior sac small, anterior diverticulum of 9/10 extending to IX and posterior sac large, posterior diverticulum of 10/11 extending to XIII, when filled with spermatozoa. Male funnels a pair in X placed laterally on anterior face of 10/11. Vasa deferentia (Fig. 72 D-e) long and coiled, entering atrium (Fig. 72 D-a) apically in XI. Atrial ampulla small, 275 μm long, and 64 μm wide, broader part connected to a prostate gland (Fig. 72 D-f) measuring 230 μm long and 180 μm wide, and narrow part continues into a long, coiled ejaculatory duct (Fig. 72 D-b) containing as true penis covered by short and broad chitinous sheath (Fig. 72 C, D-c) terminal part expanded into spade-shape with its margin reflected either upward or downward. Spiral muscles cover chitinous sheath. Ovi-sac single back-pouching of 11/12 extending to XIV, when filled with ova. Spermathecae a pair in X, their ducts twice or more than twice as long as ampulla. Sperm bundles 2-5 in each spermatheca. Spermathecal pores on X, male pores on XI. Penial setae absent.

Habits : Worms found along with *Branchiura sowerbyi* on three occasions.

Predators : This species is preyed upon by bird *Nycticorax nycticorax nycticorax* in Sundarbans, West Bengal (Mukherjee, 1971).

Distribution : Tibet : Monga-'tsa, Tirthapuri; Dhaka (Bangladesh); Burakan in Lorai district of Baluchistan (Pakistan); Indawgyi Lake (Upper Burma).

World distribution : Asia; Russia (Europe); California in U. S. A. (North America); Argentina, Peru, Paraguay (South America).

Limnodrilus udekemianus Claparéde, 1862
(Fig. 73)

Limnodrilus udekemianus Claparéde, 1862 : 243.

Tubifex sp. Stephenson, 1909a : 105.

Limnodrilus udekemianus, Cernosvitov, 1942a : 214; 1942b : 285; Naidu, 1966 : 220; Ali & Rashid-u-Zaman, 1976 : 91; Khatoon & Ali, 1993 : 533; Sinha, Sinha, Khan & Pandey, 1995 : 404.

Type locality : Unassigned, Switzerland.

l(p): 20-30 mm; d(p): 0.4-0.6 mm; s = 80-120 + undifferentiated region.

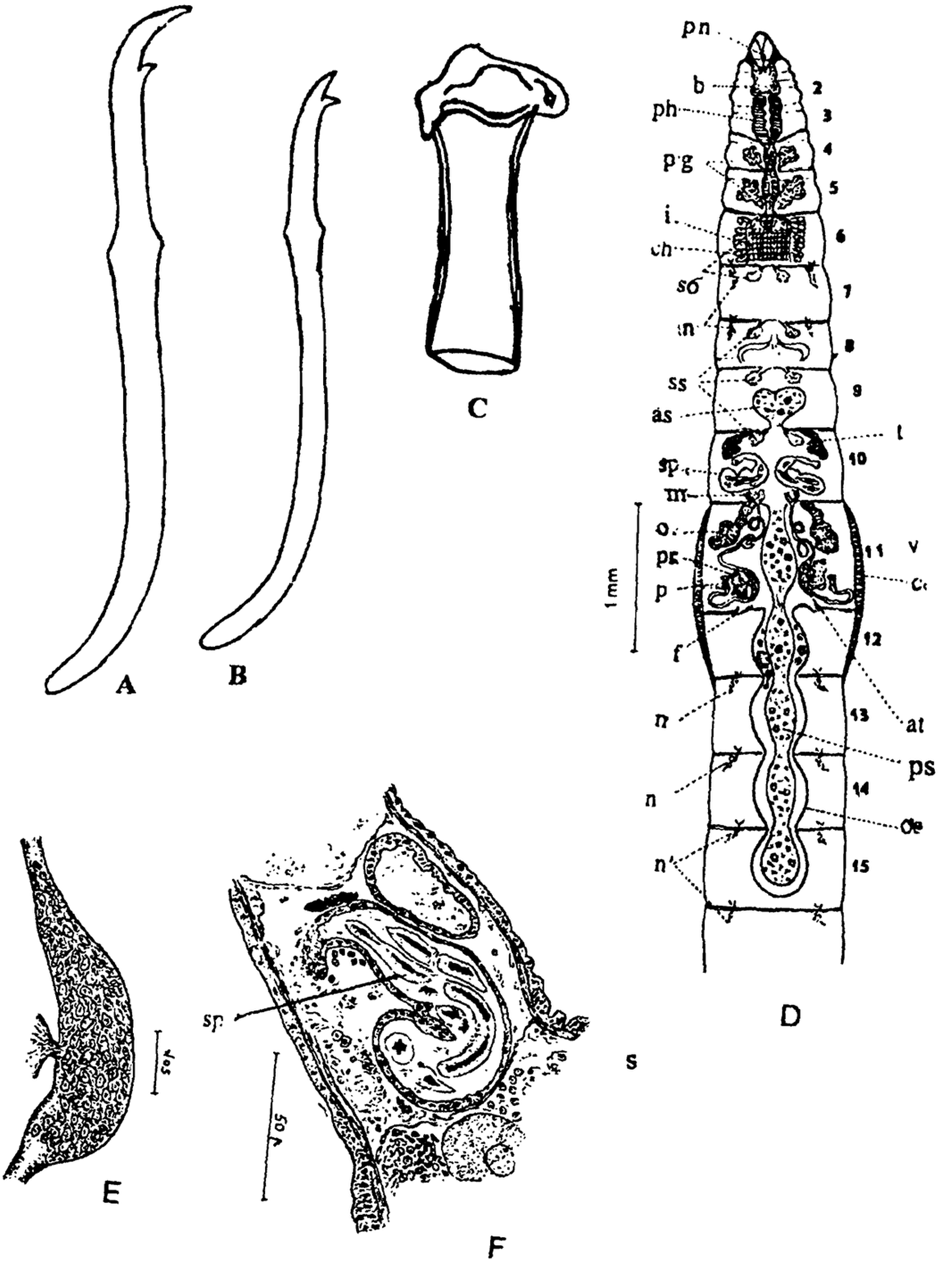

Fig 73 : *Limnodrilus udekemianus.* A, B : Ventral setae of III and LX; C : chitinous penial sheath; D : Anterior part of worm showing internal organs; E : Atrium; F : L.S. Segment X with spermatheca; (A, B from Marcus, 1942; D-F from Gavrilov & Paz (1949). as : anterior spermsac; at : atrium; b : brain; c : clitellum; ch : chloragocytes; f : female funnel; i : intestine; m : male funnel; n : nephridium; o : ovary, os : ovi-sac; p : penis; ph : pharynx; pg : pharyngeal glands; pr : prostate; ps : posterior sperm-sac; s : sperm bundle; sp : spermatheca; ss : septal gland; t : testis; v : vas deferens.

Description : Worms large, filiform, pale red in colour in life. Prostomium bluntly conical. Segments II-V biannulate. Dorsal and ventral setae (Fig. 73 A, B) begin in II, bifid setae only, both similar in type, weakly sigmoid with distal nodulus, 3-8 in anterior segments, 3-4 in middle segments, decreasing to 1-2 in posterior segments, per bundle, teeth unequal, distal strongly curved, thicker and much longer than proximal.

Pharynx (Fig. 73 D-ph) in II-III wide. Oeophageal glands (Fig. 73 D- pg) three pairs in IV, V, VI. Oesophagus in IV-V, narrow. Stomach absent. Intestine (Fig. 73 D-i) wide and sacculated from VI. Paired septal glands (Fig. 73 D-ss) three pairs on posterior face of 6/7, 7/8 and 8/9. Chloragocytes (Fig. 73 D-ch) from VI, cover gut and dorsal vessel. Coelomocytes absent. Blood red. Dorsal vessel mid-dorsal in II-VI and lateral to left of gut from VII. Sub-intestinal vessel absent. Supra-intestinal vessel arises from dorsal vessel in VIII. Hearts one pair in VIII and commissural vessels in IX and X. Commisural vessels of IV-VII are part of supra-intestinal vessel and from IX backwards from dorsal vessel. Segments I-VIII and in IX-X with complicated parietal vascular loop. Brain (Fig. 73 D-b) squarish, slightly concave in front and behind, with a median nerve (Fig. 73 D-pn) ending in prostomium. Nephridia (Fig. 73 D-n) paired, placed laterally begin from VII with preseptal nephrostome in VI.

Clitellum (Fig. 73 D-c) in XI-XII (2 sements), ring-shaped. Sperm-sacs a pair, anterior sac (Fig. 73 D-as) extending to XI and posterior sac (Fig. 73 D-ps) extending to XV when filled with spermatozoa. Testes (Fig. 73 D-t) a pair on posterior face of 9/10 laterally. Male funnels (Fig. 73 D-m) a pair in X placed laterally on anterior face of septum 10/11. Vas deferens (Fig. 73 D-v) long, coiled, opening in atrium. Atrial ampulla (Fig. 73 D-at, E) bean-shaped, 275 μm long, 64 μm wide, broader part connected to prostate gland (Fig. 73 D-pr) measuring 230 μm long and 180 μm wide, narrow part continues into a long, coiled ejaculatory duct containing true penis covered with short and broad chitinous sheath (Fig. 73 C), about 3-4 times as long as broad, 200-267 μm long, 70 μm wide at distal end, with terminal part expanded into a trumpet shape with margin reflected either upward or downward. Spiral muscles cover chitinous sheath. Spermathecae (Fig. 73 D-sp, F-sp) a pair in X. Sperm bundles (Fig. 73 E-sb) 2-5 in each spermatheca. Spermathecal apertures on X; male pores on XI. Ovaries (Fig. 73 D-o) a pair on posterior face of 10/11 laterally. Ovi-sac (Fig. 73 D-os) single back pouching of 11/12 extend to XV.

Parasites : Astomatous ciliate (Protozoa) *Triactinomyxon magnum* Granata, 1922, parasitic in gut of this species (Granata, 1922).

Distribution : Tibet : Monga-'tsa, Tirthapuri; Dhaka (Bangladesh); Burkhan in Loralla district of Baluchistan, Punjab (Pakistan).

World distribution : Cosmopolitan.

Subfamily RHYACODRILINAE Hrabe, 1963

Rhyacodrilinae Hrabe, 1963 : 251; 1965 : 57; Chekanovskaya, 1962 : 230; Brinkhurst & Jamieson, 1971 : 537; Chekanovskaya, 1980 : 23.

Diagnosis : Prostate diffuse when present. Coelomocytes present, usually abundant. Spermatophores present or absent.

This subfamily has nine genera : *Rhyacodrilus* Bretscher, 1901, *Monopylephorus* Levinsen, 1884, *Bothrioneurum* Stolc, 1888, *Epirodrilus* Hrabe, 1930, *Jolydrilus* Marcus, 1965, *Peristodrilus* Baker & Brinkhurst, 1981, *Protruberodrilus* Giani & Martinez-Ansemil, 1979, *Rhizodrilus* Smith, 1900 and *Paranadrilus* Gavrilov, 1955, of which first three genera occur in the Indian subcontinent.

Type genus : *Rhyacodrilus* Bretscher, 1901.

Key to Indian genera of subfamily RHYACODRILINAE

1. Prostomium with dorsal ciliated pit; spermathecae and atria present ..... ***Bothrioneurum***

– Prostomium without dorsal ciliated pit; spermathecae and atria absent 3

2. Vasa deferentia short, scarcely distinct from tubular atria with prostate cells ..... ***Monopylephorus***

– Vasa deferentia long, distinct from globular, pear-shaped or cylindrical atria, opening subapically ..... ***Rhyacodrilus***

Genus ***Rhyacodrilus*** Bretscher, 1901

Rhyacodrilus Bretscher, 1901 : 189; Stephenson, 1930 : 747; Chekanovskaya, 1962 : 230; Brinkhurst, 1963 : 54; Brinkhurst & Cook, 1966 : 18; Brinkhurst & Jamieson, 1971 : 544; Chekanovskaya, 1980 : 9.

Diagnosis : Dorsal setal bundles with hair setae, bifid and pectinate needle setae. Ventral bundles with bifid, pectinate, rarely simple-pointed setae, more in anterior bundles and fewer in posterior bundles. Gills absent. Coelomocytes often large, numerous, or absent. Male efferent ducts with moderately long vasa deferentia, joining atria sub-apically. Atria in IX or XI, globular, ovoid, pear-shaped or bilobed, usually covered with diffuse prostate glands, (glands communicating with atrial lumen independently or in small clusters,) terminating in ejaculatory ducts. Spermathecae usually open anteriorly in X, or displaced posteriorly in XI, or absent (replaced by external sperm bearers). Sperm occur as loose masses in spermathecae (rarely organized into bundles) or attached to walls of ampullae. Spermathecal and male pores frequently more or less median. Separate atrial glands absent. Paratrium absent. Pseudopenes present or absent. Male genital pores in IX or XI. Ventral setae of XI

modified into penial setae. Spermathecae paired in VIII or X, with or without divericula, usually communicating with gut in some species or absent. Cosmopolitan.

Type species : *Rhyacodrilus falsiformis* Bretscher, 1901.

Rhyacodrilus stephensoni Cernosvitov, 1942
(Fig. 74)

Limnodrilus sp. Stephenson, 1909a : 112.

Rhyacodrilus stephensoni Cernosvitov, 1942b : 284; Naidu, 1966 : 220.

Type locality : Te-ring Gompa, High Hill Gompa, Tibet, Asia.

l(p.) = 8-20 mm; d(p.) = 0.4 mm; s = 40-64 + undifferentiated region.

Description : Worms of medium size. Prostomium bluntly conical, marked off by a distinct groove; external annulation distinct, double in anterior segments, anterior ring considerably narrower. Dorsal and ventral setae (Fig. 74 A, B, C) of same form, begin in II, very thin, slightly curved with indistinct nodulus at junction of middle and distal third. Hair setae absent in dorsal bundles. Setae bifid, 4-6, occasionally 7 setae per bundle, more numerous in ventral bundles, 80-83 μm long, both teeth about same length or distal slightly longer, proximal more strongly curved in posterior setae than in anterior setae.

Pharynx in III, wide. Oesophagus in IV-IX or X and passes into an enlarged intestine in X or XI, constricted at septa. Chloragocytes begin in V Coelomocytes (Fig. 74 D, H-i) numerous, finely granulated about 17-18.5 μm in diameter. Integumental blood vessels present in middle and posterior parts of body. Nephridia begin in VI with a small pre-septal funnel connected to a round massive post-septal part traversed by a sinuous nephridial duct.

Clitellum in XI-XII (2 segments), sometimes extending to X and XIII, slightly developed ventrally. Testes and ovaries paired in X and XI situated laterally close to septa 9/10 and 10/11. Sperm-sacs paired, anterior sac forward pouching of septum 9/10 extend to IX and posterior sac backward pouching of septum 10/11 extend to XVIII. Ovi-sac single extend to XXV. Ova develop from morulae formed by a number of cells. Male funnels large on anterior face of septum 10/11, directed upwards, passing into short, thick and curved vasa deferentia (Fig. 74 H-v, J-v). Vasa deferentia in preserved worms about 230 μm long and 28-35 μm wide, distal ends narrow considerably to 12-15 μm width, before entering atria near upper end. Atrial ampulla (Fig. 74 H-a, J) ovoid or pear-shaped, about 70-80 μm long, 46-70 μm wide, continuing into narrower and shorter, efferent duct 45-70 μm long and 32 μm wide, formed by columnar epithelium as a continuation of epidermis of body wall, and differs considerably in its structure from ampulla. Ampulla thickly covered with long pear-shaped unicellular prostate glands (Fig. 74 H-p, J-p) which attain 70 μm length. Penis or chitinous penial sheath absent. Spermathecae (Fig. 74 H-s, I, K) a pair in X,

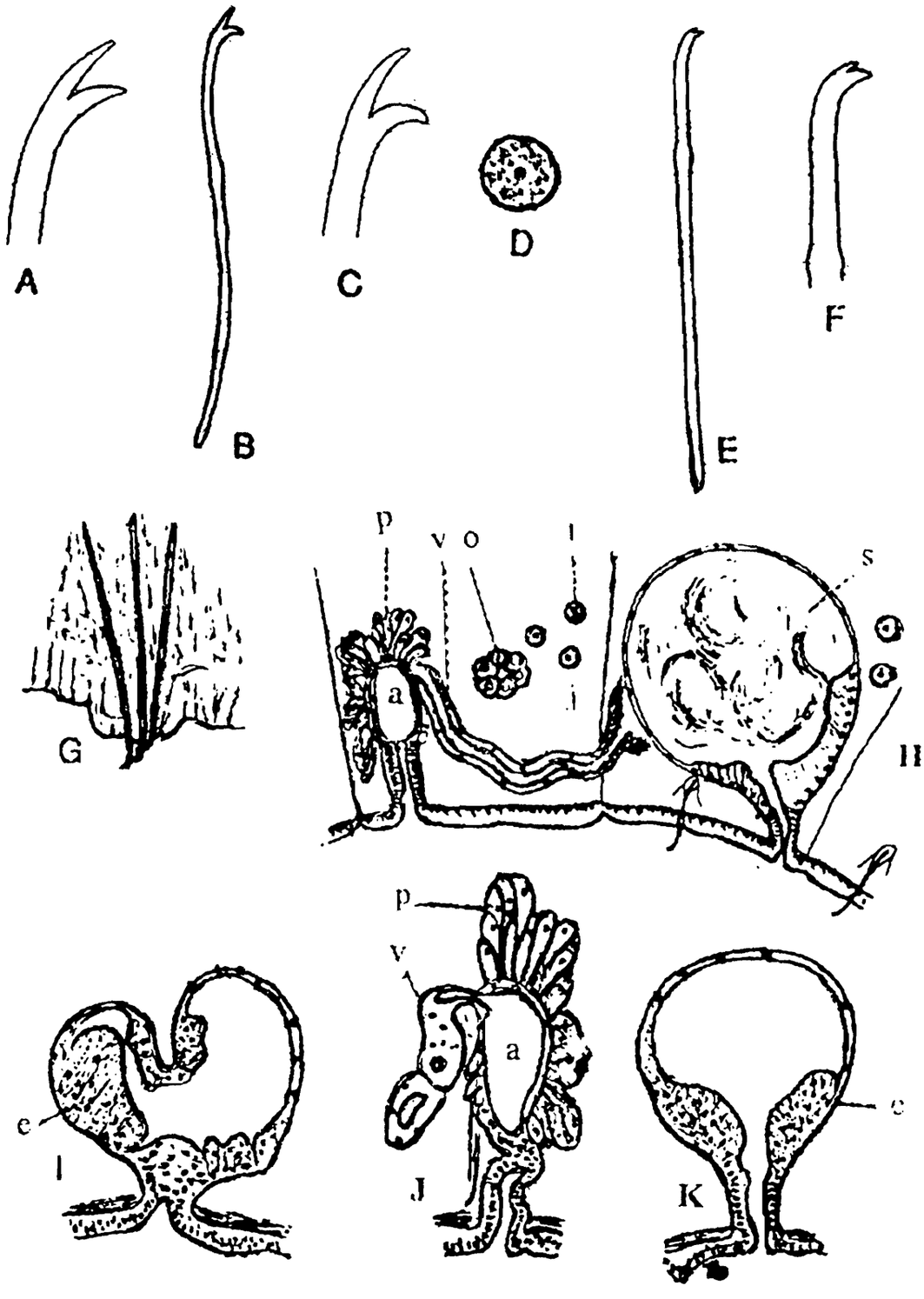

Fig 74 : *Rhyacodrilus stephensoni.* A : Dorsal seta of II; B, C : Ventral setae from posterior segment; D : Coelomocyte; E : Penial seta; F : Distal end of penial seta; G : Bundle of penial setae; H : Genital organs; I : Bilobed spermatheca; J : Atrium; K : Normal spermatheca (all from Cernosvitov, 1942b). a : atrium; e : thickened epithelium; i : coelomocyte; o : ovum; p : prostate gland; s : spermatheca; v : vas deferens.

consisting of a large thin-walled rounded or bilobed ampulla and a very short, narrow duct, which like efferent part of atrium, also formed of columnar epithelium. Duct 45 μm long and narrows considerably towards external opening. Spermathecal pores in line of ventral setae in anterior part of X near septum 9/10. Lining epithelium of ampulla much thickened near external aperture. Spermatozoa loose or aggregated in bundles fill ampulla. Ventral setae of XI modified into penial setae (Fig. 74 E, F, G) 105-140 μm long, nearly straight, with distinct nodulus 1/4 from distal end, and hooked distally, with upper tooth much reduced and considerably shorter and thinner than thick proximal tooth. Paired male pores in line with ventral setae in posterior part of XI near septum 11/12.

Distribution : Tibet : Te-ring Gompa, High Hill Gompa, Gyantse.

World distribution : Tibet (Asia); Lake Baikal in Russis (Europe); South Africa.

Genus ***Monopylephorus*** Levinsen, 1884

Monopylephorus Levinsen, 1884 : 92.

Vermiculus Goodrich, 1892 : 474.

Rhizodrilus Michaelsen, 1903 : 169; Benham, 1903 : 268.

Monopylephorus Stephenson, 1923 : 103.

Littodrilus Chen, 1940 : 96.

Rhizodrilus Hrabe, 1962 : 338.

Monopylephorus, Chekanovskaya, 1962 : 286; Brinkhurst, 1963 : 59; Marcus, 1965 : 75; Brinkhust & Jamieson, 1971 : 555; Chekanovskaya, 1980 : 10; Baker & Brinkhurst, 1981 : 941.

Diagnosis : Dorsal and ventral setae bifid setae only, hair setae when present thin, spirally twisted. Anterior bundles have 2-6 setae and fewer posteriorly. Pectinate setae also found in some species. Lateral contractile vessels in X, often also in some preceeding segments. Coelomocytes large and abundant. Testes and ovaries a pair each in X and XI respectively. Male efferent ducts with male funnels, vasa deferentia leading directly into apical end of narrow tubular prostate covered atrium ending in short ejaculatory ducts, which enter upper end of eversible pseudo-penes. Spermathecae a pair contain sperm in loose manner, or sperm heads may be attached to walls of spermathecal ampullae. Male pores and spermathecal pores frequently included in median inversion of body-wall. Spermathecal and or penial setae sometimes modified. Live in salt and brackish water. Cosmopolitan.

Type species : *Monopylephorus rubroniveus* (Levinsen, 1884).

Key to Indian species of *Monopylephorus*

Spermatheca single on left side, with median ventral pore; single-pointed setae usually restricted to posterior segments ..... *Monopylephorus parvus.*

Spermathecae a pair; bifid anterior setae with distal tooth shorter than proximal ..... *Monopylephorus limosus.*

Monopylephorus limosus (Hatai, 1898)
(Fig. 75)

Vermiculus limosus Hatai, 1898 : 103.

Monopylephorus limosus, Nomura, 1913 : 1; Nair, Dharmaraj, Azeez, Arunachalam & Krishnamurthy, 1984 : 477.

Type locality : Tokyo, Japan.

l(p.) = 50-71 mm; d(p.) = 0.31-0.52 mm; s = 120-150 + undifferentiated region.

Description : Worms large, milky white in life, with body cylindrical anteriorly and somewhat flattened posteriorly, widest at clitellar region and tapering towards both ends. Prostomium conically pointed. Dorsal and ventral setae short in II. Ventral setae of II occasionally also a few dorsal setae of II single-pointed. All others bifid (Fig. 75 A) with upper tooth shorter and thinner than lower. Setae 137-160 μm long, 3-5 occasionally 6, per bundle anteriorly, 2-3 per bundle in post-clitellar segments. Ventral setae of XI absent. Pharynx in II-III, wide. Oesophagus in IV-VI, narrow. Stomach absent. Intestine start in VII wide and sacculated. Chloragocytes cover gut from VI. Coelomocytes abundant, small, round and granulated. Dorsal vessel ventro-lateral to left of gut from hind end to VII and mid-dorsal in anterior segments. Lateral contractile vessels 5 pairs in VI-X, moniliform, connecting dorsal and ventral vessels. Integumental capillaries numerous, branching freely in hypodermal cells in dorsal side of posterior part of body. Brain roundish posteriorly with two prominent posterior lobes. Nephridia begin in VII.

Clitellum well developed with tall cells extending over XI-XIII. Testes and ovaries a pair each in X and XI attached to posterior face of septum 9/10 and 10/11 ventro-laterally. Sperm-sacs well developed, extending through IX-XV Ovi-sac single, back-pouching of septum 11/12 extending to XIX when filled with several mature ova. Male funnels (Fig. 75 B-sf) very large with backward folded lips, situated on anterior face of septum 10/11 laterally, each continued into a short vas deferens (Fig. 75 B-vd), much shorter than atrium, enters an elongated nearly spindle-shaped atrium apically. Atrium (Fig. 75 B-a) covered completely by diffuse prostate gland cells (Fig. 75 B-pr). Its lumen wide, its inner epithelium with small discrete bodies of secretion and long cilia. Ejaculatory duct (Fig. 75 B-ed) naked, folded, thin-walled without granulation, but with long cilia. Both atrium and ejaculatory duct without muscular lining. Pseudo-penis (Fig. 75 B-pp) spindle-shaped, heavily muscular, enter median bursa laterally located in posterior part of XI. Male bursa (Fig. 75 B-mb) bilobed, each lobe erect, stalked, lateral sac heavily muscular, folded in a complex manner. Middle of each lobe receiving pseudopenis, opening of latter on a pendant papilla in wall of bursa. Inner end of lobe, narrower than rest, curved towards posterior as a blind sac. Lobes on the bursa united mid-ventrally to form a small median chamber located under nerve-

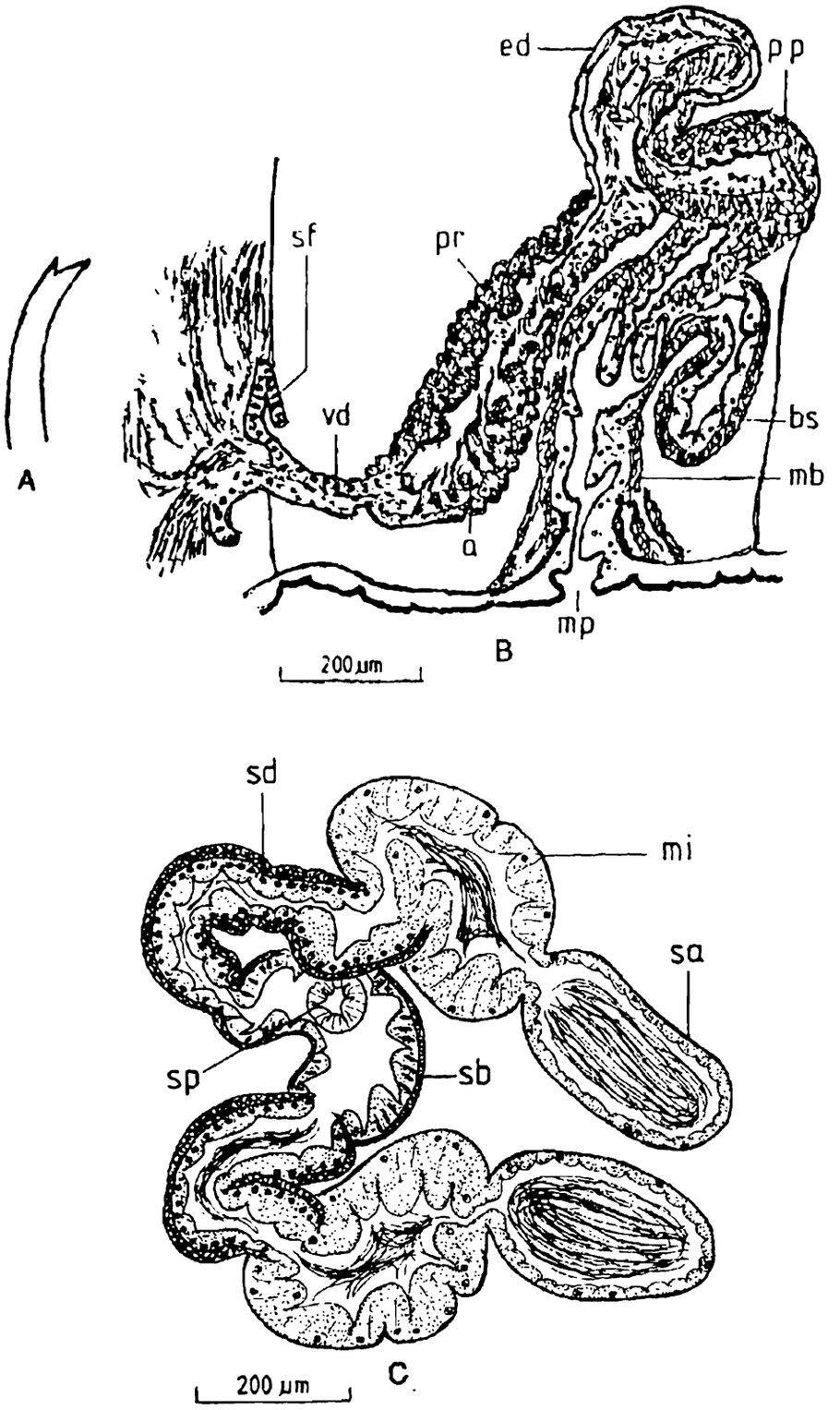

Fig 75 : *Monopylephorus limosus.* A : Bifid seta; B : Male efferent apparatus; C : Spermathecae. (B, C from Erseus and Paoletti, 1986). a : atrium; bs : blind-sac (inner end of lateral lobe of male bursa); ed : ejaculatory duct; mb : male bursa; mi : middle part; mp : male pore; pp : pseudo-penis; pr : prostate cell; sa : spermathecal ampulla; sb : spermathecal bursa (unpaired); sd : spermathecal duct; sf : sperm funnel; sp : spermatheca; vd : vas deferens.

cord, opening to exterior through a single male pore in XI. Spermathecae (Fig. 75 C) a pair, saccular, united into a muscular median bursa, opening to exterior through a common median ventral pore posterior to 9/10. Each spermatheca consists of 4 parts: (1) thin walled ampulla (Fig. 75 C-sa), followed by (2) middle part (Fig. 75 C-mi) with lumen covered with tall epithelial cells and thin muscular lining, and (3) slender spermathecal duct (Fig. 75 C-sd) entering (4) common spermathecal bursa (Fig. 75 C-sb). Sperms arranged in loose masses and scattered in ampulla and rest of spermatheca.

Habits : Unlike *Limnodrilus*, *Tubifex* and *Aulodrilus* these worms do not coil into close spirals as reaction to touch stimulus. Worms creep about on lower surface of objects submereged in water and rarely buries anterior part of their body in mud. This is a stiff species, exhibiting movements akin to those of Lumbriculids rather than Tubificids. Live in saline muddy gutters and diches in organically enriched sediments in fresh water and somewhat saline situations.

Distribution : India : Kadinamkulam backwaters near Trivandrum (Kerala).

World distribution : South-East Asia; Italy, Russia (Europe); North America.

Monopylephorus parvus Ditlevsen, 1904
(Fig. 76)

Monopylephorus parvus Ditlevsen, 1904 : 427; Stephenson, 1917a : 485; 1923 : 104; Naidu, 1966 : 220.

Rhizodrilus parvus, Vasisht, 1981 : 74.

Monopylephorus parvus, Nair, Dharmaraj, Aziz, Arunachalam & Krishnakumar, 1984 : 478; Julka, Senapati & Paliwal, 1989 : 86.

Type locality : Bermuda island.

l(p.) = 8-15 mm; d(p.) = 0.31-0.52 mm; s = 38-68 + undifferentiated region.

Description : Worms large, cylindrical, coloured pink in life. Prostomium large, prominent, bluntly conical with a rounded tip. Dorsal and ventral setae begin in II, 3-4 or 5 per bundle anteriorly, gradually reducing in number posteriorly, bifid, 50-95 μm long, 2.0-4.5 μm thick. Dorsal setae (Fig. 76 A, B) bifid with teeth almost equally long, proximal thicker than distal. Ventral setae (Fig. 76 C, D) bifid with distal tooth thinner and longer than proximal. Simple pointed setae replace one or both in mid-body and in posterior part many setae are simple pointed in dorsal and ventral bundles, and generally only setae in posterior dorsal bundles. Hair setae absent. Ventral setae of a few segments close to clitellar region and ventral setae of other segments. generally larger than dorsal setae Ventral setae of XI absent. Single pointed setae upto 70 μm long, 3 μm thick.

Pharynx in II-III, wide with prostrusible roof through mouth like a sucker as in Enchytraeidae. Pharyngeal glands in IV, V. Oesophageal glands in IV-VI arranged in

4 cords dorsally and dorso-ventrally. Oesophagus in IV-VII, narrow. Stomach absent. Intestine starts in VIII, wide and sacculated. Chloragocytes cover gut from VI. Coelomocytes abundant, circular, 6-10 μm in diameter with central nucleus. Blood yellowish. Dorsal vessel ventro-lateral to left of gut from hind end to VII and mid-dorsal in II-VI. Supra- and sub-intestinal vessels absent. Parietal vascular plexus within muscular layers of body wall. Nephridia of exonephric type begin in VII, funnel with very long upper lip.

Clitellum in ½X-XII (2½ segments). Male genitalia (Fig. 76 E) (except copulation sac) paired. Testes a pair on posterior face of septum 9/10. Sperm-sacs two, smaller anterior sac in IX and larger posterior back-pouching of septum 10/11 reaching XIII. Male funnels (Fig. 76 E-mf) a pair situated ventro-laterally on anterior face of septum 10/11. Vas deferens (Fig. 76 E-vd) about 50 μm long, 15-20 μm wide, covered with high peritoneal cells, passes backwards into XI and then rises towards dorsal wall, loses high peritoneal investment and bends downwards and enters an elongate tubular atrium, divisible into 3 parts : (1) atrial ampulla (Fig. 76 E-aa) of 185-250 μm long, 18-37 μm wide with ciliated and granulated inner epithelium and completely covered with diffuse prostate gland, (2) ejaculatory duct (Fig. 76 E-ed) of about 110-150 μm long, about 25-30 μm wide with ciliated and non-granulated inner epithelium and

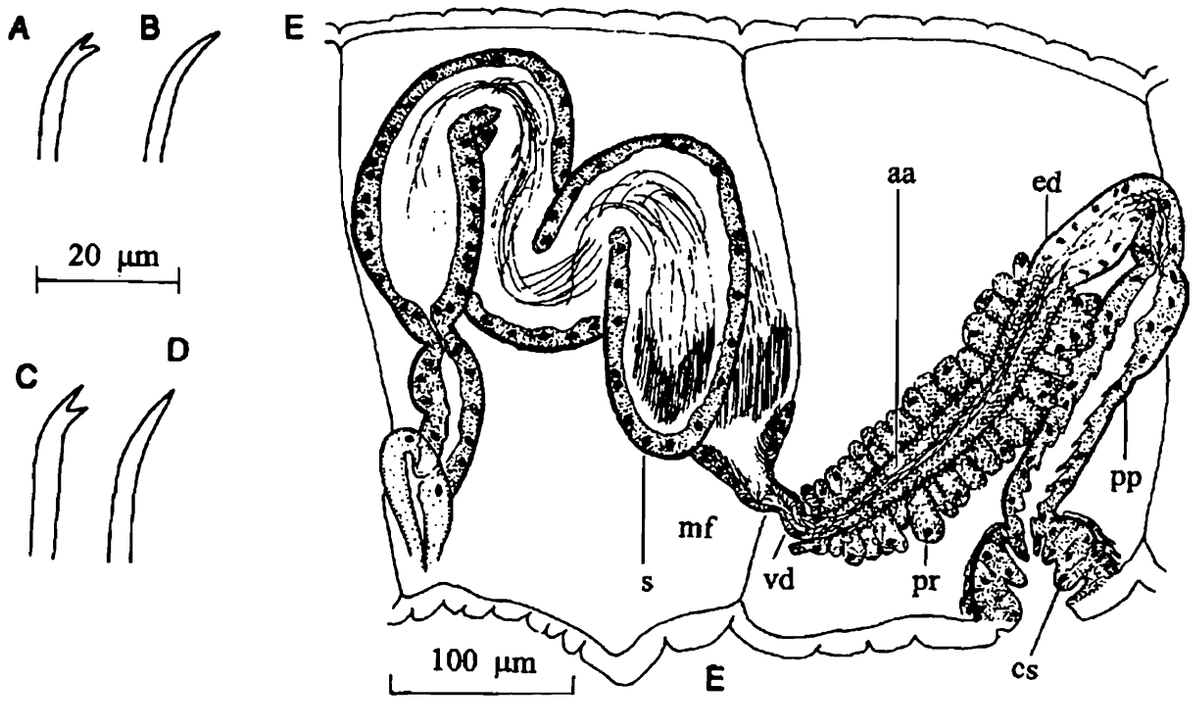

Fig 76 : *Monopylephorus limosus.* A : Anterior dorsal bifid seta; B : Posterior dorsal single-pointed seta; C : Ventral bifid seta of XII; D : Ventral single pointed seta of XII; E : Genital organs (all from Erseus, 1984). aa : atrial ampulla; cs : copulatory sac; ed : ejaculatory duct; mf : male funnel; pp : pseudo-penis; pr : prostate; sa : spermatheca; vd : vas deferens.

thin outer layer of muscles, (3) pseudo-penis (Fig. 76 E-pp) about 135-185 μm long, 26-57 μm wide, with non-ciliated and non-granulated inner epithelium and conspicuous outer layer of largely circular muscles. Unpaired copulatory sac (Fig. 76 E-cs) with an outer layer of muscles, folded inner wall and sac provided with two lateral lobes, one on each side. Male pores open separately or combined into a large median bursa. Spermatheca (Fig. 76 E-s) single, on left side in X, with an elongated, slender, twisted and folded ampulla of about 345-390 μm long, 55-80 μm wide with concentration of sperms with their heads oriented towards inner end, and its short duct of 60-105 μm long, 20-55 μm wide, opening by a median aperture in intersegmental groove of IX/X.

Habits : Littoral, in estuarine areas.

Distribution : India : Barkuda Island, Chilka Lake (Orissa); Chandigarh.

World distribution : Cosmopolitan.

Genus ***Bothrioneurum*** Stolć, 1888

Bothrioneurum Stolć, 1888 : 43; Beddard, 1895 : 268; 1901 : 86; Stephenson, 1923 : 102; 1930 : 752; Marcus, 1942 : 200; Chekanovskaya, 1962 : 288; Brinkhurst, 1963 : 63; Brinkhurst & Jamieson, 1971 : 539; Chekanovskaya, 1980 : 22; Persia, 1980 : 103; Mukhopadhyay, 1998 : 113.

Diagnosis : Prostomium with sensory pit dorsally. Dorsal and ventral setal bundles with bifid setae, hair setae absent. Gills absent. Coelom opens to exterior through dorsal pores. Large coelomocytes present. Body-wall richly vascularised anteriorly and posteriorly. Male efferent ducts with short vasa deferentia, atria tubular and covered proximally with prostate cells and partially coiled in testis bearing segment, distal part of atria naked, opening into a voluminous eversible pseudo-penes, bearing glandular paratria and accessory glands. Right and left atria open into a common copulatory chamber, which opens to exterior through an unpaired male genital pore; male pore sometimes paired. Spermathecae absent but sperm bearers formed and fixed to body-wall during copulation. Asexual reproduction by fragmentation with regeneration. Cosmopolitan.

Type species : *Bothrioneurum vejdovskyanum* Stolć, 1888

Key to Indian species of *Bothrioneurum*

Atrium simple with dorso-median paratrium; penial seta 1 per bundle, vas deferens long ..... *Bothrineurum iris*

Atrium double, paratrium dorso-median on II atrium; penial setae 4 per bundle; vas deferens short ..... *Bothrionerum vejdoskyanum*

Bothrioneurum iris Beddard, 1901
(Fig. 77)

Bothrioneurum iris Beddard, 1901 : 81; Michaelsen, 1909a : 135; 1910 : 8; Stephenson, 1910c : 241; 1923 : 102; 1924a : 322; Aiyer, 1925 : 39; Weerakonn & Samarasinghe, 1958 : 160; Mendis & Fernando, 1962 : 45; Naidu, 1965a : 475; 1966 : 220; Vasisht & Gandhi, 1972 : 100; Gates, 1972 : 316; Ali & Rashid-u-Zaman, 1976 : 92; Naidu, Kalpana & Sureshkumar, 1981 : 110; Battish & Sharma, 1997 : 83: Mukhopadhyay, 1998 : 113.

Type locality : Siamese Malaya, Asia.

l(p.) = 10-30 mm; d(p.) = 0.8-1.0 mm; s = upto 170 + undifferentiated region.

Description : Worms large, cylindrical and reddish, body-wall with white patches. Prostomium bluntly conical with a sense organ in a pit dorsally at base medianally. Dorsal and ventral setae of same type, begin in II, composed of 4 (rarely 2-3) bifid setae per bundle with distal nodulus (D : P :: 1 : 2) in dorsal setae, (D : P :: 12 : 19) in ventral setae. Dorsal setae (Fig. 77 A, B) 66.5-105 μm long, with distal tooth thinner and shorter than proximal. Ventral setae (Fig. 77 C, D) 84-108 μm long, with distal tooth much thinner and longer than proximal in outer setae and thinner and shorter in inner setae of a bundle, absent in XI and XII.

Buccal cavity in I, wide. Pharynx in II-IV, wide. Oesophagus in V, narrow. Stomach absent. Intestine starts in VI, wide, covered with brownish chloragocytes from V Coelomocytes (Fig. 77 H-z) spherical or ovoid, plate like, 10-19 μm in diameter, faintly granular with a nucleus, golden yellow with oily appearance in life. Dorsal vessel lateral to left of gut from hind end to VII and mid-dorsal in 6 anterior segments. Lateral vessels 9 pairs in II-X, of which last 4 pairs contractile, of these 3 pairs short and small, connect supra-intestinal and ventral vessels, and fourth pair large, folded and connect dorsal and ventral vessels. Anterior 6 segments and posterior half of worm highly vascularised. Brain (Fig. 77 E) hollowed narrowly and deeply behind and broadly with two concavities on either side of median nerve (Fig. 77 E-n) anteriorly. Nephridia start in VIII, one per segment, pre-septal funnel with a ciliated nephrostome in VII continues as a narrow duct, passes through septum 7/8 and connected to post-septal composed of a highly coiled and ciliated duct partly covered with gland and opening by a nephropore ventro-laterally.

Clitellum (Fig. 77 H-c) in ½X-XII (2½ segments). Testes (Fig. 77 H-t) and ovaries (Fig. 77 H-v) a pair each, on posterior face of septum 9/10 and 10/11 ventro-laterally. Sperm-sac single, back-pouching of septum 10/11 extending to XIII containing spermatozoa and sperm-morulae. Male funnels (Fig. 77 H-m) a pair of small, ciliated structures on anterior face of septum 10/11 below middle. Vas deferens long, its proximal half coiled in a mass of spermiducal gland, distal half coiled, but wide and thin walled, non-granular, entering atrium (Fig. 77 H-x) apically. First part of atrium fusiform in shape and next part irregular, with a number of folds or small diverticula; paratrium small, ovoid, with a cap of prostate cells (Fig. 77 H-p) with hardly

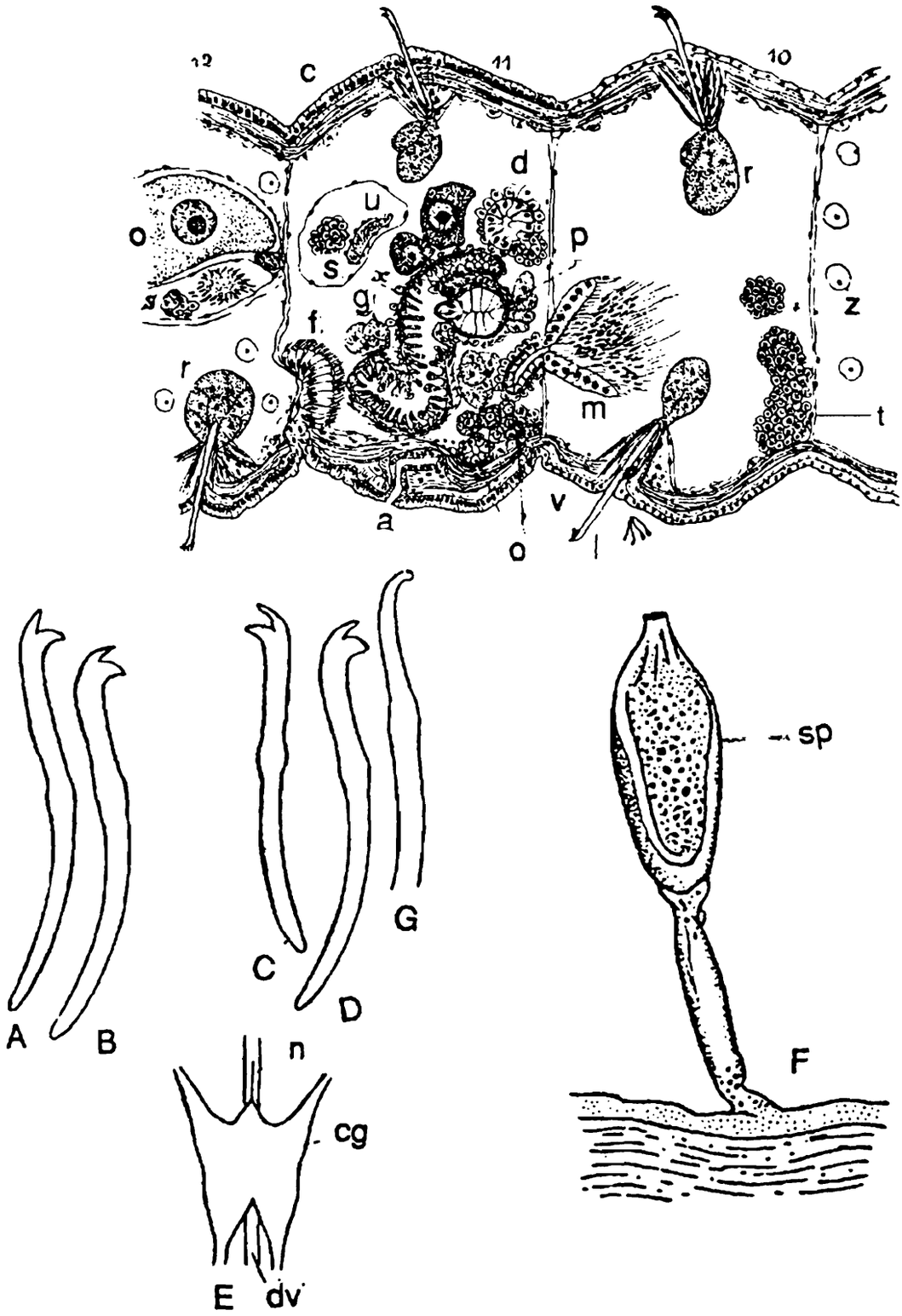

Fig 77 : *Bothrioneurum iris.* A, B : Dorsal setae of IV and XI; C, D : Ventral setae of IV and XXV; E : Brain; F : Sperm bearer; G : Penial seta; H : Genital organs. (F from Beddard, 1901; H from Marcus, 1942). a : male pore; c : clitellum; d : vas deferens; dv : dorsal vessel; f : female funnel; g : post-parietal gland; m : male funnel; n : nerve; o : ovum; p : prostate gland cells; r : setal follicular gland; s : spermatheca; sp : sperm bearer; t : testis; u : spermathecal blood vessel; v : ovary; x : atrium; z : coelomocyte.

distinguishable lumen, its mouth invaginated into second part of atrium; terminal part of atrium unites with its fellow underneath ventral nerve cord. Male pore (Fig. 77 H-a) single and median. Spermathecae absent. Sperm bearers (Fig. 77 F) fusiform or irregular in shape, attached by solid stalks to clitellar segments, 1-5 in number. Female pores a pair, behind male pore. Ventral setae of XI replaced by penial setae (Fig. 77 G) one per bundle, resembling in shape those of *Nais* sp. of family Naididae. Female funnels (Fig, 77 H-f) a pair on anterior face of septum 11/12. Ovi-sac single back-pouching of septum 11/12 extending to XIV with ova (Fig. 77. H-o). Asexual reproduction by architomy also occurs

Habits : Live in fresh and brackish water.

Commensals : Number of epizoic ciliates, *Spirocoma* sp. were found attached to posterior end of a number of worms.

Distribution : India : Trivandrum (Kerala); Palani, Kodaikanal (Tamil Nadu); Cuddapah, Vizianagaram (Andhra Pradesh); Chandigarh; Punjab; Panchakula (Haryana); Kurseong, Darjeeling, Bangar (West Bengal). Dhaka (Bangladesh); Meegoda near Colombo (Sri Lanka).

World distribution : South-East Asia; Bolivia (Europe); Brazil (South America); Tasmania (Australia).

Bothrioneurum vejdovskyanum Stolć, 1886
(Fig. 78)

Bothrioneurun vejdovskyanum Stolć, 1886 : 647; 1888 : 43; Brinkhurst & Jamieson, 1971 : 540; Ali & Rashid-u-Zaman, 1976 : 92.

Type locality : Unassigned, Czechoslovakia.

l(p) = 28 mm; d(p) = 0.42 mm (clitellum), 0.34 mm (ante-clitellum); s: ?

Description : Worms of large size, orange-yellow in colour in life. Prostomium with dorso-median pit. Body wall without papillae. Setae (Fig. 78 A, B) all bifid, 4-6 per bundle in anterior segments, decreasing to 1-4 per bundle in posterior segments. Teeth closer with distal longer and slightly thinner than proximal in anterior segments, but widely apart with distal tooth longer or shorter much thinner than proximal in posterior segments.

Buccal cavity in I, wide. Pharynx in II-V, wide. Pharyngeal glands present. Oesophagus in VI narrow. Stomach absent. Intestine from VII wide. Coelomocytes few. Dorsal vessel lateral to left of intestine from hind end to VII and mid-dorsal in anterior 6 segments.

Clitellum in ½X-XII, sometimes extending slightly to XIII. Testes and ovaries paired on posterior face of 9/10 and 10/11 ventro-laterally. Sperm-sac single, back-pouching of 10/11 extending upto XIII. Vas deferens (Fig. 78 E-vd) short, ciliated,

about 300 μm long, followed by a glandular and much coiled atrium. Atrium divisible into two atria. First atrium (Fig. 78 E-at1) provided with a mass of glandular cells in X. Second atrium (Fig. 78 E-at2) conical, wider, behind septum 10/11, opening with a narrow neck into a spaceous copulatory chamber (Fig. 78 E-c). Paratrium (Fig. 78 E-p) dorso-median to second atrium, opens directly into copulatory chamber with glandular epithelium and paratrial glands cells (Fig. 78 E-pg). Male pore single, ventro-median on XI, with lateral sides of swollen flaps but depressed around and anterior to male pore. Penial setae (Fig. 78 C, E-ps) 4 per bundle, enclosed in copulatory chamber, each seta bluntly hooked, with two rows of teeth on inner margin near distal end. Spermathecae absent. Sperm bearers (Fig. 78 D-sp) upto 5, implanted on dorsal and lateral surfaces of XI.

Habits : Lives in fresh water.

Distribution : Bangladesh : Dhaka.

World distribution : Asia; Africa; Europe; North America.

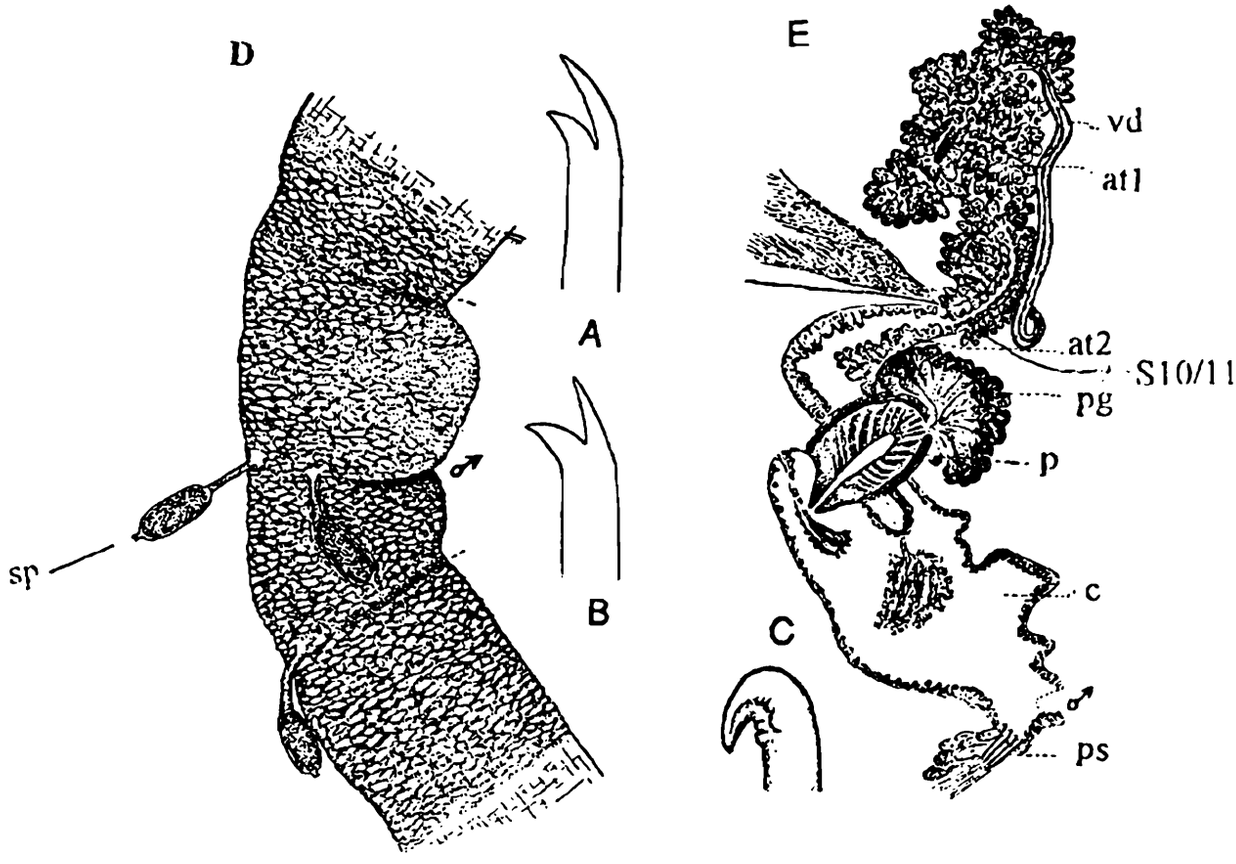

Fig 78 : *Bothrioneurum vejdovskyanum.* A, B : Seta from anterior and posterior segments; C : Penial seta, lateral view; D : Clitellar region, dorso-lateral view; E : Male genital organs, sagittal section. (all from Chen, 1940). at1 : atrium 1; : at2 : atrium 2; c : copulatory chamber; p : paratrium; pg : paratrial gland; ps : penial setae; sp : sperm bearer; S10/11 : septum 10/11; vd : vas deferens.

Subfamily BRANCHIURINAE Hrabe, 1966

Branchiurinae Hrabe, 1966 : 70;1967 : 353; Brinkhurst & Jamieson, 1971 : 562; Chekanovskaya, 1980 : 24.

Diagnosis : Prostate glands diffuse. Spermathecae present. Spermatophores or sperm bearers and coelomocytes absent. Posterior half or a third of body with mid-dorsal and mid-ventral gills, a pair in each segment. Atria diverticulate.

Type genus : *Branchiura* Beddard, 1892.

This subfamily has only one genus, *Branchiura* Beddard, 1892, which occurs in the subcontinent.

Genus ***Branchiura*** Beddard, 1892

Branchiura Beddard, 1892 : 325; 1895 : 270; Stephenson, 1923 : 98; 1930 : 749; Chekanovskaya, 1962 : 290; Brinkhurst, 1963 : 59; Brinkhurst & Jamieson, 1971 : 562; Baker & Brinkhurst, 1981 : 964; Chekanovskaya, 1980 : 22; Persia. 1980 : 103; Mukhopadhyay, 1998 : 113.

Diagnosis : Hair setae and bifid setae present in dorsal bundles, but only bifid setae in ventral bundles. Segments of hinder part of body each with a dorsal and a ventral gill. Coelomocytes absent. Male efferent ducts with short vasa deferentia enter into tubular atria covered with prostate cells, atrial diverticula present. Ejaculatory ducts enter eversible pseudo-penis. Right and left atria discharge into a common unpaired copulatory chamber. Male genital opening unpaired. Spermathecae paired in X, spermatozeugmata absent. Penial setae absent. Cosmopolitan.

Type species : *Branchiura sowerbyi* Beddard, 1892.

Branchiura sowerbyi Beddard, 1892)
(Fig. 79)

Branchiura sowerbyi Beddard, 1892 : 325; Stephenson, 1912a : 234; 1912b : 285; 1913a : 741; 1918 : 12; 1920 : 200; Mehra, 1920 : 457; Stephenson, 1921 : 752; 1923 : 99; 1924a : 321; 1929 : 226; 1930 : 749; Michaelsen, 1936 : 95; Naidu, 1965a : 473; 1966 : 220; Vasisht & Gandhi, 1972 : 100; Gates, 1972 : 316; Ali & Issaque, 1975 : 60; Ali & Rashid-u-Zaman, 1976 : 92; Sharma, Handa & Sahi, 1976 : 102; Naidu & Srivastava, 1980 : 270; Naidu & Naidu, 1981a : 535; Naidu, Kalpana & Sureshkumar, 1981 : 110; Vasisht, 1981 : 74; Sobhana & Nair, 1984 : 302; Castello, 1984 : 66; Julka, Senapati & Paliwal, 1989 : 86; Ghosh & Konar, 1991 : 156; Khatoon & Ali, 1993 : 533; Battish & Sharma, 1997 : 83; Mukhopadhyay, 1998 : 114.

Type locality : London, Britain.

l(p.) = upto 185 mm; d(p.) = 0.75-1.3 mm; s = upto 270 + undifferentiated region.

Description : Worms (Fig. 79 A) very large, cylindrical, delicate, pale red, posterior third of body length with hollow cylindrical, mid-dorsal and mid-ventral gills, a pair per segment. First few pairs mere tubercles, gradually increasing in length to reach a length of 1.5-2.0 mm towards hind end. Gills contractile enclosing a part of coelom and a vascular loop in each. Prostomium bluntly conical. Dorsal setae from II, anterior bundles with 1-3 (6) short hair setae and (7-9) 11-12 pectinate needle setae. Hair setae bayonet-shaped, about twice as long as needle setae in anterior segments and gradually decreasing to half that in branchial region. Bifid dorsal setae (Fig. 79 B, C) 84-105 μm long, with proximal tooth thicker and longer than distal in anterior 5-6

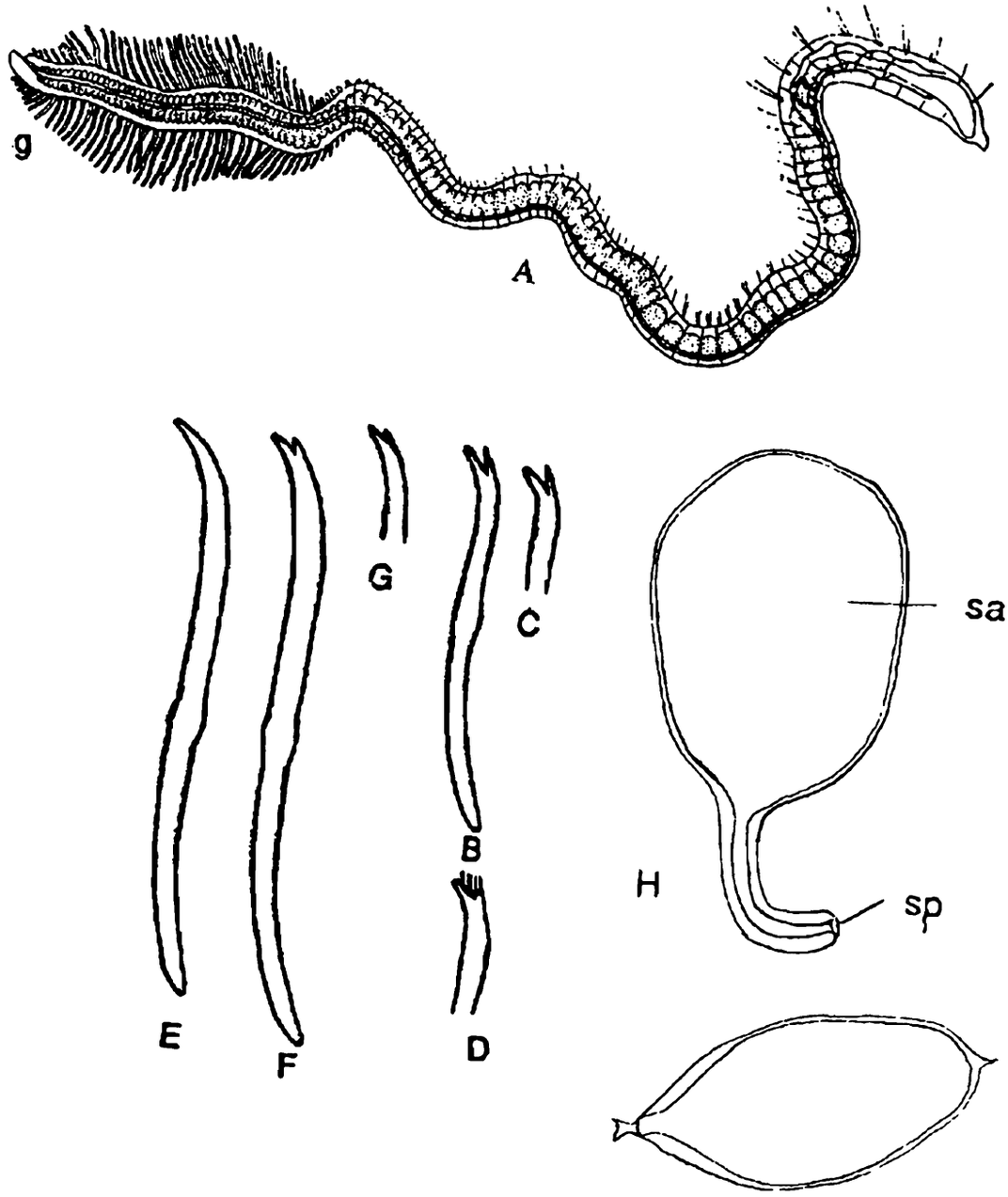

Fig 79 : *Branchiura sowerbyi*. A : Entire worm; B, C : Bifid dorsal setae; D : Pectinate dorsal seta; E : Single pointed ventral seta; F, G : Bifid ventral setae; H : Spermatheca, I : Cocoon. (A from Brinkhurst, 1982). sa : spermatheca; sp : spermathecal pore.

segments, bifid with delicate pectinate out-growths (Fig. 79 D) between two main teeth in other segments. Angle between teeth more acute in lateral needle setae of bundle. Ventral setae 5-6 per bundle anteriorly, gradually decreasing to 1-2 posteriorly, 63-119 μm long with distal nodulus; in II-V simple-pointed (Fig. 79 E), in others bifid (Fig. 79 F, G), more curved than needle setae with proximal tooth longer and thicker than distal.

Pharynx in II-IV, wide. Oesophagues in V-VII narrow. Stomach absent. Intestine from VIII, wide, sacculated in middle segments and narrow and straight in branchial segments. Anus opens dorsally between a short dorsal and a long ventral lips. Intestinal anti-peristalsis with anus gulping water by gulping movements of anal lips occurs. Ascending ciliary vibration absent. Chloragocytes cover gut from VI, tall and grayish-brown. Coelomocytes absent. Dorsal vessel ventro-laterally attached to left of gut from hind end to VII and mid-dorsal in anterior 6 segments. Lateral contractile vessels 2 pairs, those of IX arise from supra-intestinal vessel and of X arise from dorsal vessel. Ventral vessel mid-ventral and unites with sub-intestinal and disappears behind septum 8/9 and again forms by union of first and second pairs of lateral contractile vessels in X and XI respectively. Dorsal vessel covered with chloragocytes but lateral contractile vessels free of them. Non-contractile lateral vessels in II-VIII connect dorsal and ventral vessels. Anterior 6 segments highly vascularised with plexuses. Each gill bears an involuted U-shaped vascular loop, two ends of which connected to dorsal and ventral vessels. Brain roughly triangular in shape with apex directed anteriorly, and deeply incised in front and less deeply behind. First nephridium in IX, placed left of gut, each nephridium with nephrostome on pre-septal ciliated funnel in one segment and post-septal of highly coiled ciliated duct in next segment, with terminal part swollen into a vesicle and opening by a nephropore in front of ventral setae.

Clitellum in X-XII (3 segments), whitish. In sexually mature worms with clitellum, testes and ovaries disappear. In early sexuality a pair of ovoid, pale yellow testes laterally attached to posterior face of septum 9/10, and a pair of ovoid, whitish ovaries with their stalks united and attached medianally to posterior face of septum 10/11 close to ventral body wall. Single sperm-sac and single ovi-sac, back-pouchings of septa 10/11 and 11/12, former within latter, extend to XI and XII respectively, when filled with sexual elements. Male funnels on anterior face of septum 10/11 laterally. Vasa deferentia very wide behind funnels, narrowing abruptly before enterlng atrium subapically but runs to apex within atrial wall. Atrium long. joining elongated paratrium about middle of its length; at its ectal end running with narrowed atrium for some distance before two lumina unite; ectal part of atrium, below union of paratrium, partly eversible as somewhat bladder-like pseudo-penis; both paratrium and ental part of atrium covered with massive investment of diffuse prostate cells. Ejaculatory ducts and glandular diverticula ciliated, surrounded by peritoneal cells and opening by transverse male pores with puckered margins a little median to

ventral bundles of XI. Pseudo-penis and ducts contained in muscular sacs. Sperm masses in spermathecae. Ventral setae of XI and penial setae absent. Spermathecae (Fig. 79 H) a pair in X, club-shaped, with ovoid thin-walled ampullae, and thick-walled duct opening behind ventral setae of X. Cocoons (Fig. 79 I) ovoid, 364 mm long and 125 mm wide, with nearly whitish translucent wall, one end rounded and other end tapering with opening sealed off by contraction of wall.

Chromosomes : 2n = 38 (Sharma, Handa & Sahi, 1976).

Habits : Live in highly polluted, foul smelling aerobic conditions along with *Limnodrilus hoffmeisteri.* Worms bury anterior half of body in mud and wave the branchial part in water.

Breeding period : In Trivandrum breeding period starts just before monsoon sets in, in July and ends in December (Sobhana & Nair, 1984).

Distribution : Palghat, Calicut, Trivandrum (Kerala); Chennai, Annamalainagar, Coimbatore, Coonoor, Udhakamandalam (Tamil Nadu); Cuddapah, Adoni, Chittoor, Tirupati, Horsley Hills, Kambakkam, Visakhapatnam, Warangal, Hyderabad (Andhra Pradesh); Bangalore, Mysore, Bellary (Karnataka); Ladhuk, Cuttack, Sambalpur, Burla (Orissa); Vehar Lake, Mumbai, Bandra, Nagpur (Maharastra); Bhopal, Ujjain (Madhya Pradesh); Agra, Belgatchia, Lucknow (Uttar Pradesh); Naini Tal (Uttaranchal); Delhi; Chandigarh; Punjab; Haryana; Pahalgam, Sonasar Lake (Jammu & Kashmir), Ranchi (Bihar); Bankura, Bardhaman, Howrah, Hooghly, Murshidabad, West Dinajpur, Andal village, Katwa, Raina in Burdwan district, Dinhata, Toofanguńje, Janai, Kamarpukur, Pandooah, Kaliachawk, Malda, Purulia, Saheeb Bandh, Kolkata, South and North 24 Paraganas districts (West Bengal); Gauhati (Assam); Inle Lake, Lohtak Lake (Manipur); Dhaka (Bangladesh); Lahore (Pakistan); Rangoon, Indawagyi Lake, Mongyai in Shan State, Kaung-Diang (Burma); Kandy, Peradeniya, Polanuaruwa (Sri Lanka).

World distribution : Cosmopolitan.

Subfamily AULODRILINAE Brinkhurst & Jamieson, 1971

Aulodrilinae Brinkhurst & Jamieson, 1971 : 523; Chekanovskaya, 1980 : 23.

Diagnosis : Male efferent ducts with short to very short vasa deferentia enter into globular or bean-shaped to elongate cylindrical atria with solid prostate, large eversible pseudo-penes. Spermathecae with sperm masses or spermathecae absent. Penial setae spoon-shaped or absent. Coelomocytes absent. Inhabit tubes, using unsegmented posterior end as respiratory organ. Cosmopolitan.

Type genus : *Aulodrilus* Bretscher, 1899.

This subfamily includes *Aulodrilus* Bretscher, 1899, *Sketodrilus* Karaman, 1976, *Thalassodrilus* Brinkhurst & Baker, 1979, *Neoaulodrilus* Giani, Martinez-Ansemil,

Moubayed & Dia, 1982, *Siolidrilus* Marcus, 1949 and *Peipsidrilus* Timm, 1977. Of these first named genus occurs in the Indian subcontinent.

Remarks : After finding stalked prostates in *Aulodrilus pluriseta* and *A. limnobius* Giani, Martinez-Ansimil & Brinkhurst (1984) concluded that *Aulodrilus, Sketodrilus* and *Peipsidrilus* of the subfamily Aulodrilinae should be included in subfamily Tubificinae. Till such time more information is available confirming the decision *Aulodrilus* should continue to be in the subfamily Aulodrilinae.

Genus ***Aulodrilus*** Bretscher, 1899

Aulodrilus Bretscher, 1899 : 388; Michaelson, 1900 : 55; Piguet, 1913 : 57; Mehra, 1922 : 945; Stephenson, 1923 : 106; 1930 : 752; Marcus, 1944 : 75; Chekanovskaya, 1962 : 223; Brinkhurst, 1963 : 65; Brinkhurst & Jamieson, 1971 : 523 Chekanovskaya, 1980 : 5; Persia, 1980 : 102; Mukhopadhyay, 1998 : 112.

Diagnosis : Setae mainly bifid, numerous, with distal tooth shorter and thinner than proximal; dorsal bundles of some species, with short hair setae and needle setae which may be replaced by oar-shaped setae with flattened and expanded distal end. Large coelomocytes absent. Alimentory canal much dilated from VIII segment onwards. Hearts in VI or VII, in II-V anastomosing lateral loops; from VII or X onwards a pair of loops in each segment. Non-segmental section evident behind zone of formation of segments at posterior end of body devoid of setae, but enriched with blood vessels and thus function as a respiratory organ. Clitellum on VII-VIII or X-XI. Testes one to three pairs in IV to VI. Vasa deferentia short. Atrium tubular to round with solid prostate gland, followed by a terminal section of male canal, which either surrounded by a muscular sac or enclosed in compact muscular bulb with mainly radiating fibres; terminal part of canal evaginable as a pseudo-penis. Paratrium absent. Male pores in VII to IX. Spermathecae in VI or IX. Penial setae present or absent. Cosmopolitan.

Type species : *Aulodrilus limnobius* Bretscher, 1899.

Key to Indian species of *Aulodrilus*

1. Hair setae present from II, dorsal setae bifid or pectinate from II, penial setae absent ..... *Aulodrilus pluriseta*

– Hair setae usually absent from II or III, dorsal setae change in form from about VI, penial setae present 2

2. Dorsal setae behind VII oar-shaped ..... *Aulodrilus pigueti.*

– Dorsal setae behind VII with equal sized intermediate teeth .... *Aulodrlus pectinatus*

Aulodrilus pectinatus Aiyer, 1928
(Fig. 80)

Aulodrilus pectinatus Aiyer, 1928 : 345; Naidu, 1966 : 221.

Type locality : Trivandrum, Kerala, India.

l(p.) = 5.0-6.5 mm; d(p.) = 0.5-0.6 mm; s = 32-43 + setaless region.

Description : Worms of medium size, slender, cylindrical and taper gradually to posterior end. Prostomium bluntly conical, rounded without stiff cilia on margin. Dorsal setae from II consisting of hair and needle setae. Hair setae (Fig. 80 A) begin in IV, 1-3 per bundle, 52 μm long, bayonet-shaped with indistinct nodulus about 1/3 from proximal end. Needle setae (Fig. 80 B) in anterior segments 39 μm long, bifid, with two equally long teeth, with distal nodulus (D : P :: 12 : 17) and from VII or VIII pectinate needle setae with 2 to 4 intermediate teeth, 3-5 per bundle, 39 μm long with distal nodulus, all teeth equally long. Ventral setae (Fig. 80 C) bifid, 3-9 per bundle, 39 μm long, with distal nodulus, but in II-IV nodulus at middle or very slightly distal, with equally long teeth and distal thinner than proximal.

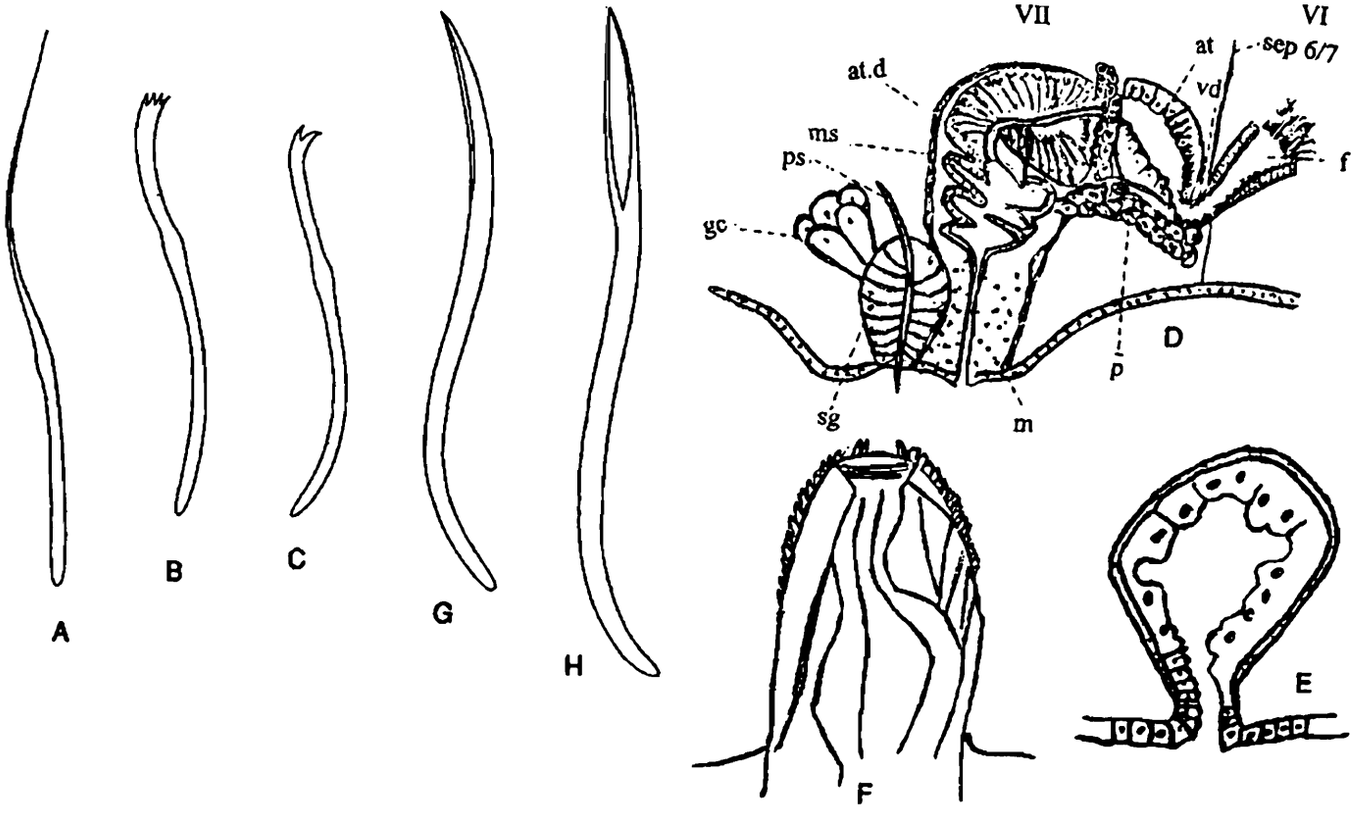

Fig 80 : *Aulodrilus pectinatus.* A : Hair seta; B : Pectinate needle seta; C : Ventral seta; D : Male efferent apparatus; E : Spermatheca; F : penis; G, H : Penial setae; (all from Aiyer, 1928). at : atrium; at.d : atrial duct; f : male funnel; gc : gland cell; m : muscle; ms : muscular sac; p : prostate; ps : penial seta; sep 6/7 : septum 6/7; sg : penial setal gland; vd : vas deferens; VI, VII : segments.

Pharynx in II-III lined by strongly ciliated columnar epithelium and attached to body wall by radiating muscle fibres. Oesophagus in IV-VI, narrow. Stomach absent. From VII gut dilates into a wide intestine filling whole body cavity in VII-IX, and narrowing slightly from XII. Blood pale red. Dorsal blood vessel ventral to left of gut from hind end to VI and mid-dorsal in anterior segments. A pair of stout lateral contractile vessels connect dorsal and ventral vessels. Two supra-intestinal and sub-intestinal vessels present.

Clitellum in ½VI-½VIII (2 segments). Testes a pair in VI on posterior face of septum 5/6, disappearing in mature worms. Sperm-morulae and bundles of ripe spermatozoa in VI. A small sperm sac, formed by the back-pouching of septum 6/7 present. Male funnels (Fig. 80 D-f) in VI in front of septum 6/7, 27 μm in height and 25 μm wide at mouth. Vasa deferentia (Fig. 80 D-vd) short, 12 μm thick with a lumen of 6 μm in diameter, opening into atria behind septum 6/7. Atrium (Fig. 80 D-at) an ovoid chamber, 45 μm long, 30 μm wide with a lumen of 9 μm in diameter, lying longitudinally, with atrial duct (Fig. 80 D-at.d) in VII. Prostate (Fig. 80 D-p) a trilobed mass lying between vas deferens and muscular chamber of atrial duct, its lobes finger-shaped, one lobe extending backwards as far as muscular sac of atrial duct, second lobe lying transversely over narrow hind end of atrium and third lobe extending forwards and lying close to atrium. Prostate opens into atrium at its widest part in middle. Posteriorly atrium narrows to 12 μm thick and leads into a long convoluted atrial duct, distinguishable, an ental ovoid part of 36-45 μm long and 45 μm wide, with a lumen of about 2-3 μm in diameter and wall of considerable thickness and an ectal part consisting of convoluted, longer and much thinner than ental part, 12 μm thick with a lumen of 7 μm in diameter, opening ventrally in VII. Ectal part of atrial duct enclosed in an evertible penis (Fig. 80 F) when fully everted the outer surface of penis has several rows of minute teeth-like projections borne on a cuticular layer. Ovaries a pair in VII, 90 μm long, 18-27 μm wide, having longitudinal rows of minute oocytes, with a narrow stalk. Ovi-sac a back-pouching of septum 7/8, containing single large ovum. Female funnels not recognisable. Spermathecae (Fig. 80 E) a pair in VI, their ampullae pear-shaped, 65 μm high, and 35 μm wide at middle, continued ectally into 9 μm thick ducts, opening ventrally at level of ventral setae of VI, lost during sexual maturity. Ventral setae of VII modified into penial setae (Fig. 80 D-ps, G, H) 70-75 μm long, one on each side. They have double curve, without nodulus, and with a broad concave side of distal 1/3 of seta, with a boat-like excavation extending to tip. In VII two ovoid penial setal glands (Fig. 80 D-sg), 54 μm high, 37 μm wide, each surrounding penial setae, and open to outside, behind male pores.

Habits : Worm live in tubes at bottom of fresh-water lake Vellayani near Trivandrum (Aiyer, 1928). Hind part of body projects from tube and waved about.

Distribution : Trivandrum (Kerala).

World distribution : China, India (Asia); Russia (Europe); Brazil (South America).

Aulodrilus pigueti Kowalewski, 1914
(Fig. 81)

Aulodrilus pigueti Kowalewski, 1914 : 601.

Aulodrilus remex Stephenson, 1921 : 753.

Aulodrilus kashi Mehra, 1922 : 946

Aulodrilus stephensoni Mehra, 1922 : 963.

Aulodrilus remex, Stephenson, 1923 : 107.

Aulodrilus kashi, Stephenson, 1923 : 509.

Aulodrilus stephensoni, Stephenson, 1923 : 510.

Aulodrilus remex, Stephenson, 1923 : 107; Aiyer, 1925 : 35; 1929f : 81; Mendis & Fernando, 1962 : 45; Naidu, 1965a : 470; 1966 : 221; Vasisht & Gandhi, 1972 : 100; Ali & Issaque, 1975 : 60.

Aulodrilus pigueti, Naidu & Srivastava, 1980 : 269; Naidu & Naidu, 1981a : 536.

Aulodrilus stephensoni var. *anjani* Sharan, 1971 : 75.

Aulodrilus remex, Muhkhopadhyay, 1998 : 112.

l(p.) = 10-15 mm; d(p.) = 1.0-1.2 mm; s = 90-100 + undifferentiated region.

Description : Worms of medium size, cylindrical, pale red with ends pale yellow in life, posterior third of body slender. Prostomium bluntly conical. Dorsal setal bundles (Fig. 81 A) start in II with hair and needle setae. Hair setae (Fig. 81 B) bayonet-shaped, 84-119 μm long. Needle setae of 3 types, single-pointed, bifid and oar-shaped, single-pointed setae only in II, single-pointed and bifids in III-V, single-pointed, bifids and hair setae in VI-VII, bifids, oar-shaped (Fig. 81 C) and hair setae from VIII. Single-pointed and bifids similar in shape to those of ventral setae, except in single-pointed needle setae, distal tooth suppressed. In II needle setae 50-60 μm long, in III-VI 70-84 μm long and in others length gradually decreases from 70 μm to 56 μm. Nodulus distal in all needle setae (D : P :: 9 : 14). Ventral bundles have 6-8 bifid setae (Fig. 81 D) in II 59-63 μm long, in III-VI 70-84 μm long and in rest gradually decreasing from 63 to 49 μm, distal tooth thinner and shorter than proximal.

Buccal cavity globular in I lined with fine cuticle. Pharynx in II-III, wide, ciliated, its roof eversible through mouth in form of globular mass. Oesophagus in IV-VII narrow and wavy. Stomach absent. Intestine from VIII, wide and sacculated gradually narrowing posteriorly. Large clusters of pear-shaped cells occur in III, IV and V, close to ventral body wall on either side of nerve cord. Coelomocytes small, flat, translucent and of various shapes and sizes. Dorsal vessel ventro-lateral from hind end to VII and mid-dorsal in anterior 6 segments. Lateral contractile vessels a pair in VI, connect dorsal and ventral vessels. Body wall of posterior half of worm highly vascularised with plexuses. Brain small and crescent shaped. First nephridium in IX or X, succeeding

segments have one each, and in posterior segments, it is not found in every segment. Pre-septal funnel connected by a short duct to post-septal consisting of a long, highly coiled, ciliated duct opening by a nephropore ventro-laterally.

Clitellum in ½ VI-½VIII (2 segments). Testes and ovaries developed before formation of clitellum. Testes 2 pairs attached to posterior face of septa 4/5 and 5/6 laterally, of which posterior pair functional. Sperm-sac (Fig. 81 F-ss) single, a wide back-pouching of septum 6/7 extending to VIII. Ovaries (Fig. 81 F-ov) pair of whitish bodies attached on posterior face of septum 6/7 laterally below male funnels close to ventral body wall. Ovi-sac (Fig. 81 F-os) a wide back-pouching of septum 7/8 extending to X. Female funnels (Fig. 81 F-ff) on septum 7/8 with their pores lateral in grooves in clitellum at septum 7/8. Male funnels (Fig. 81 F-mf) on anterior face of septum 6/7 laterally, ciliated, 45-60 μm wide at mouth, each continuing into a vas deferens (Fig. 81 F-vd), 12 μm thick with a lumen of 5 μm in diameter and on passing into VII, forms a broad

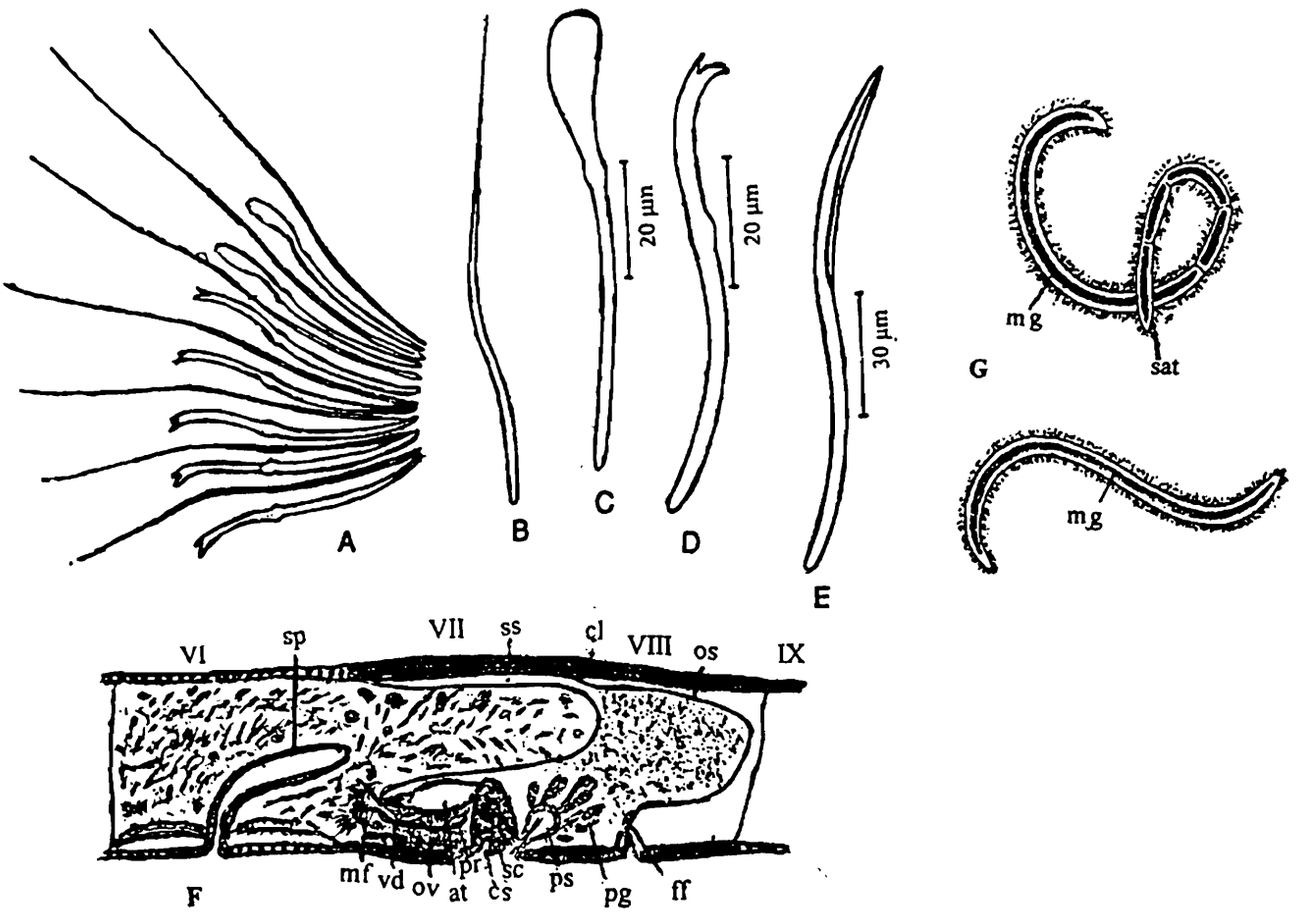

Fig 81 : *Aulodrilus pigueti.* A : Dorsal setal bundle; B : Hair seta; C : oar-shaped needle seta; D : Ventral seta; E : Penial seta; F : Genital organs; G : Protozoan astomatus ciliates. (A from Du Bois Raymond Marcus, 1947; F, G from Mehra, 1922). at : atrium; cl : clitellum; cs : coelomic sac; ff : female funnel; mf : male funnel; mg : meganucleus; os : ovi sac; ov : ovary; pg : penial gland; pr : prostate gland; ps : penial setal sac; sat : satellite; sc : spermathecal chamber; sp : spermatheca; ss : sperm sac; vd : vas deferens.

loop gradually rises upwards and opens into atrium apically. Atrial ampulla (Fig. 81 F-at) large, thick-walled with a ventral short bulbous ejaculatory duct opening to exterior by male pores separately side by side in a median depression, wide copulatory chamber. Prostate glands (Fig. 81 F-pr) compact opening into atrium near junction of vas deferens. Ventral setae of VII replaced by a pair of penial setae (Fig. 81 E) in each penial setal sac (Fig. 81 F-ps) 135-140 μm long in each bundle without nodulus and with double curve, distal curve with a boat-shaped excavation. Spermathecae (Fig. 81 F-sp) a pair of cylindrical sacs of uniform diameter opening ventrally close together in bursa about middle ventrally. Asexual reproduction by architomy and regeneration of 6 anterior segments to posterior fragment and several segments to anterior fragment. (Timm, 1981).

Habits : Worms generally live in soft mud in unbranched tubes of mucous, sand and clay particles along with one or all of *Aulophorus hymanae*, *Branchiodrilus semperi*, *Limnodrilus hoffmeisteri, Branchiura sowerbyi*. Posterior half of worm, used as respiratory organ is protruded beyond tube and waved about in water; when disturbed they disappear into mud leaving tubes empty and return to them after some minutes of stillness and wave hind part of body.

Parasites : Large number of parasites belonging to Astomatous ciliates (Fig. 81 G) are reported from the intestine of majority of worms from Agra (Mehra, 1922).

Distribution : India : Trivandrum (Kerala); Chittoor, Adoni, Cuddapah (Andhra Pradesh); Bangalore, Bellary (Karnataka); Powai Lake, Mumbai, Nagpur (Maharastra); Bhopal, Burhanpur (Madhya Pradesh); Varanasi (Uttar Pradesh); Chandigarh; Punjab; Haryana; Patna (Bihar); Midnapore, Lalbag in Midnapur district (West Bengal); Gauhati (Assam). Dhaka (Bangladesh); Sri Lanka.

World distribution : Cosmopolitan.

Aulodrilus pluriseta (Piguet, 1906)
(Fig. 82)

Naidium pluriseta Piguet, 1906 : 218.

Aulodrilus trivandranus Aiyer, 1925 : 36; Stephenson, 1925a : 884; Aiyer 1929a : 43; Mendis & Fernando, 1962 : 45.

Aulophorus pluriseta, Naidu, 1965a : 466; 1966 : 221; Ali & Rashid-u-Zaman, 1976 : 92; Naidu & Naidu, 1981a : 536.

Type locality : Unassigned, Switzerland.

l(p.) = 12-17 mm; d(p.) = 0.5-0.6 mm; s = 80-100 + undiferentiated region.

Description : Worms large, orange red, cylindrical, posterior half of body slender and tapering, ending in a narrow part which becomes abruptly narrow unsegmented achaetous gill. Prostomium bluntly conical, twice as broad as long. Dorsal setae begin

in II with 5 hair setae and 6 needle setae in II, 10-15 hair setae and 9-11 needle setae in preclitellar segments; 4-6 hair setae and 5-7 needle setae in post-clitellar segments, decreasing to 4, 3 and finally 2 hairs and needle setae each posteriorly. Hair setae (Fig. 82 A) 105-160 μm long, bifid needle setae (Fig. 82 B) 58-78 μm long, with nodulus a third from distal end (D : P :: 1 : 2), teeth equally long distal thinner than proximal. Ventral setae (Fig. 82 C, D) bifid, 11-14 per bundle in preclitellar segments, and 10-11 per bundle in post-clitellar segments, gradually diminishing to 3 per bundle posteriorly, 50-63 μm long with distal nodulus (D : P :: 7 : 11). Both bifid needle setae and ventral setae similar in shape, former slightly longer than latter. In ventral setae proximal tooth longer and thicker than distal.

Pharynx in II-III, wide, and slightly protrusible. Oesophagus in IV-VI, narrow. Stomach absent. Intestine starts in VII, narrow in VII-X and wide and sacculated in subsequent segments, again becoming narrow and tubular in undifferentiated region, where lumen increases and decreases alternately. Intestinal anti-peristalsis vigorous causing food particles to move up and down in undifferentiated region. Chloragocytes start in VI. Coelomocytes absent. Dorsal vessel attached to left of gut except in 6 anterior segments, where it is mid-dorsal. Lateral contractile vessels, stouter than dorsal vessel, in VI connecting dorsal and ventral vessels. Achaetous region posteriorly highly vascularised by vascular plexuses and acts as a gill. Brain more broad than long. Nephridia begin from IX, one per segment. Pre-septal funnel with a ciliated nephrostome in VIII, continues through a duct into post-septal consisting of an ampulla followed by a long coiled, ciliated duct, partly enclosed in gland tissue and opening to outside by a nephropore in front of ventral bundles in IX.

Clitellum in ½VI-VIII (2½ segments). Testes two pairs, both functional, pale white attached laterally to ventral body wall of V and VI behind septa 4/5 and 5/6. Sperm-sac single, posterior diverticulum of septum 6/7, extending to VIII filled with spermatozoa and sperm-morulae, partly filling ovi-sac. Ovaries a pair of pale white structures, attached to ventral body wall of VII next to septum 7/8. Male funnels (Fig. 82 E-es) a pair of large ciliated structures in VI on anterior face of septum 6/7, continue into a long coiled vasa deferentia (Fig. 82 E-cd), which open into club-shaped atria (Fig. 82 E-a) dorsally in VII. Atrium enclosed in a thick-walled pear-shaped coelomic sac, contraction of which evert atrium as a short cylindrical pseudo-penis (Fig. 82 E-p) with rough granular wall into copulatory chamber (Fig. 82 E-s). Male pores large transverse apertures in position of ventral setal bundles of VII. Ventral setae of VII and penial setae absent. Prostate glands (Fig. 82 E-pr) whitish, ovoid bodies, opening by short ducts into antria dorsally. Spermathecae (Fig. 81 F) a pair in VI, with long narrow, thin-walled cylindrical ampullae and thick-walled muscular ectal ducts, opening by transverse slits with wrinkled margins, slightly median and anterior to ventral bundles of VI. Spermatozoa in spermathecae, tightly packed together. Asexual reproduction by architomy and regeneration of 6 anterior segments to posterior fragment and several posterior segments to anterior fragment.

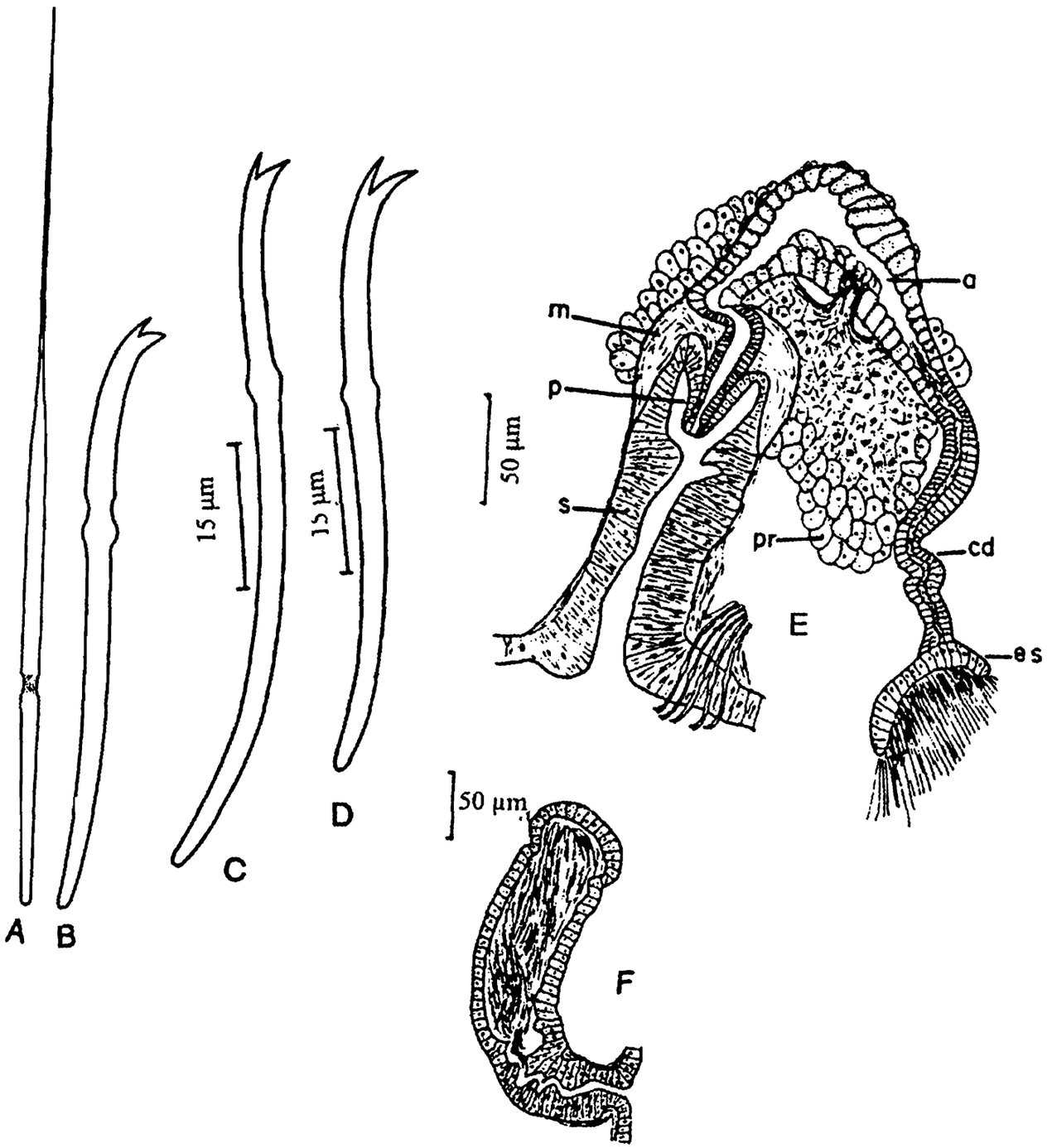

Fig 82 : *Aulodrilus pluriseta.* A : Hair seta; B : Dorsal needle seta; C, D : Ventral setae; E : Male efferent organs; F : Spermatheca; (A, D from Hiltunen, 1967; E, F from Giani Martinez Ansimil & Brinkhurst, 1984). a : atrium : cd : vas deferens; es : male funnel; m : muscle; p : pseudo-penis; pr : prostate gland; s : copulatory sac.

Habits : Worms live in tubes of mucous, sand and clay particles burying in mud protruding and waving hind part of their bodies. Separating them from tubes and objects that come in contact with them difficult as sticky mucous attaches worms to them. When disturbed they coil into small compact balls.

Commensals : Vorticellids (Protozoa, Ciliata) found attached to their setae. They live along with *Aulodrilus pigueti* in soft mud.

Distribution : India : Trivandrum (Kerala); Annamalainagar (Tamil Nadu); Bellary (Karnataka); Vehar Lake, Mumbai (Maharastra); Burhanpur (Madhya Pradesh); Varanasi (Uttar Pradesh). Dhaka (Bangladesh); Meegoda near Colombo (Sri Lanka).

World distribution : Cosmopolitan.

Subfamily TELMATODRILINAE Eisen, 1886

Telmatodrilinae Eisen. Brinkhurst & Jamieson, 1971 : 531; Chekavovskaya, 1980 : 24; Erseus, 1984 : 38.

Diagnosis : Prostate glands small and numerous opening by separate ducts into each atrium. Coelomocytes absent. Spermatozeugmata present.

Type genus : *Telmatodrilus* Eisen, 1879.

This subfamily includes two genera : *Telmatodrilus* Eisen, 1879 and *Alexandrovia* Hrabe, 1962, both occur in India.

Key to genera of subfamily TELMATODRILINAE

Hair setae present; body covered with secretion layer studded with detritus ... . ***Alexandrovia***

Hair setae absent, body not covered with layer of secretion ..... ***Telmatodrilus***

Genus ***Telmatodrilus*** Eisen, 1879

Telmatodrilus Eisen, 1879 : 8; Beddard, 1895 : 263; Stephenson, 1930 : 752; Brinkhurst, 1963 : 76; Brinkhurst, 1963 : 72; Brinkhurst & Jamieson, 1971 : 532.

Diagnosis : All setae simple pointed but occassionally bifid setae occur. Body surface not covered with secretion. Coelomocytes absent. Male efferent ducts with vasa deferentia moderately long, atria globular or tubular with several small discrete prostate glands with separate ducts discharging into them throughout entire length. Distal end on male gonoduct terminates in a pseudo-penis. Spermathecae present, spermatozoa not forming in spermatogonium. Spermatophores present. Penis present or absent. California in North America, Onega Lake in Europe; Kamchatka and India in Asia; Tasmania in Australia.

Type species : *Telmatodrilus vejdovskyi* Eisen, 1879.

Telmatodrilus multiprostatus Brinkhurst, 1971
(Fig. 83)

Telmatodrilus multiprostatus Brinkhurst, 1971 : 117; Brinkhurst & Jamieson, 1971 : 535; Oommachan & Belsare, 1986 : 58.

Type locality : Tasmania, Australia.

l = upto 16 mm; s = 65.

Description : Prostomium broadly conical. Setae (Fig. 83 A) all sigmoid, simple-pointed upto 8 in anterior bundles, decreasing to 3 per bundle in posterior segments. Superficial pores crescentic, lie within line of ventral setae of XI.

Pharynx with a cuticular lining and thickened roof provided with a large number of tall gland cells. Foregut narrow, telescoped into wider part of gut through V-VI.

Testes in X, elongate, protruding into anterior sperm-sac from 9/10 into XI. Male funnels (Fig. 83 B-mf) in posterior sperm-sac on 10/11. Vasa deferentia (Fig. 83 B-vd) less than twice as long as atria, entering atria apically. Atria (Fig. 83 B-at) elongate, pear-shaped, discharging into inverted sacs from body wall or eversible pseudo-penes. Minute rudiments of true penes at point of union of atria and pseudo-penes being distal end of atria lined with a cuticle and protruding slightly into pseudo-penes. Prostate glands (Fig. 83 B-c) several on each atrium, each entering separately in upper third of atrium, lower third of atrium covered in tissue, possibly a post-prostate gland. Ovaries in XI on 10/11, near midline on posterior wall of sperm-sac. Spermathecae large, bilobed in X, containing spermatozeugmata. Spermathecal seta single, large spatulate in ventral bundles of X in large sacs and their associated

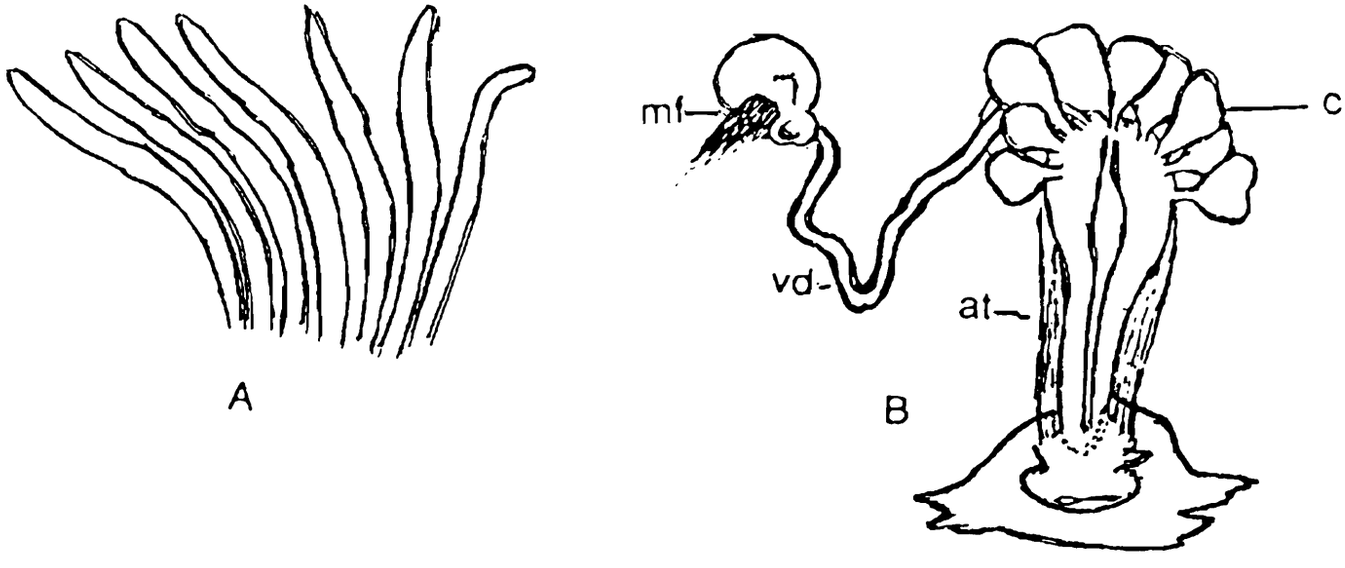

Fig 83 : *Telmatodrilus multiprostatus*. A : Anterior setal bundle; B : male efferent organs (all from Brinkhurst & Jamieson, 1971). at : atrium; c : prostate glands; mf : male funnel; vd : vas deferens.

glands fill posterior sperm-sacs which protrude into XI. Spermathecal pores lie outside line of ventral setae, lateral and anterior on X. Female pores not observed.

Distribution : India : Bhopal (Madhya Pradesh).

World distribution : India; Tasmania (Australia); New Zealand.

Genus ***Alexandrovia*** Hrabe, 1962

Alexandrovia Hrabe, 1962 : 326; Chekanovskaya, 1980 : 19.

Diagnosis : Dorsal bundles with hair-like bristles, and ventral bundles with bifid setae. Body covered with a layer of secretion studded with detritus but without lump. Multiple gland cells present in body wall. Anterior two segment can be withdrawn into III segment. Prostate glands 10-17 with separate ducts discharging into atrium as in *Telmatodrilus,* Vas deferens very long, atrium ends in pseudo-penis. Spermathecal setae long and slender with curved distal end. Russia.

Type species : *Alexandrovia* Hrabe, 1962.

Alexandrovia onegensis Hrabe, 1962
(Fig. 84)

Alexandrovia onegensis Hrabe, 1962: 291.

Telmatodrilus onegensis, Brinkhurst & Jamieson, 1971: 534; Oommachan & Belsare, 1986: 59.

Type locality : Onega Lake, Russia.

l : 10-20 mm; d: 0.85 mm on segment II; s: upto 35.

Description : Prostomium short, distal part rounded, mostly retracted together with peristomium and foremost part of II segment into anterior part of body. Body wall with sensory papillae (Fig. 84 A-p) covered with secretion layer (Fig. 84 G-s) mixed with numerous mineral particles. Anterior dorsal bundles with 3-6 long hair setae and some short hair like needle setae. Ventral bundles with 3-4 bifid setae (Fig.84 B-E) decreasing to 2 behind clitellum and 1 per bundle in posterior segments. Ventral setae of II with distal tooth pointed, thinner and twice as long as proximal, distal tooth progressively shorter in more posterior bundles until teeth equally long and equally thick at the base posteriorly.

Pharynx in III-IV, ducts of pharyngeal cells open between epithelial cells into pharyngeal cavity. Intestine begin from V with chloragogen cells covering from later half of V. First two pairs of nephridia in VII and VIII. Brain without a large posterior projection. In mature worms bases of posterior part of lateral nerves in anterior segments and 4 anterior segments with large glandular cells filled with vacuoles without granular secretion.

Clitellum in X-XI. Layer of secretion with detritus absent on clitellum. Testes (Fig 84 G-t) in X attached to 9/10. Male funnels (Fig. 84 G-mf) on 10/11 in posterior sperm-sac on 10/11. Vasa deferentia very long, with ental end 24 μm wide, ectal end 30 μm wide, enter short cylindrical atrium. Atrium 340 μm long, 44-64 μm wide, terminating in ectal eversible ejaculatory duct surrounded by 10-17 globular or ovoid prostate glands opening individually into atrium. Male pores a pair in XI in place of ventral bundles. A circular wall of ejaculatory duct, pseodo-penis present. Ovaries in XI attached to10/11. Oviducts a pair on 11/12. Penes rudimentary in eversible penis sacs. Spermathecae with straight ovoid ampullae (Fig 84 G-sp) 160 μm long, contain spermatozeugmata, with short and narrow ducts open in X in line of ventral setae.

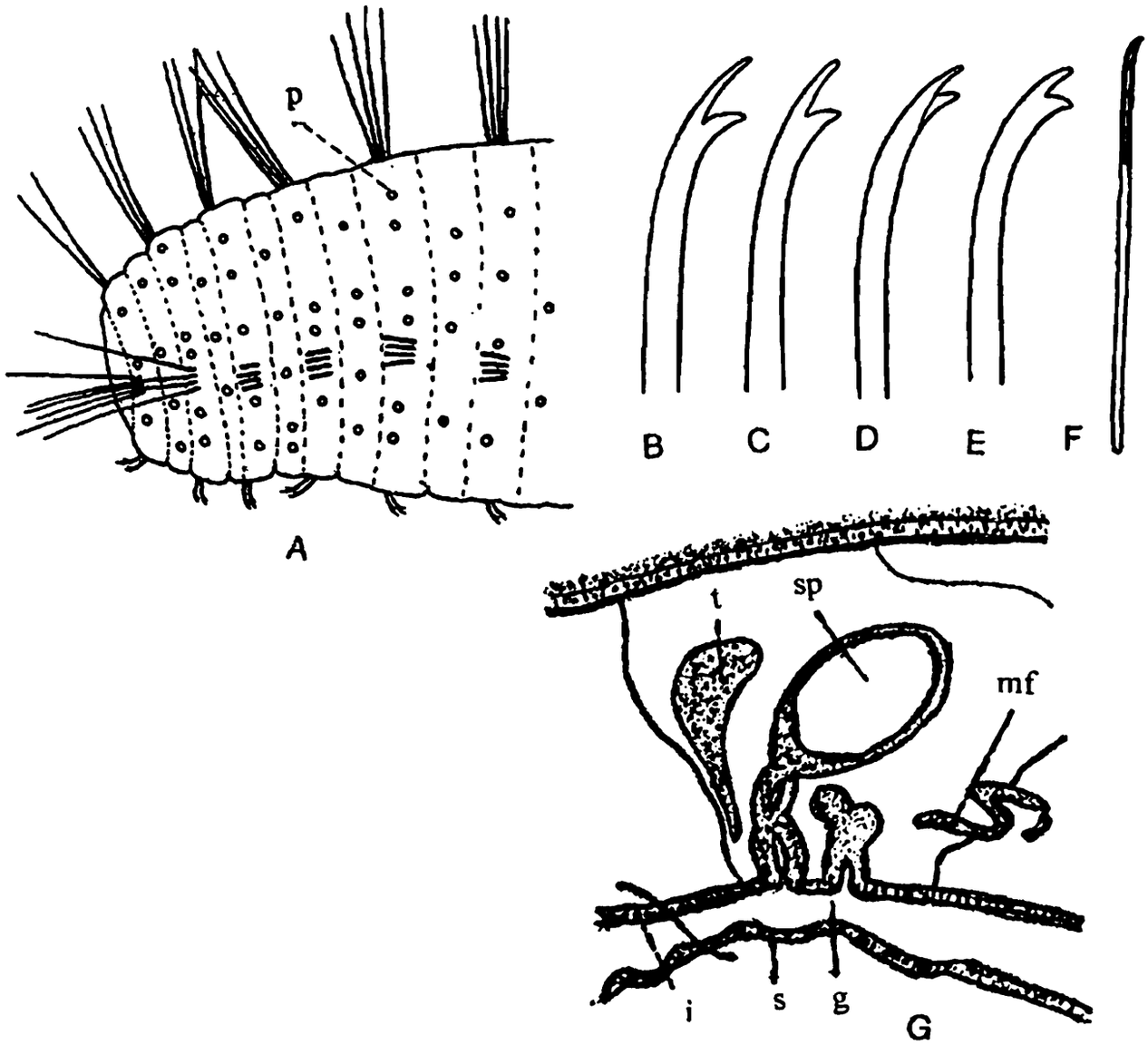

Fig 84 : *Alexandrovia onegensis.* A : Anterior end of worm, lateral view; B-E : Distal part of ventral setae, B of II, C of III, D of XV, E of posterior segment; F : Spermathecal seta; G : L. S. through X; (all from Hrabe, 1962). g : gland of spermathecal seta; i : epidermis; mf : male funnel; p : sensory papilla; s : layer of secretion; sp : spermatheca; t : testis.

Spermathecal setae (Fig.84 F) 160 μm long, straight with a groove in ectal third with slightly curved ectal end. Spermathecal pores, a pair in X in lines of ventral setae behind 9/10 in front of spermathecal setae.

Distribution : India : Bhopal (Madhya Pradesh).

World distribution : India; Lake Onega (Russia).

Family PHREODRILIDAE

Phreodrilidae. Stephenson, 1923 : 108; 1930 : 754; Brinkhurst & Jamieson, 1971: 627; Brinkhurt, 1981: 106.

Diagnosis : Dorsal setae from III or V, hairs and very small needles, or restricted to a few posterior segments. Ventral setae 2 per bundle, often slightly dissimilar in length and thickness, often one simple-pointed and one bifid setae in each pair. Pharynx with eversible roof, with tall ciliated cells and pharyngeal glands (at least in *Phreodriloides*), but these may be missing in other taxa. Septal glands in IV or V to VII or VIII, loose cellular aggregations. Nephridia restricted to a few pre-clitellar segments, or a single large nephridium in VII. Testes in XI, ovaries in XII, sperm-sacs and ovi-sacs mostly present, male pores on XII, female pores in 12/13, spermathecal pores in XIII. Reproductive segments shifted two segments forward in some taxa. Spermathecae may be duplicated. Spermathecal setae modified or not modified. Spermatophores and spermathecal diverticula absent. Southern hemisphere.

Type genus : *Phreodrilus* Beddard, 1891.

Family Phreodrilidae is divided into two subfamilies: Phreodrilinae Brinkhurst, 1991 with two genera *Phreodrilus* Beddard, 1881 and *Antarctidrilus* Brinkhurst, 1965 and Phreodrloidinae Brinkhurst, 1991 with three genera *Phreodriloides* Benham, 1907, *Schizodrilus* Stout, 1958 and *Astacopsidrilus* Goddard, 1909. Of these subfamily Preodriloidinae with single species occurs in the subcontinent.

Subfamily PHREODRILOIDINAE Brinkhurst, 1991

Phreodriloidinae Brinkhurst, 1991: 2039.

Diagnosis : Worms with ventral spermathecal pores. (Paraphylectic).

Type genus : *Phreodriloides* Benham, 1907.

Genus ***Phreodriloides*** Benham, 1907

Phreodriloides Benham, 1907 : 260; Brinkhurst & Jamieson, 1971 : 627.

Diagnosis : Resembles *Phreodrilus*. Sperm duct opens into a muscular, but non-glandular atrium containing spermatozoa, which in turn opens to exterior in XII.

Worms without ventral spermathecal vestibules, without pendent eversible penes. (Paraphyletic).

Type species : *Phreodriloides* Benham, 1907.

Phreodriloides zeylanicus (Stephenson, 1913)
(Fig. 85)

Hespirodrilus zeylanicus Stephenson, 1913b : 257.

Phreodrilus zeylanicus (Stephenson). Stephenson, 1923 : 109; 1930 : 257.

Phreodrilus (*Phreodriloides*) *zeylanicus,* Brinkhurst, 1965b : 389.

Phreodriloides zeylanicus, Brinkhurst, 1991 : 2039.

Type locality : Nuwara Eliya, Sri Lanka, Asia.

l(p.) = 8 mm; d(p.) = 0.6 mm; s = 34 + undifferentiated region.

Description : Worms of medium size, cylindrical. Prostomium short, bluntly conical, about equal to length of body segment. Dorsal setae begin in III, all hair setae, 4-5 per bundle, varying in thickness, some much stouter than others, longest equal to diameter of body. Ventral setae as a rule 2 per bundle, except in VII and XIV, where they are 4 per bundle, one simple-pointed (Fig. 85 A) and other bifid seta, both having usual double curve. Bifid setae (Fig. 85 B) 118-123 μm long and 6.3 μm thick, distal tooth much smaller, about half as long as proximal, nodulus distal (D : P :: 45 : 73 or 47 : 76), considerably thicker than single pointed setae. Single-pointed setae about same length as bifid setae and 3.4 μm thick, but curves of shaft slightly less pronounced, nodulus absent.

Buccal cavity in I-½II, and its epithelium flat, but its roof lined with ciliated columnar epithelium. Pharynx in ½II-III, wide. Oesophagus in IV-VII, narrow. Stomach absent. Intestine starts in VIII, wide. Septal glands present on septa 4/5, 5/6, 6/7 and 7/8. Brain intimately attached to roof of pharynx. Ventral nerve-cord closely united with ventral body-wall, which in transverse section shows a median ventral groove externally corresponding to nerve cord. There are 3 giant fibres in cord, middle one largest.

Clitellum in 1/5 XII-XIII (11/5 segments) absent ventrally in XII. Testes a pair in XI. Sperm-sac absent, but sperm morulae found in X and XI dorsal to intestine. Male funnels a pair on anterior face of septum 11/12 laterally; vas deferens about 12-15 μm in diameter, ventral to intestine in XII, running forwards from level of septum 13/14 and arching dorsally to enter atrium at latter's proximal end. Atrium conspicuous glandular structure, vertically elongated, situated in anterior part of XIII, narrowing towards its lower end and prolonged obliquely forwards to male pores on XII. Ventral setae absent in XII. Spermathecae two ovoid sacs situated dorsally, first one 80 μm long, 70 μm wide in XIV with a long narrow duct of 20 μm in diameter leading

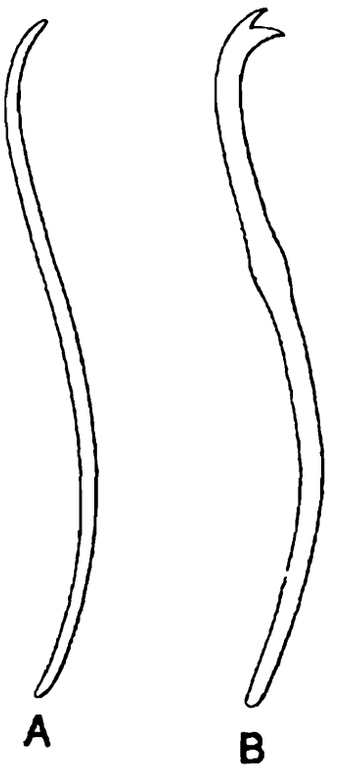

Fig 85 : *Phreodriloides zeylanicus.* A : Single pointed ventral seta; B : Bifid ventral seta. (from Stephenson, 1913b).

directly ventralward, and second in XVI, 120 μm long, 95 μm wide, with a duct wider at first, narrowed gradually, lead downwards and then forwards ventral to setae in XV, and open in or near intersegmental groove 14/15. Penes and penial setae absent.

Distribution : Known only from type locality.

Family ENCHYTRAEIDAE Henle, 1837

Enchytraeidae Beddard, 1895 : 308; Stephenson, 1923 : 110; 1930 : 759; Nielsen & Christensen, 1959 : 89; Chekanovskaya, 1962 : 292; Brinkhurst & Jamieson, 1971 : 655.

Diagnosis : Small worms, aquatic and terrestrial in habit, whitish or in some genera pinkish in colour. Setae mostly in four bundles per segment; dorsal and ventral setae similar in form, single-pointed (except in *Propappus),* without distinct nodulus. Gizzard absent. Septal glands present, connected with septum 4/5 and some following segments (except in *Propappus).* Dorsal vessel exists only in anterior part of body, and its hinder end joining intestinal plexus. Nephridia usually of compact form, a solid mass within which canal undergoes a number of windings. Testes and ovaries in XI and XII respectively. Male funnels as a rule elongated, cylindrical, composed of large glandular cells; deferent tube usually with glandular and muscular termial apparatus, ending on XII. Spermathecae usually in V, opening in and behind furrow 4/5, not infrequently communicating with oesophagus. (Occasionally male and female

oragans displaced 3 or 4 segments forward, spermathecae keeping their typical position. Cosmopolitan.

Type genus : *Enchytraeus* Henle, 1837.

This family consists of following 24 genera: *Enchytraeus* Henle, 1837, *Fridericia* Michaelsen, 1889, *Hemienchytraeus* Cernosvitov, 1936, *Henlea* Michaelsen, 1889, *Marionina* Michaelsen, 1889, *Stephensoniella* Cernosvitov, 1934, *Buchholzia* Michaelsen, 1887, *Cernosvitoviella* Nielsen & Christensen, 1959, *Achaeta* Vejdovsky, 1877, *Chirodrilus* Smith & Verril, 1871, *Cognettia* Nielsen & Christensen, 1959, *Enchylea* Nielsen & Christensen, 1963, *Enchytraeina* Bulow, 1958, *Bryohenlea* Cernosvitov, 1934, *Bryodrilus* Ude, 1892, *Enchytronia* Nielsen & Christensen, 1959, *Grania* Southern, 1913, *Guaranidrilus* Cernosvitov, 1937, *Hemifridericia* Nielsen & Christensen, 1959, *Lumbricillus* Ørstead 1844, *Mesenchytraeus* Eisen, 1878, *Propappus* Michaelsen, 1905, *Stercutus* Michaelsen, 1888, and *Aspidodrilus* Baylis, 1914. Of these first six genera occur in the Indian subcontinent.

Key to Indian genera of *Enchytraeidae*

1. Spermathecae not connected to oesophagus ..... *Hemienchytraeus*
– Spermathecae connected to oesophagus 2
2. Peptonephridia present 3
– Peptonephridia absent 4
3. Preseptale of nephridium with funnel only ..... *Enchytraeus*
– Preseptale of nephridium with funnel and nephridial canal ..... *Fridericia*
4. Transition between oesophagus and intestine abrupt ..... *Henlea*
– Transition between oesophagus and intestine gradual 5
5. Seminal vesicles absent ..... *Marionina*
– Seminal vesicles present ..... *Stephensoniella*

Genus ***Enchytraeus*** Henle, 1837

Enchytraeus Henle. Beddard, 1895 : 335; Stephenson, 1923 : 113; 1930 : 772; Nielsen & Christensen, 1959 : 89; Chekanovskaya, 1962 : 305; Brinkhurst & Jamieson, 1971 : 660.

Diagnosis : Setae straight with single pointed tips and without nodulus, sometimes missing on some segments. Head-pore at 0/I, dorsal pores absent. Brain rounded posteriorly. Oesophagus merging gradually into intestine. Paired, unbranched peptonephridia present. Oesophageal appandages and intestinal diverticula absent. Dorsal vessel arising in or behind clitellar region. Blood colourless or faintly yellowish. Three pairs of primary septal glands present; secondary glands absent. Interstitial

tissue of nephridia well developed, pre-septale consisting of funnel only; efferent duct usually of postero-ventral origin. Male funnels cylindrical, vas deferens confined to XII or quite long extending backward through several segments. Sperm-sacs present and usually well developed. Penial bulb present. Male pores without atrial glands. Spermathecae simple, communicating with oesophagus. Ectal duct usually with glands. Small to large species in marine rarely fresh-water, limnic and terrestrial habitats. Cosmopolitan.

Type species : *Enchytraeus albidus* Henle, 1837.

Key to Indian species of genus *Enchytraeus*

Dorsal setae 3, ventral setae 4 per bundle, 95-110 μm long; spermathecae sac-like with long diverticulum; penial body bulbous with 20-30 accessory glands; sperm-sacs present ..... *Enchytraeus albidus*

Dorsal setae 2, ventral setae 3 per bundle, 50 μm long; spermathecae small, spherical or ovoid; penial body small, spherical or ovoid without accessory glands; sperm-sacs absent ..... *Enchytraeus indicus*

Enchytraeus albidus Henle, 1837
(Fig. 86)

Enchytraeus albidus Henle, 1837 : 74; Rao & Ganapati, 1968 : 111

Type locality : Unknown.

l(p) = 20-35 mm; d(p) = 0.5-1.0 mm; s = 52-74.

Description : Worms of medium to large size, whitish, rarely yellowish translucent in life. Prostomium bluntly conical, with a head pore between it and I segment. Dorsal pores absent. Both dorsal and ventral setae begin in II, straight with proximal end slightly or sharply curved. Dorso-lateral pre-clitellar setae 2, 3, 4, normally 3 per bundle; dorso-lateral post-clitellar setae 2 or 3, normally 3 per bundle; ventro-lateral pre-clitellar setae 3, 4, 5, normally 4 per bundle; ventro-lateral post-clitellar setae 2, 3 or 4, normally 3 per bundle. Setae (Fig. 86 A, B) 95-110 mm long, about 10 μm thick, without nodulus. As a rule sexual worms lose setae on XII.

Mouth in I, buccal cavity in II with a small mass of a tongue on its floor. Pharynx in III with a characteristic roof of pallisade cells, from dorsal tips of these cells a duct runs posteriorly to drain septal glands situated on septa 4/5, 5/6 and 6/7. Behind pharynx in III, a dorsal diverticulum of gut gives rise to a pair of salivary glands (peptonephridia). At first single, peptonephridium divides as it passes through septum into IV, each branch forming an elongated sac-like structure, unbranched but with rugose walls, lying against septal gland behind and extending to ventral reaches of coelom of IV. Oesophagus enlarges gradually to become intestine, it has no other

diverticula or glands. Stomach absent. Chloragocytes (Fig. 86 C) cover gut from V, small, 20 μm in height with a few granules; from VI to hind end, 50 μm in height and clear. Coelomocytes (Fig. 86 D) abundant, flat, elliptic to spindle-shaped, 35 μm long, 10-25 μm wide and 4 μm thick. Brain (Fig. 86 E) 180 μm long, 120 μm wide, with its anterior margin between nerves broadly concave, posterior margin slightly concave, in postero-lateral margin, with 1-3 small aggregations of refractive globules on either side. Transverse section of brain elliptic in outline. Anterior margin of brain situated in prostomium and posterior margin at first setal bundle in II. Ventral nerve-cord fairly cylindrical, not enlarged segmentally, with a canal in its mid-dorsal region from VII to hind end. Blood colourless. Dorsal vessel arises from dorsal portion of blood sinus between XII and XVII, runs forward without special swellings or valves and comes to lie beneath brain in II, dividing into 2 branches, passing ventralward and backward to unite to form sub-intestinal vessel in III. Lateral commissural vessels in III-V. First nephridia (Fig. 86 F) in VII. with their preseptal funnel with nephrostomes in VI. Each nephridium consists of a preseptale composed of a funnel (Fig. 86 F-pf) with a nephrostome of about 50 μm long, and a stalk, and a postseptale (Fig. 86 F-p) of about 250 μm long, 150 μm wide, 50 μm thick, composed of a mass of fine, ciliated tubules bound into a solid body, from end of which excretory duct arises and passes to form a bladder at end and opens just anterior to ventral setae.

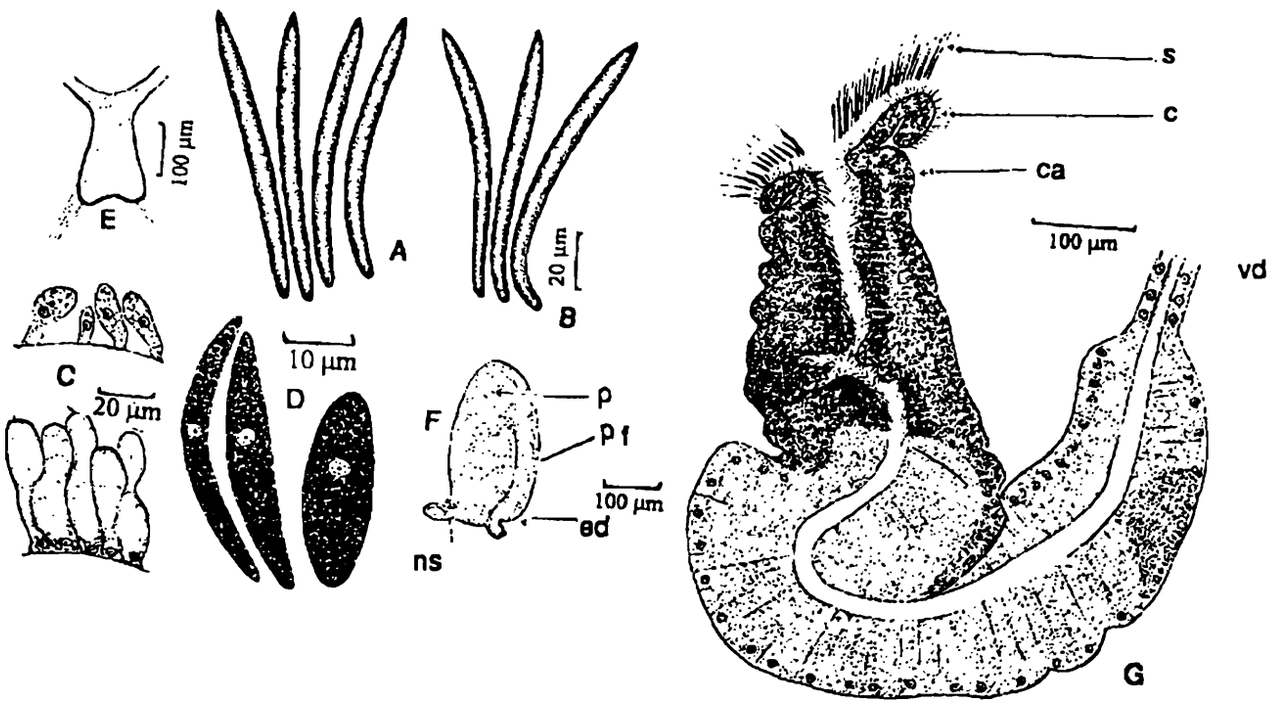

Fig 86 : *Enchytraeus albidus.* A, B : Ventral setae of VI and LII; C : Chloragocytes; D : Coelomocytes; E : Brain; F : Nephridium; G : L. S. of male funnel (all from Bell, 1958). c : collar; ca : ciliated gland cell; ed : ectal duct; ns : nephrostome; p : post-septale; pf : pre-septal funnel; s : sperm; vd : vas deferens.

Clitellum in XII-XIII (2 segments), slightly elevated with gland cells scattered irregularly. Testes a pair situated at base of septum 10/11 in XI, at first covered by a peritoneal membrane, but at sexual maturity, it is ruptured by prodigious growth of spermatogenic tissue. Sperm-sac forward pouching of septum 10/11 extending to X. Male funnels (Fig. 86 G) large, 1200 μm long, 200 μm wide, each folded upon itself into U-shape, lying beside gut in XI. Mouth of funnel has a collar (Fig. 86 G-c), broad on one side. In sexually mature worms, vast number of sperm cells (Fig. 86 G-s) lie parallel to one another towards mouth of funnel. Cavity of funnel large and ciliated in its first quarter. Vas deferens (Fig. 86 G-vd) begins at end of funnel, 50 μm wide and extends posteriorly to XIV-XX, decreasing to 25 μm before making its exit at penial body in XII. Penial body consists of a central bulb, surrounded by 20-30 or more accessory glands, which empty together with vas deferens, into a deep ectodermal depression in XII. Ovaries a pair in XII at base of 11/12, just anterior to penial bulb, from these small masses of oocytes released into body-cavity, and from them single cells develop, one at a time, into large ova, requiring 2 or more segments to contain them. Oviduct, female funnel and ovi-sac absent. Ova liberated directly to outside through an inconspicuous pore posterior to male pores. Spermathecae in V, each consists of a sac-like ampulla with a fairly large diverticulum of about 200 μm long, and an ectal duct of about 200 μm long, and 30-40 μm wide. Its ental duct very short with which ampulla directly connected to side of oesophagus. Ectal duct possesses a rich covering of gland over its distal half.

Habits : Worms were collected from sand and mud mixed with effluent at edge of sea at Visakhapatnam.

Parasites : Astomatous ciliate, *Radiophrya elongata* Puytorac, 1954 is reported from the gut of this species (Puytorac, 1954).

Distribution : India : Visakhapatnam harbour (Andhra Pradesh).

World distribution : Cosmopolitan.

Enchytraeus indicus Stephenson, 1912
(Fig. 87)

Enchytraeus indicus Stephenson, 1912a : 238; 1923 : 115; Subbarao & Venkateswararao, 1980a : 222.

Type locality : Mumbai, Maharastra, India.

l(p) = 4 mm; d(p) = 0.3 mm; s = 31.

Description : Worms small, filiform, brownish in colour. Prostomium short, and bluntly conical, with a head pore between it and I segment. Dorsal setae 2 per bundle throughout, 50 μm long, without nodulus, shaft straight with a slight proximal curve, gently swollen towards middle and free extremity pointed. Ventral setae (Fig. 87 A) 3 per bundle in II-XI, absent in XII, 2 per bundle from XIII to hind end.

Buccal cavity in I, tubular lined by low cubical epithelium. Pharynx in II-III, wide, with a protrusible roof. Oesophagus narrow, and ciliated in IV-VI, a little wider in VII and VIII, continues thus to XIII and in XIV, becoming wide intestine. Cilia specially long in VII-XI. Septal glands 3 pairs on 4/5, 5/6 and 6/7, last pair united ventrally beneath oesophagus. Peptonephridia narrow coiled tubes in IV. Dorsal vessel begins in XIII and runs forward, dividing into two just behind mouth and branches descend down on either side of pharynx and unite into ventral vessel in V. Brain large in II with dorsal vessel closely applied to it underneath, slightly convex behind. Nephridia (Fig. 87 B) of compact type start in V, with a small pre-septal part with ciliated nephrostome (Fig. 87 B-ns) and post-septal part, with a long coiled nephridial duct (Fig. 87 B-nd) enclosed in glandular mass (Fig. 87 B-g) which passes downwards and backwards opening by nephropore (Fig. 87 B-np).

Clitellum in XII-XIII (2 segments), absent mid-ventrally. Testes a pair in XI attached laterally to septum 10/11. Sperm-sacs absent. Male funnels a pair in XI, small, succeeded by vasa deferentia of 7-8 μm thick, passing through septum 11/12, coiled in anterior part of XII, but straight in its posterior part. Penial body in posterior part of XII, spherical, 40-45 μm in diameter and opens ventrally by a wide aperture. Ovary attached on posterior face of septum 11/12. Ova found in all segments from VIII-XII, segment XII largely filled by ova. Female funnels backward depressions of septum 12/13 on each side, at its ventral attachment to body wall, whence short, narrow oviduct leads directly to outside. Spermathecae a pair in V, their ampullae

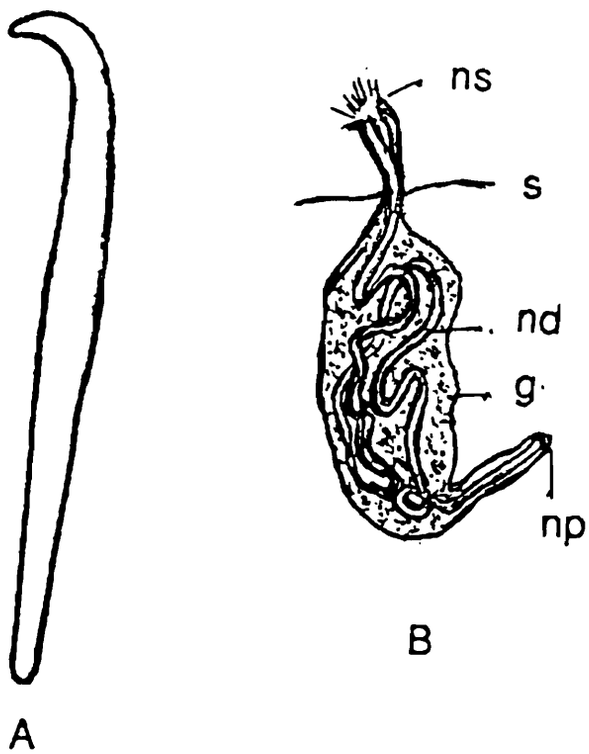

Fig 87 : *Enchytraeus indicus.* A : Seta; B : Nephridium. g : gland; nd ; nephridial duct; np : nephropore; ns : nephrostome; s : septum.

small, spherical or ovoid, 30 μm in diameter, probably communicates with oesophagus through their ental ducts, several times longer than ampullae, their ectal ducts open to exterior in inter-segmental groove of IV/V.

Habits : Worms were found in egg membranes of pond snail *Ampullaria* sp. in Mumbai.

Distribution : India : Visakhapatnam (Andhra Pradesh); Mumbai, (Maharastra).

World distribution : Known only from India.

Genus ***Fridericia*** Michaelsen, 1899

Fridericia. Stephenson, 1923 : 111; Nielsen & Christensen, 1959 : 68; Chekanovskaya, 1962 : 302.

Diagnosis : Head pore at 0/I. Dorsal pores on all segments from about VII. Setae straight without nodulus. Innermost setal bundles pair wise shorter than outer ones. Setae 2-16 per bundle. Oesophagus merges gradually into intestine. Peptonephridia present. Oesophageal and intestinal divericula absent. Coelomocytes two kinds, large nucleated and small hyaline, anucleated. Brain rounded or truncated posteriorly. Septal glands 3 pairs. Blood colourless or (rarely) coloured. Dorsal vessel begins in post-clitellar region. Nephridial interstitial tissue well developed; pre-septale large, oval with coils of nephridial duct arising ventrally or terminally on post-septale. Testes, all compact; seminal vesicles present or absent. Ovi-sac absent. Sperm funnel cylindrical; vas deferens long, narrow, in XII. Penial bulb present. Spermathecae simple or with diverticula; ectal duct long, often with glands at ectal opening; entally communicate with oesophagus. Small to large species mostly occurring in terrestrial habitats, sometimes in limnic surroundings. Cosmopolitan.

Type species : *Fridericia callosa* (Eisen, 1899).

Fridericia bulbosa (Rosa, 1887)
(Fig. 88)

Neoenchytraeus bulbosus Rosa, 1887 : 2.

Fridericia bulbosa Stephenson, 1914b : 334; 1923 : 111; Rao & Ganapati, 1968 : 111; Rao, 1969 : 98.

Type locality : ?Italy.

l(p) = 8-18 mm; d(p) = 0.4 mm; s = 32-70.

Description : Worms pale white, transparent. Cutaneous glands small in 1-3 rows on each segment. Prostomium rounded. Head pore at 0/I. First dorsal pore anteriorly in VII. Setae in bundles of 3-5 in anterior and 2 in posterior segments, maximum length of setae about 60 μm.

Pharynx in ½II-III. Oesophagus in IV with several branches directed cephalad, then pass back into V, giving off branches in IV and 4 or 5 branches in V, which pass caudad for 80-100 μm, then gradually widens into intestine without diverticula or pouches. Septal glands 3 pairs on 4/5, 5/6, 6/7, last pair with a lobe cephalad. Peptonephridia start as simple, very wide tubes, taper considerably and terminate on level with spermatheca, usually entire but may have one or two, rarely three, terminal or subterminal branches. Branching may be absent in some. with pouches on ventral surface. Chyle cells (Fig. 88 A-ch) in middle of XIII to middle of XVI, with intracellular duct straight and narrow, bent and slightly distended only at innermost end. .Chloragocytes (Fig. 88 A-cc) well developed. Coelomic cavity contains numerous detached setae. Brain (Fig. 88 C) truncated behind and slightly convex in front. Coelomocytes (Fig. 88 D) elliptical, 10-12 x 20 μm in size, non-granular. Dorsal vessel arises in XVI-XVII. A cardiac gland, when present poorly developed. Nephridia (Fig. 88 F) large with pre-septale shorter than post-septale with winding duct in both.

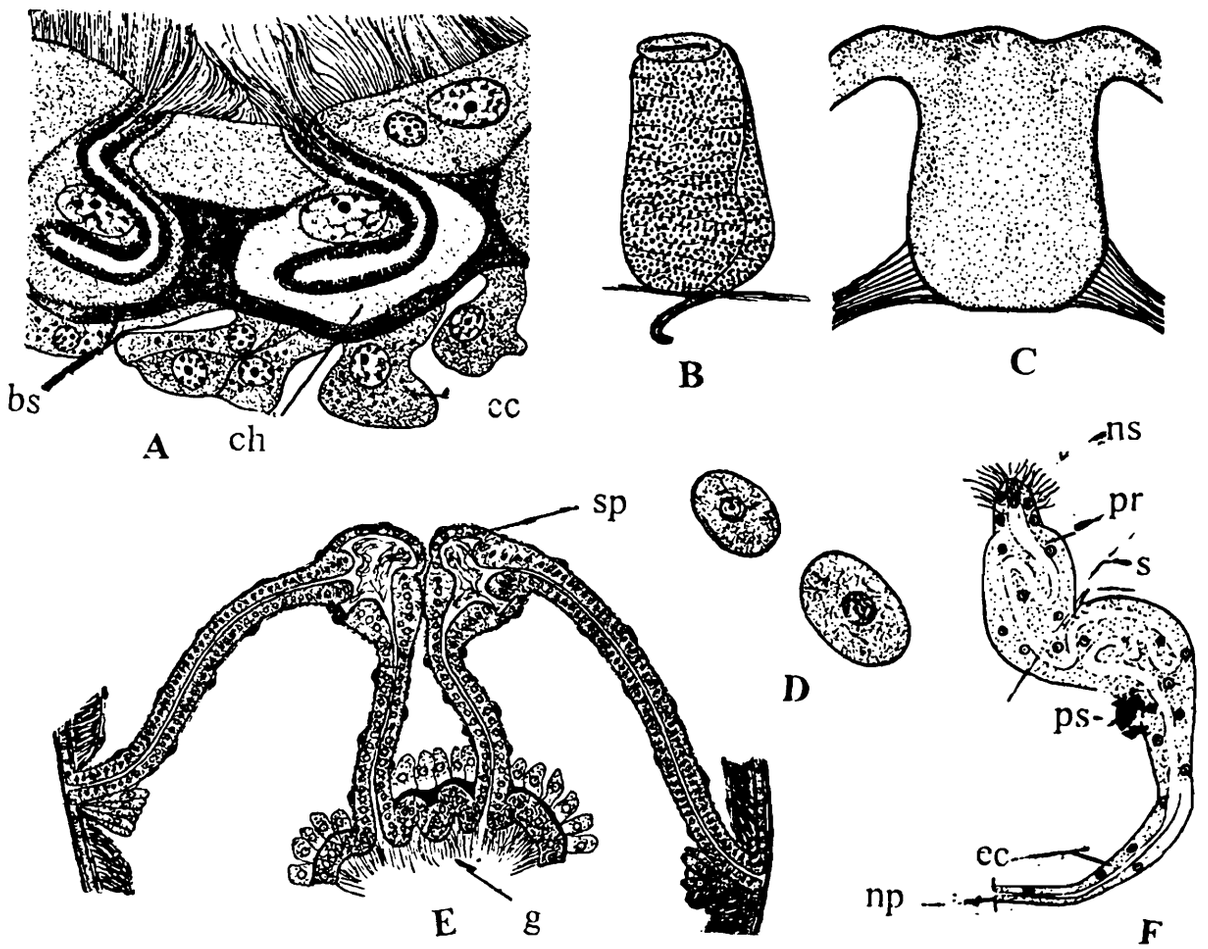

Fig 88 : *Fridericia bulbosa.* A : C. S. through XV showing intestine and chyle cells; B : Sperm funnel, lateral view; C : Brain, dorsal view; D : Coelomocytes; E : Section showing relationship of spermatheca with gut and body wall; F : Nephridium in XVII. (all from Bell, 1942). bs : blood sinus; cc : chloragocytes; ch : chyle cells; ec : excretory duct; g : gut; np : nephropore; ns : nephrostome; pr : pre-septale; ps : post-septale; s : septum; sp : spermatheca.

Clitellum from XII-½XIII and slightly elevated, and its gland cells not arranged in distinct rows. Paired testes in XI and ovaries in XII. Sperm-sacs absent. Male funnel broadly ovoid 1½-2 times longer than wide, with a constricted and everted delicate collar, about 150 x 80 μm in size. with small anterior collar. Vas deferens begins behind 11/12, coiled and restricted to XII. Penial bulb lumbricillid type. Spermathecae (Fig. 88 E-sp) with bulbous ampulla, without diverticula, about 1/3 length of ectal duct. Ental duct about half of ectal duct length, communicate with oesophagus dorso-laterally in V. Their ectal duct possess 1, rarely 2, usually stalked gland at ectal orifice. Spermatozoa abundant in ampulla. Copulatory glands in XIII and XIV.

Chromosomes : n = 32 (Nielsen & Christensen, 1959).

Habits : Inhabits brakish and salt water, rarely in fresh water.

Distribution : India : Waltair beach (Andhra Pradesh); Orissa beach (Orissa). Wagah near Lahore (Pakistan).

World distribution : Cosmopolitan.

Genus ***Hemienchytraeus*** Cernosvitov, 1935

Hemienchytraeus Cernosvitov, 1935 : 303; Nielsen & Christensen, 1959 : 44.

Diagnosis : Setae straight, 2 in all segments. Head pore on prostomium. Dorsal pores absent. Brain slightly incised or rounded posteriorly with strong circum-pharyngeal connectives. Transition between oesophagus and intestine gradual or sudden. Dorsal salivary glands unpaired. Oesophageal and intestinal diverticula absent. Primary septal glands 3 pairs. Dorsal blood vessel begins in clitellar region. Blood colourless. Nephridia with well developed interstitial tissue; pre-septale large consisting of a funnel and post-septale with coiled nephridial duct. Origin of efferent duct variable in position. Vasa deferentia long, coiled into a spiral. Penial bulb compact, but often much reduced in size. Spermathecae simple, not communicating with oesophagus. Cosmopolitan.

Type species : *Hemienchytraeus stephensoni* (Cognetti, 1927).

Hemienchytraeus stephensoni (Cognetti, 1927)
(Fig. 89)

Enchytraeus cavicola Stephenson, 1924b : 127.

Enchytraeus rangoonensis Stephenson, 1931c : 177.

Hemienchytraeus stephensoni (Cognetti, 1927), Cernosvitov, 1935 : 303; Gates, 1972 : 316.

Hemienchytraeus rangoonensis (Stephenson), Gates, 1972 : 316.

Type locality : Garo Hills, Assam, India.

l(p) = 5-9 mm; d(p) = 0.3 mm; s = 24-36.

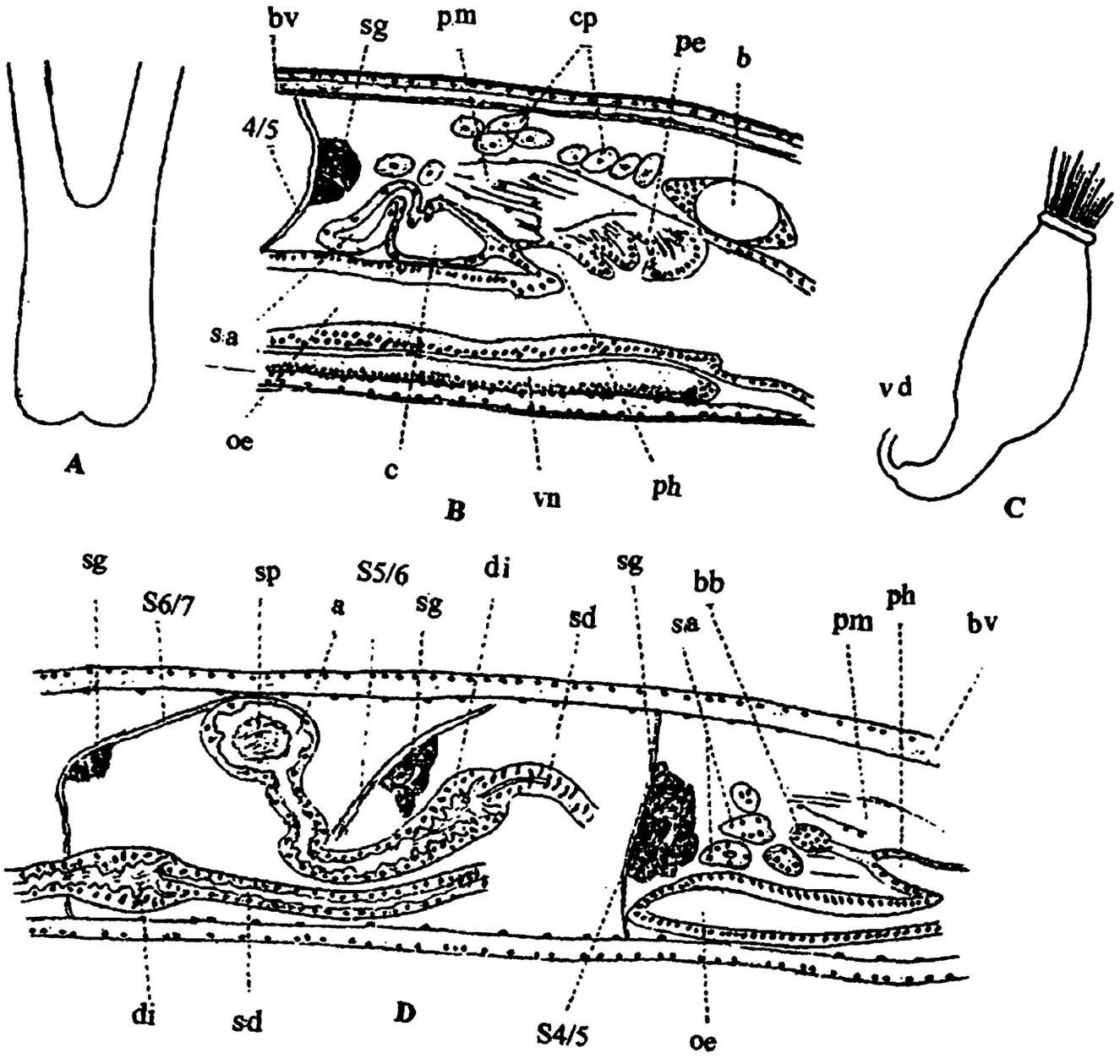

Fig 89 : *Hemienchytraeus stephensoni.* A : Brain; B : L. S. through anterior segments; C : Male funnel; D : L. S. through IV-VII segments. (all from Stephenson, 1931c). a : spermathecal ampulla; b : brain; bb : post-pharyngeal bulb; bv : body wall; c : chamber receiving salivary glands; cp : coelomocytes; di : dilatation of spermathecal duct; oe : oesophagus; pe : pharyngeal epithelium; ph : pharyngeal wall recess; pm : pharygneal muscle; sa : salivary gland; sd : spermathecal duct; sg : septal gland; sp : spermtozoal ball; vd : vas deferens; vn : ventral nerve cord; S4/5, S5/6, S6/7 : septa 4/5, 5/6, 6/7.

Description : Worms of medium size, white without pigment. Prostomium bluntly conical with a large head pore. Dorsal pores absent. Lateral and ventral setae from II, enchytraeine, 2 per bundle throughout body, shaft straight, without nodulus, distal end bluntly pointed, 38 μm long, 4 μm thick in anterior segments increasing to 70 μm long, 7 μm thick in posterior segments.

Pharynx (Fig. 89 B-ph) in II-III, wide with protrusible roof through mouth, a pair of rounded, knob-like pharyngeal bulbs. Salivary glands (Fig. 89 B-sa, D-sa) short, twisted tubules in IV. Septal glands (Fig. 89 B-sg, D-sg) 3 pairs in IV, V, VI. Oesophagus (Fig. 89 D-oe) begins in IV, dilates abruptly into intestine in X. Oesophageal pouches and chyle cells of intestine absent. Coelomocytes (Fig. 89 B-cp) broadly elliptic or fusiform, 24-27 μm long, granular with dot-like nuclei, numerous in anterior segments upto VIII, closely packed in hind segments. Blood colourless. Dorsal blood vessel begins in clitellar region, in XIII. Brain (Fig. 89 A, B-b) about 1.5 times as long as wide, incised deeply in front, truncated with a groove behind with almost parallel sides. Nephridia large, pre-septal part, ½ or ¾ as long as postseptal; its tube undergoes a number of turns, its thin neck passes through septum and connects post-septal. Post-septal part ovoid, gives off a duct from its lower surface, which goes backwards, then bends downwards and opens to outside ventrally.

Clitellum in XII-½XIII. Testes disappear on development of clitellum. Sperm morulae and spermatozoa in XI. Male funnel small (Fig. 89 C), thistle funnel shaped, 60 μm wide, 3 times as long as wide, with anterior part 33 μm wide with thick collar, posterior third of funnel narrow, about 25 μm wide. Vas deferens (Fig. 89 C-vd) narrow, long, 7 μm wide, coiled in XII, its ectal end with a small penial bulb covered by a few gland cells. Ovaries a pair on anterior face of 11/12 ventro-laterally. Ova in IX, X, XI and extend backwards upto XV. Spermathecae a pair in V, their ampullae (Fig. 89 D-a) small, round, 44 x 52 μm in size, with spermatozoal ball (Fig. 89 D-sp). Their ducts (Fig. 89 D-sd) narrow, cylindrical, 20 μm thick with 1 or 2 bends, not connected to oesophagus, ectal end narrowing towards body wall, ending on surface in furrow 4/5. Copulatory glands absent.

Distribution : India : Assam; Rangoon (Burma).

World distribution : Asia.

Genus ***Henlea*** Michaelsen, 1889.

Henlea Michaelson. Beddard, 1895 : 349; Stephenson, 1930 : 766; Nielsen & Christensen, 1959 : 55; Chekanovskaya, 1962 : 299; Brinkhurst & Jamieson, 1971 : 659.

Diagnosis : Setae straight or slightly bent, unequal or equal in size within bundle, without nodulus, distal end single pointed. Head pore at 0/1, dorsal pores absent. Oesophagus expanding abruptly into intestine. Oesophageal appendages in IV or IV-V or absent. Peptonephridia absent. Intestinal diverticula present or absent. Nephridia with well developed interstitial tissue. Brain slightly longer than broad and incised posteriorly. Coelomocytes uniform in size, slightly oval or discoidal. Blood colourless.

Dorsal vessel arises in preclitellar region. Sperm-sacs and ovi-sacs absent. Spermathecae simple usually without diverticula and glands (glands found in some species), their ental ducts unite before attachment to oesophagus. Terrestial and limnic.

Type species : *Henlea ventriculosa* (d'Udekem, 1854).

Key to Indian species of genus *Henlea*

Lateral and ventral setae 2 per bundle; chambered body absent on oesophagus ..... *Henlea harurami*

Lateral and ventral setae 4-7 per bundle; chambered body present on oesophagus ..... *Henlea ventriculosa*

Henlea harurami (Stephenson, 1914)
(Fig. 90)

Enchytraeus harurami Stephenson, 1914b : 334; 1915e : 142; 1923 : 114.

Type locality : Lahore, Pakistan, Asia.

l(p) = 4-5 mm; d(p) = 0.3-0.4 mm; s = 32-40.

Description : Worms small and opaque white, anterior end narrower than posterior end. Prostomium bluntly conical, wider than long. Head pore and dorsal pores absent.

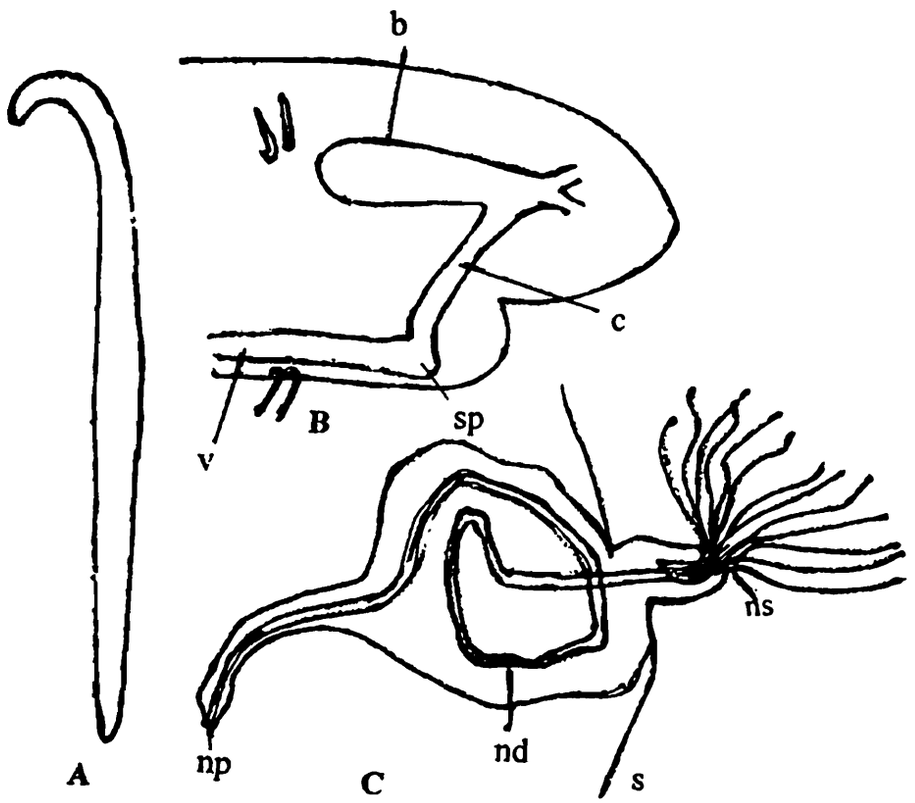

Fig 90 : *Henlea harurami.* A : Seta; B : Brain, subpharyngeal ganglion and ventral nerve cord, lateral view; C : Nephridium, lateral view. b : brain; c : peripharyngeal connective; nd : nephridial duct; np : nephridiopore; ns : nephrostome; sp : subpharyngeal ganglion; s : septum; v : ventral nerve cord.

Setae (Fig. 90 A) without nodulus, with ental curve, 2 per bundle, both in dorso-lateral and ventral bundles, about 40-46 μm long in anterior segments and about 53 μm long in posterior segments. Ventral setae of XII absent.

Pharynx in II-III, roof thickened into a plate connected by retractor muscles to body wall of IV and V, eversible through mouth. Oesophagus begins in IV and insensibly continues into intestine. Brain (Fig. 90 B-b) large, broad, thick, slightly concave behind, tapering and deeply hollowed anteriorly. Septal glands 3 pairs on 4/5, 5/6 and 6/7, laterally. Chloragocytes start in VI. Peptonephridia a pair in IV, extending into V. Coelomocytes numerous, nucleated, oval, circular or ellipsoid, 10-15 μm long. Blood colourless. Dorsal vessel begins in XII or XIII, mid-dorsal and runs anteriorly. Paired nephridia (Fig. 89 C) start in VII, absent in XI to XIII; again present from XV; pre-septale consists of ciliated funnel with nephrostome (Fig. 89 C-ns), and post-septale ovoid with highly coiled duct (Fig. 89 C-nd) packed in gland mass, opening by nephropore (Fig. 89 C-np) ventro-laterally.

Clitellum in XII-XIII (2 segments) not conspicuous, opaque white. Testes in sacs attached to posterior face of septum 10/11 laterally. Sperm-sac single formed by delamination of superficial layer from testis itself. Sperm morulae fall off into sperm-sac and mature in it. Male funnels small, longer than broad, thistle funnel-shaped, with well marked rim on anterior face of septum 11/12. Vas deferens narrow, long. coiled in XII, bending downwards to enter upper surface of penial body, latter a small spherical mass of tightly packed cells. Spermathecae small, cylindrical, ampulla marked off from duct, latter twice as long as ampulla, its ental end connected to oesophagus, and ectal part swollen before opening ventro-laterally in the furrow 4/5.

Distribution : Known only from the type locality.

Henlea ventriculosa (d'Udekem, 1854)
(Fig. 91)

Enchytraeus ventriculosus d'Udekem, 1854 : 864.

Fridericia stewarti Stephenson, 1909a : 109.

Michaelseniella stewarti Cernosvitov, 1937 : 287.

Henlea ventriculosa Cernosvitov, 1942b : 282; Nielsen & Christensen, 1959.

l(p) = 8-15 mm; d(p) = 1 mm; s = 39-50.

Description : Worms of medium size, cylindrical, colour often yellowish to brownish in some segments behind clitellum, owing to colour of gut. Cutaneous glands arranged in several rows on each segment. Prostomium (Fig. 91 A-pr) short, rounded. Setae all of same type in 2 lateral, 2 ventral bundles, small with single blunt point at distal end, and shaft straight or curved slightly, arranged fan-shaped transversely, those in

centre smallest, their size increase towards outermost. Anterior segments with 7 laterally, 8 ventrally, posterior segments with 4-6 or 7 laterally, 6-7 ventrally. Longest setae 80 μm long.

Buccal cavity in I-II, pharynx (Fig. 91 A-ph) in III with some dorsal thickening of wall from which radiate muscular bands (Fig. 91 A-mb) attached to body wall. Oesophagus (Fig. 91 A-oe, D-oe) passes behind septum 8/9 into wide intestine (Fig. 91 A-in, D-in). Demarcation absent between oesophagus and intestine. Oesophageal glands (Fig. 91 A-og, D-og) 3 or 4 pairs in V, VI, VII, round or pear-shaped attached to gut and body wall by muscle bands. In VIII four intestinal pouches closely applied to one another and to intestine throughout segment to form a chambered body (Fig. 91 A-ch, D-ch) with walls much folded, and canals irregularly arranged. Outline of gut and pouches subspherical. Chloragocytes start from VI, oval, round or of irregular

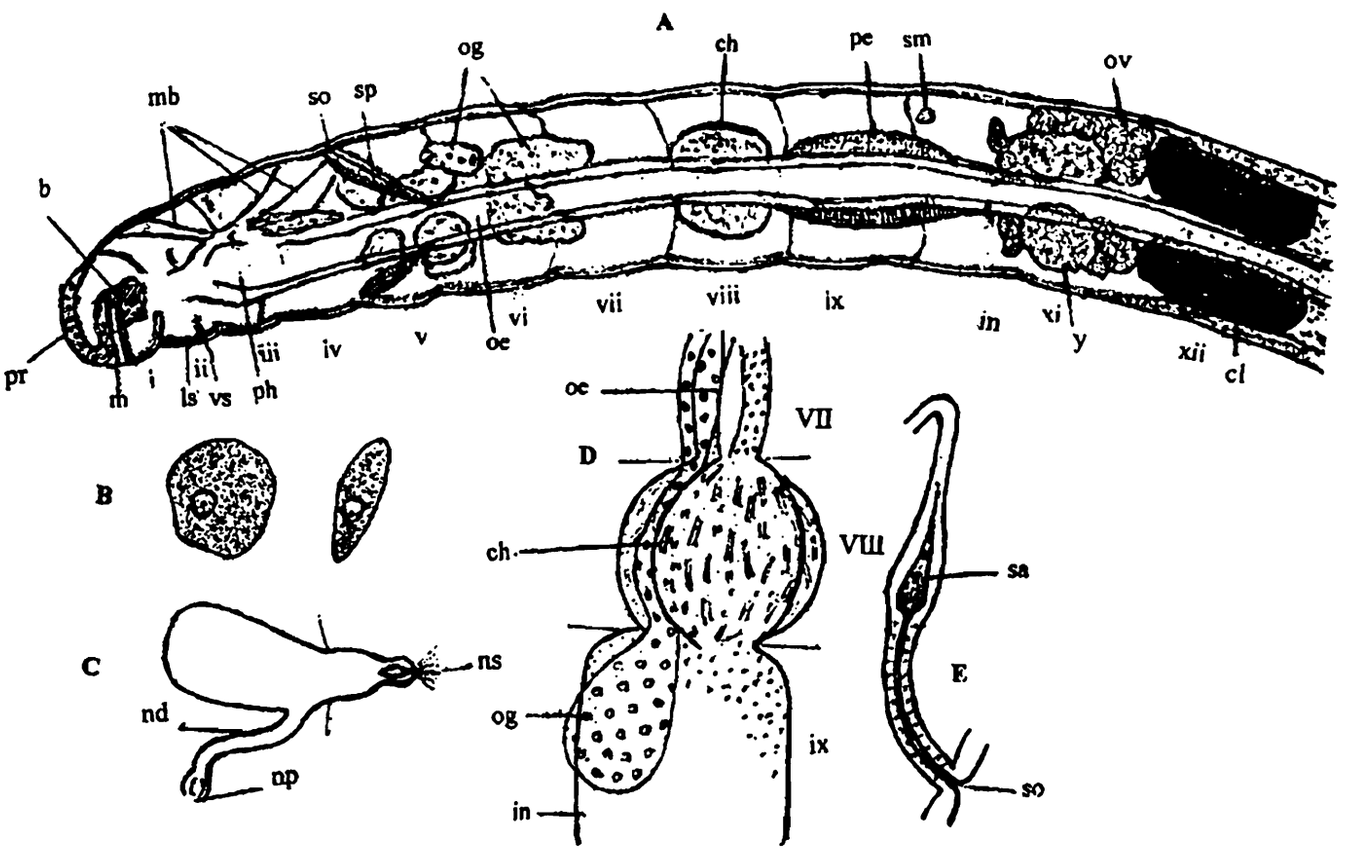

Fig. 91 : *Henlea ventriculosa.* A : Lateral view of anterior part of body; B : Coelomocytes; C : Nephridium; D : Dorso-lateral view of segment VII-IX; E : Spermatheca. (A, B from Stephenson, 1909a; C-E from Nielsen & Christensen, 1959). b : brain; ch : chambered body in VII; cl : clitellum; in : intestine; ls : lateral setal bundle; m : mouth; mb : muscular bands; nd : nephridial duct; np : nephropore; ns : nephrostome; oe : oesophagus; og : oesophageal glands; ov : ovum; pe : peritoneal epithelium; ph : pharynx; pr : prostomium; sa : spermathecal ampulla; sd : spermathecal duct; sm : sperm morula; so : spermathecal opening; sp : spermatheca; vs : ventral setal bundle; y : yolk mass; i-xi : segments I-XI.

shape, granular with a distinct nucleus and much smaller than coelomocytes. Coelomocytes (Fig. 91 B) spherical or oval, finely granulated. Septal glands 3 pairs. Brain (Fig. 91 A-b) in I, deeply incised in front than behind. Ventral nerve cord formed in II by union of commissures. Blood colourless. Dorsal vessel arises in anterior half of IX, heart-like expansions present in VII, VIII and IX. Pre-septale of nephridium half as thick with nephrostome (Fig. 91 C-ns) and 1/3 as long as post-septale, latter thick and oval, granular mass, with nephridial duct (Fig. 91 C-nd) runs outwards and backward, open externally by nephropore (Fig. 91 C-np) in front of level of setae.

Clitellum (Fig. 91 A-cl) from ½XI-½XIII, slightly elevated with gland cells irregularly scattered. Testes attached to posterior face of 10/11. Some clusters of sperm morulae (Fig. 91 A-sm) and spermatozoa occur in X, One to eight ova occur at a time in XI. Ovi-sac absent, Spermathecae (Fig. 91 E) simple, elongated pear-shaped in V, attached to dorsal wall of oesophagus, its ectal duct opening (Fig. 91 E-so) to exterior.

Chromosomes : n = 17 (Nielsen & Christensen, 1959).

Habits : Abundant in various habitats.

Distribution : Tibet : High Hill Gompa, Gyantse at 14,000 feet.

World distribution : Asia; Europe, North and South America; New Zealand.

Genus ***Marionina*** Michaelsen, 1889

Marionina Michaelsen, 1889 : 10; Nielsen & Christensen, 1959 : 108; Chekanovskaya, 1962 : 313.

Diagnosis : Setae straight in most species but distinctly sigmoid in some, without nodulus. Setae variable in number but usually low. Setal bundles may be absent in some segments. Head pore at 0/I. Dorsal pores absent. Brain rounded or incised posteriorly. Peptonephridia absent. Oesophageal appendages usually absent but present in some species in IV or VI. Intestinal diverticula absent. Primary septal glands 3 pairs, secondary glands absent. Blood mostly colourless but coloured in a few species. Dorsal vessel begins in clitellar or rarely in post-clitellar region. Nephridial interstitial tissue well developed; pre-septale with funnel and few coils of nephridial canal, rarely only funnel, duct usually arising in posterior part of post-septale, but origin may be variable in some species. Testes small, compact. Well developed sperm-sac usually absent. Vas deferens long, narrow. Penial bulb present. Atrial glands absent. Spermathecae with or without diverticula, usually attached to oesophagus, in a few species free. Glands usually associated with spermathecae along ectal duct, at ectal opening or in both these positions. Small species inhabiting marine, limnic and terrestrial habitats. Cosmopolitan.

Type species : *Marionina georgianus* Michaelsen, 1889.

Marionina subterranea (Knollner, 1935)
(Fig. 92)

Michaelsena subterranea Knollner, 1935a : 136.

Marionina subterranea, Nielsen & Christensen, 1959 : 110.

Michaelsena subterranea, Rao & Ganapati, 1968 : 111.

Type locality : Poland.

l(p) = 4-6 mm; d(p) = 1 mm; s = 22-29, usually 26.

Description : Worms small, whitish. Dorsal bundles absent but replaced by cuticular pad- or cushion-like structures (Fig. 92 C-c) consisting of a single or a few specialized cells. Cutaneous glands arranged in about 4 transverse rows on each segment. Ventral bundles present, with 2, rarely 1 straight setae with ental hook.

Pharynx in III-IV. Oesophagus in V-VII, insensibly continuing as intestine from IX. Septal glands small, 3 pairs on 4/5, 5/6, 6/7, all united mid-dorsally, those of 4/5, 5/6 with small ventral lobes, and of 6/7 large. Chloragocytes with prominent refractile granules from V, forming a dense layer from VII. Coelomocytes oval, about same size as chloragocytes, with yellowish brown granules and prominent refractile globules. Brain slightly longer than wide, truncate or slightly convex posteriorly. Blood colourless. Dorsal vessel begins in XIII. Pre-septal part of nephridia ovoid with coils of nephridial canal; nephrostome simple. A narrow neck connects elongate post-septale, its duct short, stout, not demarcated from post-septale but forming a terminal continuation.

Clitellum in XII-½XIII, its gland cells arranged in transverse rows. Sperm-sac large, often bulging forward to reach VIII. Male funnel (Fig. 92 B) about 1.5, times longer than wide, length being almost equal to diameter of worm, with lobular outline and collar of about half width of funnel, covered with dense fan of sperms (Fig. 92 B-sa). attached to collar. Vas deferens short, irregularly coiled in XII. Penial bulb small, compact. Mature egg one at a time present. Spermathecal ampulla (Fig. 92 A-s) ovoid with a central mass of sperms (Fig. 92 A-sa), its duct (Fig. 92 A-sd) short, with a few separate or fused glands (Fig. 92 A-p) around spermathecal pore (Fig. 92 A-so). Ental duct short, wide, connected to oesophagus dorso-laterally.

Chromosomes : n = 18 (Nielsen & Christensen, 1959).

Distribution : India : Waltair coast (Andhra Pradesh).

World distribution : Cosmopolitan.

Genus ***Stephensoniella*** Cernosvitov, 1934 emended Coats, 1983

Stephensoniella Cernosvitov, 1934 : 243; Nielsen & Christensen, 1959 : 95; Brinkhurst & Jamieson, 1971 : 662; Coates, 1983 : 412.

Diagnosis : Setae in 4 bundles from II; 2 (rarely 3) setae per bundle in intra- and post-clitellar segments; single-pointed, straight or slightly sigmoid, bent proximally, without nodulus. Head pore anterior to 0/1, dorsal and coelomic pores absent. Oesophageal-intestinal transition gradual, intra- or post-clitellar. Pharyngeal glands well developed, broadly united at 3/4, 4/5 and 5/6 but with solid paired dorsal post-pharyngeal bulbs. Oesophageal and intestinal diverticula absent. Dorsal blood vessel originate intra- or post-clitellar. Dorsal vessel bifurcating anterior to brain, in prostomium. Blood colourless. Coelomocytes nucleate. Chloragocytes present from pre-clitellar segments. Pre-septal part of nephridia includes funnel only, interstitial tissue around post-septal nephridial canal well developed; ectal duct terminal and ventral. Muscular layers of some of septa 6/7 to 9/10 thickened. Testes paired enclosed in large sperm-sacs. Ovaries paired. Male funnels well developed cylindrical in XII, vasa deferentia non-glandular long, confined to XII surrounded medially at ectal pores by compact penial bulbs. Accessory prostate glands absent. Ventral copulatory glands absent. Spermathecae paired in V, always attached to, if not actually communicating with, oesophagus via short ental ducts; their ampulla with a rounded or ovoid diverticulum and ectal duct with or without glands. Brackish and littoral, marine. Cosmopolitan.

Type species : *Stephensoniella marina* (Moore, 1902).

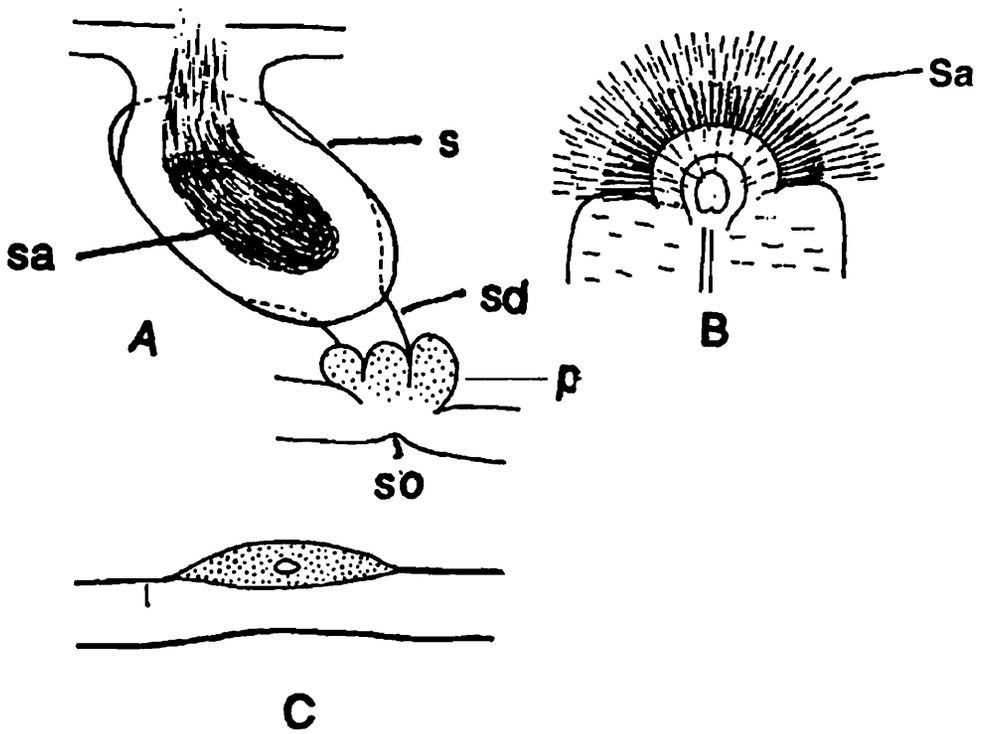

Fig 92 : *Marionina subterranea.* A : Spermatheca; B : Male funnel, anterior end, lateral view; C : Body wall with cuticular pad, lateral view; (from Nielsen & Christensen, 1959). c : cuticular pad; p : glands; s : spermathecal ampulla; sa : sperm; sd : spermathecal duct; so : spermathecal opening.

Stephensoniella marina (Moore, 1902) emended Coats, 1983 (Fig. 93)

Enchytraeus marinus Moore, 1902 : 80.

Enchytraeus barkudensis Stephenson, 1915e : 142; 1915d : 45; 1923 : 113; Michaelsen, 1924 : 383; Aiyer, 1929a : 44; Rao & Ganapati, 1968 : 111; Rao, 1969 : 98; Subbarao, Venkateswararao, Chandrasekharareddy & Venkataraman, 1980 : 279; Subbarao & Venkateswararao, 1980 : 290.

Stephensoniella marina, Coates, 1983 : 413.

Stephensoniella barkudensis, Julka, Senapati & Paliwal, 1989 : 85.

Type locality : Gibson Hil Tip, Coney Sol, Bermuda.

l(p) = 6-10 mm; d(p) = 0.5 mm; s = 46-73.

Description : Worms small, filiform, opaque in life, light brown in preserved condition. Cutaneous glands in 3 or 4 transverse rows per segment. Prostomium very short, bluntly conical. Setae straight, 50–120 μm, usually 80 to 90 μm long. Setae of II markedly short, 50-60 μm long; lateral setae shorter than ventrals of same segment. Two or 3 setae in antero-lateral bundles, 3 setae in ventral bundles in X or XI, 2 (occasionally 3) setae in post-clitellar segments, none ventrally in XII.

Pharynx (Fig. 93 A-ph) in II-III, wide with a sucker-like plate dorsally, eversible to exterior through mouth. Salivary glands (Fig. 93 A-sa) a pair of club-shaped backwardly directed evaginations of pharynx, arising from posterior part of pharyngeal roof behind sucker-like epithelial plate, one on each side near median line. Oesophagus (Fig. 93 A-oe) starts in IV, narrow, uniformly ciliated tube passing suddenly into intestine beginning in XI or XII, wide. Stomach absent. Septal glands 3 pairs on anterior face of septa 4/5, 5/6 and 6/7, members of each pair continuous dorsally on oesophagus and each gland continues forwards by an anteriorly projecting lobe situated laterally to oesophagus. Coelomocytes numerous in anterior part of worm, nucleated and flattened plates of oval or broadly spindle-shaped, 20-30 μm in diameter. Postclitellar segments with intra-segmental muscular bands extending from circular epidermal muscles of gut. Blood colourless. Dorsal blood vessel variable in origin, arising postclitellar in XXIII. Lateral vascular commissures 4 pairs in II-V, first pair runs obliquely downwards and forwards, end ventrally at level of between setae of II and III, second pair less oblique, ends between setae of III and IV; third pair almost vertical ends behind setae of IV, and last pair ends behind setae of V. Ventral vessel formed by union of two branches of dorsal vessel in IV. First two pairs of commissures join branches before their union and last two pairs join ventral vessel. Nephridia of two types, first type (Fig. 92 B) in pre-clitellar segments, thin, elongated continued behind without sharp demarcation into a duct, and second type (Fig. 93 C) in post-clitellar segments, pyramidal in shape with a relatively narrow duct which leads off

from ventral and posterior angle with an arched course downwards and backwards to surface. Both types have short pre-septal and a large post-septal portions, opening to exterior in front of ventral setae.

Clitellum over XII and XIII, with glands in numerous, regular transverse rows. Testes a pair attached to inner face of wall of sperm-sac near floor of sac where the septum 10/11 joins it. Sperm-sacs a pair, distinct from each other, of large size ovoid, forward diverticula of septum 10/11 and extending forwards to 9/10. Their walls very thin but complete and contain large masses of sperm-morulae in various stages of development. Male funnels (Fig. 93 D-f) a pair of cylindrical bodies in XI, 2-3 times

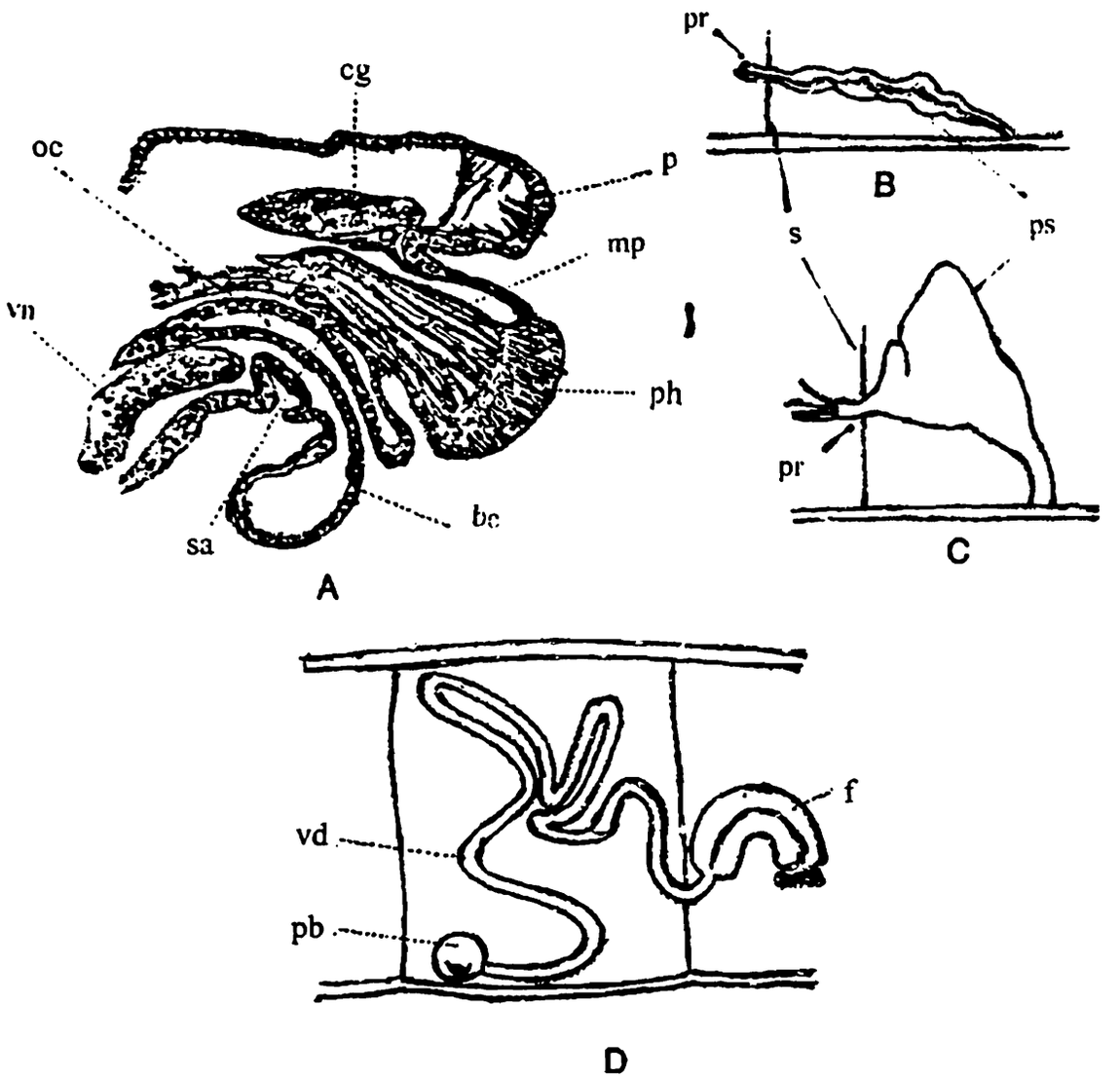

Fig 93 : *Stephensoniella marina.* A : L.S. of anterior part showing everted pharynx, oesophagus and salivary gland; B : Nephridium from IX; C : Nephridium from post-genital segment; D : Male efferent apparatus. (all from Stephenson, 1915e). bc : buccal cavity everted; cg : brain; f : male funnel; mp : muscular strands to pharyngeal 'sucker'; oe : oesophagus; p : prostomium; pb : penial body; ph : pharyngeal 'sucker'; pr : preseptale; ps : postseptale; s : septum; sa : salivary gland; vd : vas deferens; vn : ventral nerve cord.

as long as wide, length about half of body width, continued into long, thin, coiled vasa deferentia (Fig. 93 D-vd) of 14-24 μm wide, non-muscular, in XII and end in small nearly spherical penial bulbs (Fig. 93 D-pb) 53-68 μm high, and open to exterior at position of absent ventral setae of XII. Male pore simple. Spermathecae a pair in V, their ampulla 80 μm long, 50 μm wide, diverticulum 80 μm long, 30 μm wide, more or less ovoid, their ducts 14-16 μm wide, 3-4 times as long as wide without any glands, communicating basally with ampulla at constriction between ampulla and thin walled dorsally directed diverticulum. Ampulla connecting laterally to oesophagus in posterior part of V. Sperms densely bundled in diverticula, and in random masses in ampullae. Spermathecal pores at 4/5, just ventral to level of lateral setae. Ovaries and masses of ova in XII. Female funnels a pair on anterior face of septum 12/13 ventro-laterally, continue into oviducts.

Habits : Worms live in estuarine salt lakes and littoral and supra-littoral, usually in medium coarse sands. They are found below the surface of sand along with *Pontodrilus bermudensis* (Stephenson, 1915e).

Distribution : India : Kovilam near Trivandrum (Kerala); Ennur near Chennai (Tamil Nadu); Visakhapatnam harbour (Andhra Pradesh); Barkuda Island, Chilke Lake (Orissa).

World distribution : Persian Gulf, Saudi Arabia (Asia); Florida, in U. S. A. (North America); Bermuda (Atlantic Ocean); French Guyana (South America).

Family LUMBRICULIDAE Vejdovsky

Lumbriculidae Beddard, 1895 : 207; Stephenson, 1930 : 781; Chekanovskaya, 1962 : 326; Brinkhurst & Cook, 1966 : 3; Brinkhurst & Jamieson, 1971 : 202.

Diagnosis : Prostomium prolobic or zygolobic, sometimes elongated and produced into proboscis. Setae eight per segment, in two ventro-lateral and two dorso-lateral pairs, all single-pointed or distinctly bifid, sigmoid with distinct nodulus; setae rarely or partially absent. Hair setae and modified genital setae absent. Alimentary canal without gizzard (except in *Agriodrilus*). Clitellum in region of genital pores, one cell thick, in segments (VI) VII to X (XI). Testes variable in number and position, usually 1-4 pairs in IX-XII. Sperm-sacs present, extend many segments posterior to testes. Vasa deferentia each discharging into an atrium, or vasa deferentia of same side discharging into a common atrium. Male pores on segments which contain corresponding pair of testes, or on that which contains hinder-most pair of testes. Atria paired or unpaired, always in testes-bearing segment, associated with 1 or 2 pairs of testes. Commonly one pair of atria in segment bearing posterior testes, two vasa deferentia and male funnels on each atrium, one funnel in anterior testes segment, other on posterior septum of segment containing atrium. Anterior testes, funnels and vasa deferentia often absent, leaving testes, atrium, posterior funnels and vasa

defrentia within a single segment. This arrangement sometimes serially repeated. Posterior vasa deferentia may penetrate posterior septum before returning to atrial segment. Sperm-sacs present, extend for many segments posterior to testes. Ovaries one or two pairs, located one or rarely two segments behind most posterior testicular segment. Prostate in distinct masses. Spermathecae variable in number and position, in front of or behind segments of gonads, with which segments of spermathecae normally form a continuous series. Asexual reproduction by paratomy or architomy and regeneration.

Type genus : *Lumbriculus* Grube, 1844.

Genus ***Lumbriculus*** Grube, 1844

Lumbriculus Grube,1844 : 207; Beddard, 1895 : 211; Stephenson, 1930 : 788; Chekanovskaya, 1962 : 330; Brinkhurst & Cook, 1966 : 11; Brinkhurst & Jamieson, 1971 : 204.

Diagnosis : Prostomium conical, not elongated as a proboscis. Setae bifid with distal tooth smaller than proximal or reduced. Throughout middle region of body, dorsal vessel bears caecal contractile appendages. One pair of blind, branched, lateral blood vessels present in anterior part of each posterior segment, beginning between X to XV. One to four pairs of testes, in VII to XIII; one to two pairs of testes associated with each pair of atria. Atria cylindrical to sacciform. Penes double, internally a protrusible penis composed of a pad of elongate cells and externally a protrusible porophore, composed of concentric ridges in body wall, which when turgid, produce conical papilla. Male pores one to four pairs in VIII to XIII, though often displaced, each pore surrounded by series of concentric ridges in body wall. Prostate gland cells in discreet masses. One to two pairs of ovaries, starting behind last pair of testes. Female pores usually paired, and hinder limit of one or two segments succeeding those bearing male pores. Spermathecal pores variable in number, but usually two to five pairs starting behind last atrial segment and open always dorsal to line of ventral setae. Cosmopolitan.

Type species : *Lumbriculus variegatus* (Müller, 1773).

Lumbriculus variegatus (Müller, 1773)
(Fig. 94)

Lumbricus variegatus Müller, 1773: 241.

Lumbriculus variegatus, Grube, 1844 : 207; Cernosvitov, 1942b : 286.

Type locality : Unassigned, Germany.

l(p) = 40-100 mm; d(p) = 1.5 mm; s = 140-170.

Description : Worms (Fig. 94 A) large, slender at both ends and pigmented dark green in anterior body wall in life. Prostomium (Fig. 94 A-pr) bluntly conical and rounded. Setae in 4 bundles, all of same type, 2 dorso-lateral and 2 ventro-lateral, 2

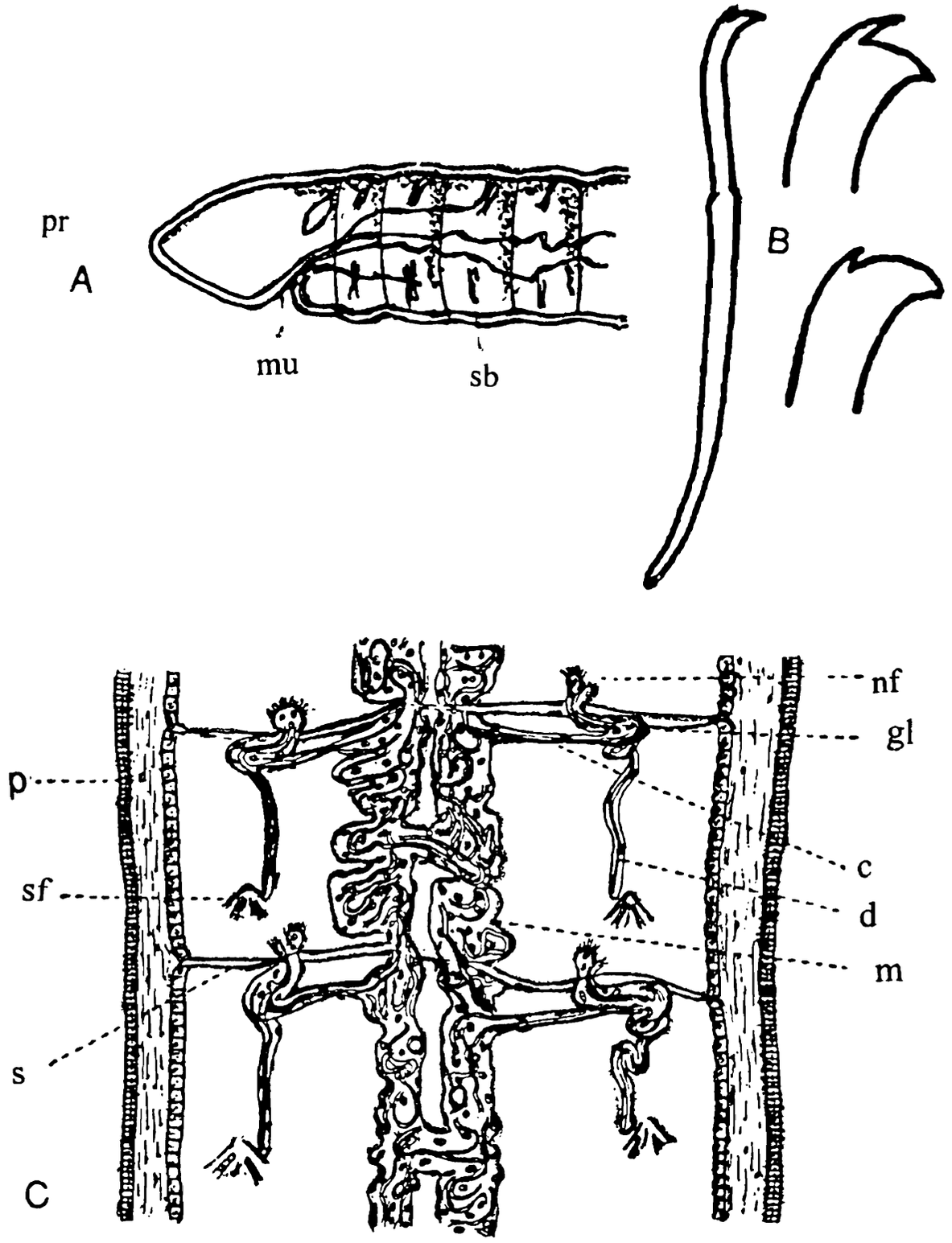

Fig 94 : *Lumbriculus variegatus.* A : Anterior part of worm; B : Setae; C : Nephridial system. (A, B from Brinkhurst & Jamieson, 1971; C from Stephenson, 1930), c : connecting strand between nephridium and median part of system; d : duct; gl : glandular swelling of nephridium; m : median part of nephridial system; mu : mouth; nf : nephridial funnel; p : parietes; pr : prostomium; s : septum; sb : setal bundle; sf : setal follicle.

per bundle, bifid with rudimentary upper tooth. Setae (Fig. 94 B) sigmoid with nodulus 1/3 from distal end, about 168 μm long, proximal tooth much thicker and longer than distal.

Pharynx in II-III, wide. Oesophagus in IV-VII, narrow. Stomach absent. Intestine narrow in VIII and wide, and sacculated from IX. Pharyngeal glands stout and reaching to VIII and a part of IX. Dorsal blood vessel with lateral vessels bearing blind diverticula especially posteriorly. Lateral commissural vessels from IX. Nephridia (Fig. 94 C) begin in X. Each nephridium consists of pre-septal funnel (Fig. 94 C-nf), post-septal nephridial duct (Fig. 94 C-d) and median part of nephridial system (Fig. 94 C-m).

Clitellum in XI-XII. Testes 3 or 4 pairs, usually in X to XII or XIII. One pair of testes associated with each pair of atria, Male funnels narrow, continue into a long, narrow, coiled vas deferens and open into atrial ampulla about middle. Atria 1-2 (rarely 5) while left and right ones may be located in different segments. Atrial ampulla cylindrical to sacciform with inner layer of circular muscles and outer layer of muscles arranged longitudinally to atrial axis. Efferent duct always makes a Z-form double bend. Porophores weakly developed without concentric folds. Male pores usually one pair, situated between VII to XII. Spermathecae normally 4 pairs beginning with ovarial segment or behind it occupying about upto 6 segments. Spermathecal ampulla spherical or ovoid, about 370 μm long, with a distinct, narrow duct, 220 μm long, opening dorso-laterally, lateral to ventral setae. Spermathecal pores usually four to five pairs, beginning two segments or sometimes one segment, posterior to atrial segment; open between lateral line and line of dorsal setae, Spermatozoa in spermathecal ampulla. Ovaries 1-2½ pairs beginning in post-atrial segment, i.e., XI. Female pores usually paired, at hinder limit of one or two segments succeeding those bearing male pores. Asexual reproduction by architomy Timm (1981). Mature worms fragment in middle, and posterior fragment regenerates 7-8 anterior segments, and anterior fragment several segments.

Commensals : Protozoan ciliate commensals *Ptychostomum lumbriculi* and *Mesniella clavata* were found attached to body of this species (Falls, 1975).

Distribution : Tibet : Tirthapuri in West Tibet.

World distribution : Cosmopolitan.

Family MICROCHAETIDAE

Microchaetinae (part, Glossoscolecidae) Beddard, 1895 : 664.

Microchaetinae (Glossoscolecidae) Michaelsen, 1900: 447; 1917 : 56. Michaelsen, 1915 : 326.

Microchaetinae (Lumbricidae) Michaelsen, 1918b: 305.

Microchaetidae 1918b : 305; 1921 : 141.

Microchaetinae (Lumbricidae) Stephenson, 1923 : 490; 1930 : 889.

Microchaetidae, Gates, 1959: 255; 1972 : 233.

Diagnosis : Worms with simple pointed sigmoid setae, in eight longitudinal rows. Dorsal pores absent. Gizzard absent or if present oesophageal and in front of testicular segment. Calciferous glands absent or if present (*Microchaetus* and *Kynotus*) restricted to IX-X. Intestine, with or without some initial muscular strengthening but without definite gizzard. (Vascular system ?). Excretory system, of holoic nephridia except in *Tritogenia*. Clitellum multilayered. Sperm-sacs, tuberculate. Male pores, not postclitellar. Penial setae absent. Sexual setae when present not of the grooved lumbricid kind. Prostates with muscular ducts, none. Spermathecae (behind testis segments) without diverticulum. Ovaries in XIII, fan-shaped?. (Ovi-sacs ?). Ova, not yolky. Cosmopolitan.

Type genus : *Microchaetus* Perrier.

This family has a single genus *Glyphidrilus* Horst, 1889 which occurs in Indian subcontinent.

Genus ***Glyphidrilus*** Horst, 1889

Glyphidrilus Horst, 1889: lxxvi.

Bilimba Rosa, 1890: 386.

Glyphidrilus, Horst, 1893: 37.

Annadrilus Horst, 1893: 44.

Glyphidrilus, Beddard, 1895: 679.

Bilimba, Beddard, 1895: 686.

Annadrilus, Beddard, 1895: 680.

Glyphidrilus, Michaelsen, 1900 : 459; 1909 : 103; 1910 : 101; 1918b : 343; Stephenson, 1923 : 490. 1930 : 901; Gates, 1958 : 53; Brinkhurst & Jamieson, 1971 : 746; Gates, 1972 : 234.

Diagnosis : Prostomium zygolobous. Body white (unpigmented), nearly circular in cross section anteriorly, then becoming elliptical, posteriorly quadrangular (after preservation), with setae at four corners and *dd* only slightly larger than *aa*. Anus dorsal. Dorsal pores absent. Setae 8 per segment, in four pairs, paired widely anteriorly, usually closely paired postereiorly. Setae with one or more transverse or oblique ridges distally. Body wall with longitudinal lamellar ridge protruberant at maturity on each side, forming delicate wing or ala, dorsal to ventral setal pair, in *bc* through several clitellar segment. Clitellum annular (?), starting in or behind XII and extending over number of segments including all with reproductive apertures, intersegmental furrows not obliterated. Genital setae absent, but setae of clitellar region sometimes enlarged. Genital pores, all minute and superficial.

Digestive system with an oesophageal gizzard in VII-VIII, Alimentary diverticula absent. Intestinal origin behind XIV, with dorsal intestinal typhlosole but without caeca and calciferous and supra-intestinal glands. With a ciliated "straining apparatus" between oesophageal and intestinal blood sinuses. Vascular system, with single dorsal, complete ventral and subneural trunks, latter adherent to parietes (?), a supra-oesophageal trunk in V-XIV, a sub-oesophageal complex on gu in VIII-XIII, paired anterior and posterior (from anal region?) latero-parietal trunks passing to sub-oesophageal complex in XII-XIV, but extra-oesophageal trunks absent. Excretory system, of holoic (avesiculate?) nephridia, absent in many preclitellar segments. Septa, all present at least from, 5/6.

Clitellum annular (?), starting in or behind XII segment and extending to many segments. Holandric. Testes and their funnels free in X and XI. Vasa deferentia intramural, sperm-sacs usually 4 pairs, in IX-XII. Prostate glands absent. Genital setae absent, but setae of clitellar region sometimes enlarged. Seminal vesicles, in IX-X. Ovaries fan-shaped with several egg strings, and their funnels in XIII or XII and XIII. Ovi-sacs present or absent. Polythecal. Spermathecal pores inconspicuous, in some or all setal lines, or more numerous, in 2 to 6 intersegments from 12/13 to 18/19; exceptionally more extensive and including testis segments. In rivers, lakes and moist soil. Asia; Tanzania (Africa); Celebes.

Type species : *Glyphidrilus weberi* Horst, 1889.

This genus includes *Glyphidrilus* Horst, 1889, *Bilimba* Rosa, 1890 and *Annadrilus* Horst, 1893. Of these only first named occurs in the Indian suncontinent.

Key to Indian species of genus *Glyphidrilus*

1. Gizzard in VII or mainly so 2
– Gizzard in VIII or mainly so 3
2. Intestine begins in XV ..... *Glyphidrilus tuberosus*
– Intestine begins behind XV ..... *Glyphidrilus ceylonensis*
3. Intestine begins in XV 4
– Intestine begins behind XV 6
4. Wings begin in XVII-XIX ..... *Glyphidrilus papillatus*
– Wings begin behind XX 5
5. Genital marking absent in *aa* ..... *Glyphidrilus birmanicus*
– Unpaired median genital marking in *aa* ..... *Glyphidrilus annandalai*
6. Intestine begins in XVI, dorsal blood vessel ends in XI ..... *Glyphidrilus gangeticus*

– Intestine begins in XVI, dorsal blood vessel ends in VIII .... *Glyphidrilus spelaeotes*

Glyphidrilus annandalei Michaelsen, 1910

Glyphidrilus annandalei Michaelsen, 1910 : 101; Cognetti, 1911 : 502.

Glyphidrilus achencoli Cognetti, 1911 : 506.

Glyphidrilis annandalei, Stephenson, 1916 : 349; Michaelsen, 1918a : 349; Stephenson, 1921 : 767; 1922c : 387.

Glyphidrilus fluviatalis Rao, 1922 : 53.

Glyphidrilus elegans Rao, 1922 : 62.

Glyphidrilus rarus Rao, 1922 : 64.

Glyphidrilus saffronensis Rao, 1922 : 66.

Glyphidrilus annandalei, Stephenson, 1923 : 491; Nair, K. B., 1937 : 39; Gates, 1958 : 54.

Type locality : Calicut, Kerala, India.

l = 90-265 mm, d = 2.5-11 mm, s = 125-322.

Description : Prostomium zygolobous, sometimes prolobous. Anus dorsal. Setae widely paired throughout, more closely posteriorly. *aa* : *ab* : *bc* : *cd* : *dd* : 2.2-2.3 : 1.0-1.1 : 2.3-2.4 : 1.0-1.2 : 2.5-3.0, in segment XII; *dd* : *u* = 0.18-0.20; = 3.0: 1.0 : 2.5 : 4.4 : or 2 : 1 : 2 : 1 : 3.5 in hind body, *dd*: *u* = 0.25-0.43. Wings wavy 1.25-1.5 mm high in XXV, XXVI, XXVII to XXXII, ½XXXIII, XXXIII or occasionally XXXV in bc : usually continued forward as ridges, angles, or whitish lines to ½XVII or XVIII and sometimes posteriorly as wings as far as XXXVI. Genital markings with rims, in 2 series, median and lateral; lateral markings 1 on each side between *b* and beginning in XIII, or on or behind XV and ending, in front of wing as far posteriorly as XXXVI, with a second, lateral series often XIII or XIV to XXVI, occasionally present behind wings, on some XXXIII-XXXVIII, total number varying from 2 to 14. According to Nair (1937) markings always absent in segments with wings, but Cognetti (1911) reported additional paired markings in XVII-XXXII in some specimens.

Alimentary canal with a large gizzard in VIII, sometimes extending to VII. Intestine begin behind XV or XVI. Dorsal typhlosole in VI or VII. Hearts in VII-XI, "Hearts" in VII formed by bifurcation of dorsal vessel, non-pulsatile and non-valvular, unlike others. Hearts of VII-IX dorso-ventral, of X and XI latero-oesophageal. Supra-oesophageal in XIII to anterior extremity. Latero-parietal vessels uniting in XX-XXIII to form subneural vessels; a slender subneural continuing forward from junction to XIV. Nephridia in XII, XIII or XIV (sometimes IX) posteriad. Single nephrostome with 15 marginal cells, avesiculate.

Clitellum annular, starting in XIII-XVIII and extending to XXXV-?LLI,

(approximately 19-25 segments) well developed only from XVII posteriorly; its limits usually indistinct. Male pores two point-like depressions in or slightly anterior to intersegment 28/29 or 29/30, in both *b* lines. Female pores in or immediately median or lateral to *b* lines, in XIV nearer anterior margin than setal arc. Spermathecal pores inconspicuous in 4 intersegments, 13/14-16/17 and occasionally in 17/18 also, basically in setal lines *a, b, c* and *d* and in mid *bc,* rarely ventral to *a*; usually 10 or 11, in a transverse row with extremes of variation 1-13 per row, never present in mid-dorsal or mid-ventral intersetal spaces. Seminal vesicles in IX-XII, those of XII largest, pushing septum 12/13 back to 13/14. Septal pouches in XIII, dependent from 12/13. Vasa deferentia deeply embedded in longitudinal muscle of body wall, with their terminal cells ciliated and glandular. Plicate ovaries and their funnels in XIII; ovi-sacs located above funnels, back-pouchings of septum 13/14. Spermathecae located in segment behind their pores. Ovi-sacs 125 x 75 mm or more in size, embedded in body wall or protruberant into coelom, their ducts short.

Distribution : India : Arumanallur, Madatoray, Trivandrum, Velliany, Neyyantikara, Calicut, Malapuram, (Kerala); Mettupalyam, Tiruvallur (Tamil Nadu); Bangalore, Bhadravati, Mysore, Coorg, Dubari, Madapur, Fraserpet, Shimoga, Kadur district (Karnataka).

Known only from India.

Glyphidrilus birmanicus Gates, 1958

Glyphidrilus papillatus (part ?), Gates, 1931 : 431; 1933 : 603.

Glyphidrilus sp. Gates, 1931 : 604; Gates, 1958 : 62.

Glyphidrilus birmanicus Gates, 1958 : 61; Brinkhurst & Jamieson, 1971 : 756; Gates, 1972 : 236.

Type locality : Burma, Asia.

l = 95-103 mm; d = 5-6 mm in clitellar region, 5 mm elsewhere.

Description : Prostomium zygolobous. Anus dorsal or dorso-terminal. Wings low, begin one of XXI-XXIII and end in one of XXIX-XXX. in *bc*, just lateral to genital markings. Genital markings primarily post-setal, lateral to *b,* in XII-XXVI, XXIX-XXXIV.

Gizzard in VIII or also partly of VII?. Intestine begins in XV. Typhlosole thickly lamelliform, begins in XVIII. Dorsal blood vessel, aborted in front of hearts of VII, hearts of X, XI (last two pairs) latero-oesophageal. Septal pouches in XIII and XIV. Hearts of VII-IX lateral, of X-XI latero-oesophageal. A large vessel supra-oesophageal runs downwards on each side in VII. Nephridia in contracted specimens, fill space between gut and body wall nearly to mid-dorsal region. Nephridia absent in first 11 or 12 segments. Nephropores on *b* lines.

Clitellum deep red on XII or XIII to XLIII, and XXX to XXXI, XXXIII or XXXIV. Holandric. Male funnels iridescent. Seminal vesicles in IX-XII. Pseudovesicles present in XIII and XIV, in latter segment larger than in XIII. Spermathecae mostly concealed in parietes, 2 to 8 on each side in XIV-XVIII, with pores in 13/14 to 17/18.

Habits : Banks of lakes, ponds, tanks, rivers, in irrigation ditches and in almost any soil with organic matter that is saturated throughout the year.

Distribution : Burma : Bana, Mongmong, Na Hang, Mong Kung, Lashio, A Kin De, Shan Plateau.

Known only from Burma.

Glyphidrilus ceylonensis Gates, 1945

Glyphidrilus ceylonensis Gates, 1945 : 89; Brinkhurst & Jamieson, 1971 : 757.

Type locality : Palmadulla, Sri Lanka.

l = 180-280 mm, d = 5-7 mm.

Description : Prostomium zygolobous. Anus a dorsal triangular opening with anterior apex. Setae *ab* = *cd* < *bc* < *aa* < *dd*. Body surface with low ridges beginning in XVI-XIX and ending on XXXII-XXXV, slightly dorsal to *b* lines posteriorly, but passing gradually dorsal further anteriorly, anterior end markedly curved upwards and reaching nearly to *c* lines; almost twice as high over XXVI, XXVII or XXVIII-XXX, XXXI or XXXII than elsewhere. Post-setal genital markings with central area and peripheral rim, just ventral to ridges of puberty and close to *b* lines, on some or all of XVI-XXV and XXXI-XXXV. In one specimen, a marking just median to seta on one side in XXXIII and XXXIV.

Gizzard strong in VII. Intestine begins in XVI. Typhlosole begins in XVIII to XIX, fairly large, triangular. Dorsal blood vessel continues to brain region. Subneural vessel reaching pharyngeal region, but stouter behind XIX to XXIV. Hearts in (V), (VI) VII to IX, latero-oesophageal IX and XI. Nephridia absent from XI anteriorly, small in XII-XIV, large thereafter.

Clitellum? Spermathecal pores in 13/14 to 16/17 in *a* and *b* lines, "two in *bc* on each side" Holandric (?). Seminal vesicles in IX-XII.

Distribution : Known only from type locality.

Glyphidrilus gangeticus Gates, 1958

Glyphidrilus papillatus, Stephenson, 1920 : 258.

Glyphidrilus papillatus (part), Stephenson, 1923 : 493.

Glyphidrilus sp. Gates, 1947 : 121.

Glyphidrilus papillatus, Gates, 1948 : 175; Gates, 1951 : 17.

Glyphidrilus gangeticus Gates, 1958 : 55.

Type locality : Bayrani near Kallikote, Ganjam district, Orissa, India.

l (p)= 85-200 mm, d (p)= 4.0-5.5 mm, s = 202-325.

Description : Prostomium zygolobous. Anus dorsal or dorso-terminal, a median longitudinal slit widening to form a triangle posteriorly. Setae widely paired throughout; *aa* : *ab* : *bc* : *cd* : *dd* = 1.6 : 1 : 2 : 1.1 : 2.5 in XII = 2.5 : 1 : 2 : 1.2 : 3.7 in *c*. 300; *dd* : *u* = 0.20 and 0.25 respectively. Setae, all sigmoid, in clitellar region with a few distal oblique, jagged ridges giving them a minutely but sparsely toothed profile. This ornamentation less developed in posterior setae. Length and greatest width at node 418 μm and 26 μm in XXV, 300 μm and 22 μm in hind body. Wings start on XVII-XIX, ending on XXII-XXVI (= 61/2-9, usually 7 or 7½ segments). Wavy lamella 0.45 μm high and 0.15 μm wide, in *bc*. Genital markings paired, median and post-setal in (X), XLXIV (XV-XVI), XVII-XVIII, XIX, XXVIII-XXXII), or in some of these absent; paired lateral to or in dorsal half of *bc* in X, XII-XVII, XVIII (XIX-XXIII, XXIV, XXV, XXVI, XXVII (XXVIII-XXX); with rim and central portion.

Gizzard with major part in VIII or 2 separate gizzards in VII and VIII with larger in VIII. Intestine from XVI; typhlosole from XVII or XVIII, large, wide, not lamelliform. Oesophagus narrow with vascular striae in IX-XIII, aborted in front of XI, moniliform and poorly vascularised in XIV and XV. Dorsal blood vessel single exactly with commissures of IX with left commissure of VIII. Hearts in (VIII), IX-XI; only last pair latero-oesophageal. Dorsal vessel ends anteriorly with hearts of IX, with a left commissure of VIII, or with a pair of commissures to ventral trunk in VIII)?). Supra-oesophageal in XIII (XIV, XV?) anteriad. Latero-parietal vessels well developed uniting in XXII. Median neural subvessel in XVI or XVIII posteriad. Nephridia in XIII posteriad; rudimentary in XII. Nephropores in *b* lines.

Clitellum annular, in XIII, ½XIII, XIV, XVI (?)-XXVI-XXXIV (?) XXXVII (?) (= 11-23½ segments); limits indefinite. Holandric. Vasa deferentia not concealed in body wall. Seminal vesicles in IX-XII, last pair deflecting 12/13 to 13/14. Septal pouches on anterior walls of 13, 14 (15, 16). Male pores in intersegment 20/21 in *b*. Female pores minute white points in *b* lines, midway between anterior border and equator of XIV. Ovaries in XIII, transversely extensive unfolded laminar composed of longitudinal chains of oocytes. Inseminated spermathecae large laterally adpressed ellipsoidal sessile sacs with their long axes filling their segments longitudinally and projecting freely into coelom, 4 or 5 each side in a transverse row; or 2 or less in row is anterior of usual locations. Spermathecal pores chiefly in setal lines *a-d,* 4 or 5 on each side in a transverse row in 12/13, 13/14-16/17; sometimes reduced in number and size, in 17/18.

Distribution : India : Lucknow, Ahraura, Sahranpur, Sohagi (Uttar Pradesh); Kichha near Naini Tal (Uttaranchal), Yamuna River at Delhi.

Known only from India.

Glyphidrilus papillatus (Rosa, 1890)

Bilimba papillata Rosa, 1890 : 386; Beddard, 1895 : 687.

Glyphidrilus papillatus, Michaelsen, 1896 : 195; 1900: 459; 1903b : 134; 1918a : 344; Stepheson, 1920 : 258.

Glyphidrilus papillatus (part), Stephenson, 1923 : 493.

Glyphidrilus papillatus, Gates, 1926a : 472; 1926b : 183; 1926c : 218; 1926d : 169.

Glyphidrilus papallatus (part ?), Gates, 1930 : 352; 1931 : 431; 1933 : 603.

Glyphidrilus papillatus, Gates, 1958 : 60; 1972 : 237.

Type locality : Cobapo, Bapo district, Burma.

l = 74-120 mm, d = 3-6 mm, s = 130-330.

Description : Prostomium prolobous. Dorsal groove ? Anus wholly dorsal, with a posterior lobe. Setae in anterior part of body very widely paired, in posterior part of body fairly closely paired; *ab* anteriorly a little smaller than *aa*, posteriorly 1/3 *aa*; *c* and *d* dorsal. Wings begin in one of XVII-XIX and end in one of XXIII-XXVII, in *bc*. Genital markings primarily postsetal, numerous (8-40), umpaired, median in XII-XXX, paired and lateral to *a* in XII-XXX.

Gizzard in VIII (or also partly in VII). Intestine begins in XV. Typhlosole, thickly lamelliform, begins in XVIII. Dorsal blood vessel, aborted in front of hearts of VII, hearts in VII-XI (5 pairs) of VII, IX lateral, of X, XI latero-oesophageal with larger of dorsal bifurcations passing to supra-oesophageal trunk.

Clitellum red in XIII, XIV-XL. Seminal vesicles in IX-XII. Ovaries in XIII, ovi-sacs in XIV. Spermathecae in XIV-XVII, mostly within parietes, with pores in 13/14-16/17.

Habits : Banks of lakes, ponds, tanks, rivers, in irrigation ditches, swamps and in almost in any soil with saturated organic matter.

Distribution : Burma : Moulmein, Kawkareik, Pyapon, Thanchitaw Kyaiklat, Sittang, Rangoon, Kayan, Kyauktan, Bassein, Thinbawgyin, Nyaunglebin, Thanatpin, Tharrawaddy, Letpadan, Thonze, Herzada, Ingabu, Zalun, Cobapo, Prome, Taungdwingyi, Minbu, Sagiang, Monywa, Okma, Anidaung, Powindaung, Ingyindaung, Laungbyin, Bhamo, Woreabone, Tiangzup.

World distribution : Hainan (China).

Glyphidrilus spelaeotes Stephenson, 1924

Glyphodrilus spelaeotes Stephenson, 1924b : 133.

Glyphidrilus papillatus, Gates, 1972 : 237.

Type locality : Siju cave, Garo Hills, Assam, India.

l = 175 mm, d = 2-3 mm, s = 310.

Description : Prostomium zygolobous. Anus dorsal, a pear-shaped aperture with narrow end forward. Setae, lateral widely paired, ornamented ectally. Anteriorly to wings *ab* = 0.5 *aa* = 0.4 *bc* = 0.8 *cd*, *dd* = 1.7 *aa*; a little behind wings *ab* = 0.4 *aa* = 0.3 *bc* = 0.8 *cd*, *dd* > *aa* = 3 *cd;* towards hind end *dd* relatively greater, *aa* = or *ab* > *bc*, *ba* = *cd* with a few fine transverse striations near the tip. Wings in *bc*, from XVIII- XXIV, ½ XXV; on XVIII if present less than elsewhere and separated by an incision. Genital markings with rim; primarily postseptal, unpaired and median in XI, XVII-XVIII, paired in *aa* of XIX, XXVII-XXVIII, lateral to *b* in XIV-XVII and XXV, paired in (XIV, XV, XVI, XIX) XXV, XXVII, (XXVII), occasionally absent on one side; median in XI or in XVII and XVIII; each pair occupying only posterior two thirds of each segment. Dorsal median non-mamillate papillae may be present in XVIII to XXVIII, ? XXIX. Genital marking ?

Gizzard soft in VIII and posterior part of VII. Intestine begins in XV. Dorsal blood vessel aborted in front of hearts VIII. Hearts 4 pairs, in VIII to XI.

Clitellum from XIV-XV to XXX. Seminal vesicles in IX-XII, largest in XII. Ovaries on 13/14, 14/15 and 15/16; 5 (once 4) on each side in each row, in four rows, with supernumerary in *bc*. Prostates not observed. Spermathecal pores, at 13/14-15/16, at *a, b, c, d,* and in *bc*.

Distribution : Known only from the type locality.

Glyphidrilus tuberosus Stephenson, 1916

Glyphidrilus tuberosus Stephenson, 1916 : 349; 1923 : 494; Gates, 1958 : 59.

Type locality : Byrani, near Kallikote in Ganjam district, Orissa, India.

l = 70-118 mm, d = 2-3 mm, s = 310.

Description : Prostomium zygolobous, delimiting groove a shallow depression. Setae posterior to clitellum at angles of section; *aa* = *bc* = 2 *ab* = 2*cd*; *dd* = 3 *cd*; anterior to clitellum setae widely paired and irregular, *ab* = ½ *aa* or less. Papillae grow out into foliating tumour-like mass, extending nearly to *a* lines; similar papillae without rims in posterior parts of their segments; an anterior set, on X-XII, XIII, maximally a mid-ventral and each side two lateral, one in *ab* other above *b*; pre-alar and post-alar sets on XVI, XVII, XVIII-XIX and in XXIV-XXVIII, XXX respectively, in three pairs per segment, one papilla on each side median to *a*, one on *ab* and one above *b* but 1 to 5 papillae may be absent from a segment. Wings low on XX-XXIV. Grooves from wings may pass forward to XIV and back to XXVI, XXVII or XXVIII. Genital markings post-setal, small, circular to elliptical tubercles, slightly depressed peripherally, on X-XIII, XVI-XIX and XXIV-XXX, in *aa, ab* and *bc*.

Gizzard small in VII, sometimes also extending a little into VI; development variable, well developed and firm or, often, vestigeal. Intestine begins in XV. Typlosole ? Dorsal blood vessel aborted in front of hearts of VIII? Latero-oesophageal hearts present. Last hearts in XI. Nephropores on *b* lines and recognizable only from XV posteriorly.

Clitellum in XIV, XV, XVI-XXVIII, XXIX (or XXX dorsally). Wings low, on XVIII-XXV, continued forwards as a slight ridge to XV or XIV and sometimes back to XXVI, XXVII or XXVIII; they may be abnormal? Female pores minute, very slightly lateral to *b* lines and nearer to setal equator than to 13/14. Seminal vesicles in IX-XII. Ovi-sacs in XIV. Spermathecae in XIV and XV, small subspherical sacs with short, thin duct. Spermathecal pores at 13/14-14/15 on each furrow, on *a* and *b* lines and *bc*.

Distribution : India : Cuttack, Bayrani near Kallikote (Orissa); Jalpaiguri (West Bengal); South India; Arakan Yomas, western mountain wall between India and Burma.

Known only from the Indian subcontinent.

SUMMARY

This work includes introduction dealing with the anatomical section comprising of external characters and internal structure of the aquatic oligochaetes; and the systematic section comprising of diagnoses and keys of orders, suborders, families, subfamilies, genera, and descriptions, habits, distribution of 102 taxa, comprising of 8 species of family Aeolosomatidae, 61 species and 1 subspecies belonging to 12 genera of Naididae, 16 species belonging to 6 genera of Tubificidae, 1 species of Phreodrilidae, 8 species belonging to 6 genera of Enchytraeidae, 1 species of Lumbriculidae of Microdrili and 7 species of Microchaetidae of Megadrili.

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ALPHABETICAL INDEX

Names in *italics* are genera and species, while **bold** numbers indicate pages containing diagnoses and descriptions.

Ablabesmyia 81, 87, 93, 106, 197, 195
Achaeta 232
achencoli, Glyphidrilus 256
Actinospora 107
acuminata, Pristina 180
acuminata, L. imnaeae 64
acuminata, Pristina **180**
acuminata, Pristinella 179, **180**
Adelodriloides 186
Aeolosoma 15, 17, 22, 32, 35, **36**, 38, 49
Aeolosomatida 34, 35
Aeolosomatidae 1, 5, 9, 15, 18, 19, 20, 21, 31, 33, 34, **35**
aeolosomatis, Radiophryoides 40
aequalis, Nais paraguayensis var. 150
aequiseta, Pristina 7, 160, **161,** 162
agriodrilus 250
albidus, Enchytraeus 30, 170, **233**, 234
Alexandrovia 225, **227**.
Alldero 66
Allonais 6, 7, 9, 16, 23, 25, 27, 31, 32, 66, 67, **144,** 145
Alluoididae 34, 51
americana, Pristina 16, 24, 25, 26, 27, 28, 160
amphibiotica, Pristinella 16, 25, 26, 27, 28, 29, 179
Amphichaeta 6, 10, 12, 13, 14, 15, 16, 25, 27
Ampullana 237
Anatopynia 107
andhrensis, Nais **68,** 69
andina, Nais 68, **71,** 72
Arcella 129
Annadrilus 254, 255
annandalei, Chaetogaster 59
annandalei, Glyphidrilus 255, **256**
Antarctidrilus 229
Antipodrilus 186
antipodus, Epirodrilus 3
Aphanoneura 34, **35**
appendiculata, Nais 88
appendiculata, Slavina 6, 11, 16, 22, **88,** 90
aequalis, Nais paraguayensis var. 150
aequiseta, Pristina 7, 160, **161**
arcaliae, Pristinella 179
anjani, Aulodrilus stephensoni var. 220
Artidrilus 186
Arctonais 16, 24, 25, 27, 66
arenarius, Clitellio 29
asiatica, Dero 27
Aspidodrilus 232
Astacopsidrilus 229
attenuatus, Chironomus 195
Aulodrilinae 186, **216**, 217
Aulodrilus 6, 31, 30, 47, 206, 216, **217**
Aulophorus, 6, 7, 9, 11, 16, 17, 25, 26, 27, 32, 66, 67, **126**
Aurantiactinomyxon 107
austrina, Dero 108
Azolla 129
baicalensis, Lamprodrilus 3
Baikalodrilus 186

barbata, Nais 7, 67, 68, **73**, 74
barkudensis, Enchytraeus 248
barkudensis, Nais paraguayensis var. 150
barkudensis, Stephensoniella 248
beddardi, Aeolosoma 36, **37**
bedoti, Ilyodrilus 30
behningi, Nais 7
benedeni, Peloscolex 3
bengalense, Aeolosoma 38, 40
bengalensis, Chaetogaster 63
bengalensis, Chaetogaster limnaei 54, **63,** 64
bengalensis, Vivipara 95
bermudensis, Pontodrilus 250
biacuta, Radiophrya 74
Bilimba 254, 255
bilobata, Pristinella 179
biserrata, Pristina 24, 160
birmanicus, Glyphidrilus 255, **257**
Bothrioneurum 6, 22, 26, 29, 30, 31, 200, **258**
botniensis, Paranais 27
botrytis, Dero 3
branchiatus, Phreodrilus 3, 4, 17
Branchiobdellida 34, 51
Branchiobdellidae 34, 51
Branchiodrilus 3, 6, 7, 14, 16, 17, 18, 23, 25, 27, 66, 67, **96**, 99
Branchiura 4, 213
Branchiurinae 186, **213**
Bratislavia 66
bretscheri, Nais 7, 68, **75**
breviseta, Naidium 162
breviseta, Pristina 24, 25, 26, 27, 28, 118, 160, **162,** 163
Bryodrilus 232
Bryohenlea 232
Buchholzia 232
bulbosa, Fridericia **237,** 238
bulbosus Neoenchytraeus 237
caeca, Nais communis var. 76
callosa, Fridericia 237
carinata, Ephidatus 66
carteri, Aulophorus **127,** 128, 133, 167
carteri, Spongilla 63, 64, 79, 81, 149, 153, 161, 171, 175
caudata, Mrazekia 79, 171
cavicola, Enchytraeus 239
Cernosvitoviella 232
ceylonensis, Glyphidrilus 255, **258**
Chaetobranchus 96
Chaetogaster 4, 5, 6, 7, 10, 11, 12, 13, 14,15, 16, 18, 21, 23, 24, 25, 27, 29, 32, 33, **53**, 54, 55, 61
Chaetogastrinae 9, 10, 52, **53**
chelata, Allonais 6, 16
Chirodrilus 232
chlamys, Limnaea 64
claparedianus, Limnodrilus 190, **191**
Ciliata 225
clavata, Mesniella 253
Clitellata 34
Clitellinae 186
Cognettia 232
comata, Vejdovskyella 16, 27
communis, Nais 10, 16, 68, **76**, 77, 78
Conchapelepia 81, 87, 93
cooperi, Dero 102, **103**, 104
cooperi, Dero (*Dero*) 103
crassipes, Eichhornia 1, 40, 152
crassissima, Spongilla 63, 171, 175
crateriformis, Ephidatia 63

crateriformis, Spongilla 63
cristalinus, Chaetogaster 14, **54**, 55
cylindri, Maupausiella 194
Cryptochironomus 81, 195
decipiens, Spongilla 63
Dero 6, 7, 9, 10, 11, 13, 16, 17, 24, 25, 27, 32, 66, 67, **101,** 131
deronis, Juxtardiophrya 103
diaphanus, Chaetogaster 12, 13, 14, 33, 54, **57**, 58
diaphana, Nais 57
diastropha, Nais 59
diastrophus, Chaetogaster 54, **59**, 60
digitata, Dero 11, 14, 25, **105,** 106, 111, 115, 192, 194
digitata, Dero (*Dero*) 105
digitata, Nais 105
Diptera 81, 87, 93, 107, 195
dorsale, Dero 108
dorsalis, Dero 27, 84, 102, **108,** 109, 179
dorsalis Dero (*Dero*) 108
Dorydrilidae 34, 51
Dorydrilus 5, 34, 51
dubium, Triactinomyxon 190
elegans, Glyphidrilus 256
elinguis, Nais 11, 16, 24, 68, **79,** 80
elongata, Radiophrya 235
emarginata, Plumatella 81, 175
emarginata, Plumatella repens var. 56, 63, 74
Enchylea 232
Enchytraeidae 1, 9, 15, 17, 20, 34, 51, 206, **231**, 232
Enchytraeina 232
Enchytraeus **232**
Enchytronia 232
Endochirononus 87, 93
Epirodrilus 200
Epistylidae 113
evelinae, Pristina 7, 24, 25, 26, 28, 160, **164,** 165
evelinae, Slavina 25, 28
falciformis, Rhyacodrilus 6, 201
flabelliger, Aulophorus 126, 127, 129, 130
flagellum, Opistocysta 31
fluviatalis, Ephidatia 61, 64
fluviatalis, Glyphidrilus 256
foreli, Naidium 167
foreli, Pristina 7, 158, 160, **167**, 175, 177
fossularis, Stylaria 7, 24, 43, **91**, 92
frici, Paranais 27
Fridericia 232, **237**
furcata, Nais 131
furcatus, Aulophorus 126, 127, 129, **131,** 132
furcatus, Dero (*Aulophorus*) 131
fruticosa, Plumatella 74, 171, 175
gabriellae, Peloscolex 3
gangeticus, Glyphidrilus 255, **258,** 259
garlicensis, Raabeia 190
georgianus, Marionina 245
glandularis, Haplotaxis 5
Glyphidrilus **254**, 255, 257, 258
Glyptotendipes 93
gordioides, Haplotaxis 5
grandisetosus, Limnodrilus 195
Grania 232
gravelyi, Aulophorus 127, **134**
Guaranidrilus 232
gwaliorensis, Allonais **145**, 146
gwaliorensis, Nais 145
Haber 186

Haemonais 7, 9, 11, 14, 25, 66, 67, **93**
Haplotaxida 34, 51
Haplotaxidae 1, 5, 9, 34, 51
harurami, Enchytraeus **242**
harurami, Henlea **242**
headleyi, Aeolosoma 37, **38,** 39
helvatica, Hexactinomyxon 140
Hemienchytraeus 232, **239**
Hemifridericia 232
hemprichi, Aeolosoma 36, 37, 41, 42
Henlea 17, 232, **241**
hepatica, Fasciola 66
heteroseta, Paranais 7
hexacantha, Kincaidiana 3
Hirudina 34
hoffmeisteri, Limnodrilus 111, 140, 179, 189, 190, 192, 193, 216, 222
Homochaeta 6, 16, 24, 66
hortensis, Branchiodrilus 6, **96**, 98
hortensis, Lahoria 96
hyalinum, Aeolosoma 37, **43,** 44
hymanae, Aulophorus 111, 127, **135,** 136, 222
hymanae, Dero (*Aulophorus*) 135
Hystricosoma 35, 36, 37
idrensis, Pristinella 25, 29, 179
ignotum, Triactinomyxon 190
Ilyodrilus 29, 186
inaequalis, Allonais 16, 145, **147,** 148
inaequalis, Nais pectinata var. 147
indica Dero 102, **110,** 111
indica, Dero (Dero) 110
indicus, Aulophorus 127, **137**, 138
indicus, Enchytraeus 233, **235,** 236
intermedia, Vejdovskyella 7
iris, Bothrioneurum 208, **209**, 210
Isochaeta 186
Isochaetoides 186
jenkinae, Naidium 181
jenkinae, Pristina 181
jenkinae, Pristinella 179, 180, **181**
Jolydrilis 26, 30, 200
josinae, Specaria 16
Juxtaradiophrya 147
kashi, Aulodrilus 220
kashyapi, Aeolosoma 40
kempi, Stylaria 91
komareki, Radiophryoides 42
korotnoffi, Lamprodrilus 3
kozorovi, Ochridanus 194
krasnopoliskiae, Chaetogaster 7, 16
Kynotus 254
Labrundinia 93
lactea, Homochaeta 16
lacustris, Stylaria 5, 7, 13, 21, 24, 91
Lahoria 76
langi, Chaetogaster 54, 59, **61,** 62
laurentii, Haemonais 94
legeri, Triactinomyxon 190
leidyi, Pristina 26, 160
Limnaea 66
limnaei, Chaetogaster 7, 14, 54, 64
limnaei, Chaetogaster limnaei 54, **64,** 65
limnobius Aulodrilus 217
Limnodriloidinae 186
Limnodrilus 29, 30, 186, 187 **190**, 192, 195, 201, 206
limosa, Dero 103, 105
limosus, Monopylephorus 4, **204,** 205
limosus, Vermiculus 204
Littodrilus 203
littoralis, Paranais 12, 27

lomondi, Arctonais 16
longidentata, Pristinella 179
longiseta, Pristina 6, 8, 12, 24, 26, 28, 167, 168, 170
longiseta, Pristina longiseta **168**, 169, 170
longisoma, Pristinella 179
lumbriculi, Ptychostamum 253
Lumbricillus 4, 232
Lumbricomorpha 34, 51
Lumbriculida 33, 34, 51
Lumbriculidae 1, 3, 4, 5, 9, 17, 21, 22, 30, 31, 34, 51, **250**
Lumbriculus 4, 31, **251**
Lycodrilidae 34, 51
macrochaeta, Pristina 160, **172**
magna, Raabeia 194
magnum, Triactinomyxon 199
marina, Stephensoniella 247, **248**, 249
marinus, Enchytraeus 248
Marionina 232, **245**
maupasi, Radiophryoides 42
Megadrili 1
menoni, Branchiodrilus 99
menoni, Naidium 182
menoni, Nais 70
menoni, Pristina 182
menoni, Pristinella 15, 179, **182**, 183
Mesenchytraeus 232
michaelseni, Aulophorus 127, **139**, 140, 179
Microchaetidae 1, 51, **253**, 254
Microchaetinae 51, 253
Microchaetini (Glossoscolecidae) 250
Microchaetinae (Lumbricidae) 253, 254
Microchaetus 254
Microdrili 1, 3, 4, 5, 8, 15, 17, 18, 19, 20, 23, 26, 31
Microchaetidae (Glossoscolecidae) 253
minuta, Naidium 184
minuta, Pristina 184
minuta, Pristinella 179, **184**
moghei, Aulophorus 127, **141**
molesta, Salvinia 1
Moniligastrida 33, 34, 51
Moniligastridae 34, 51
Monopylephorus 26, 30, 200, 203
monospermathecatus, Phallodrilus 26, 30
montana, Slavina 88
mrazeki, Triactinomyxon 190
multiprostatus, Telmatodrilus **226**
naidanum, Triactinomyxon 79
Naididae 1, 3, 4, 5, 6, 9, 11, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 31, 32, 34, 51, **52**, 211
Naidimorpha 34, 51, 52
Naidinae 53, **66**
naidina, Homochaeta 7, 16
Naidium 179
Nais 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 16, 19, 22, 24, 25, 27, 30, 32, 33, 66, 67, 73, 83, 84, 211
naisensis, Juxtaradiophrya 74
natans, Salvinia 1
Neoaulodrilus 216
Neonais 66
niveum, Dero 112
nivea, Dero 102, **112**
niveum, Aeolosoma **45,** 46
notopora, Pristinella 179
nycticorax, Nycticorax nycticorax 197
obtusa, Dero 102, **113,** 114
obtusa, Nais 73
onegensis, Alexandrovia 3, **227,** 228

onegensis, Telmatodrilus 227
Oligochaeta 34, 35, **51**
Ophidonais 6, 9, 16, 24, 25, 26, 27, 29, 66
Opistocystidae 3, 5, 6, 34, 51
orientalis, Chaetogaster 57
osborni, Pristinella 179
palmata, Dero 80, 102, 115, **116**
palustris, Aulophorus 104, 137, 139
papillata Bilimba 260
papillatus, Bilimba 256
papillatus, Glyphidrilus 255, 258, 259, **260**
paradalis, Nais 7, 68, **81,** 82
pardalis, Nais bretscheri var. 7, 81
paraguayensis, Allonais 16, 29, 133, 150
paraguayensis, Allonais 145, **149,** 150, 151
paraguayensis, Nais 149, 150
proboscidae, Pristina **173**, 174
paraguayensis, Pristina probascidea var. 171, 173
Paranadrilus 200
Paranaidinae 52
Paranais 6, 9, 11, 16, 25, 27
parasitica, Ripistes 6
parvus, Monopylephorus 30, 203, 206, 207
parvus, Rhizodrilus 206
pectinata, Allonais 145, **152,** 153
pectinata, Dero 6, 102, **117**
pectinata, Nais 152
pectinatus, Aulodrilus 217, **218**
pectinatus, Limnodriloides 30
Peipsidrilus 216
Peloscolex 186
pellucidus, Chaetogaster 57
Pentaneura 87
Peristodrilus 200
Peritricha 113
peruviana, Pristina 118
Phreodrilidae 1, 5, 6, 9, 17, 22, 31, 34, 51, **229**
Phalodrilinae 186
Phreodriloides **229**, 230
?Phreodriloidinae 229
Phreodrilus 229
Piguetella 6, 9, 13, 16, 22, 23, 24, 25, 26, 29, 66
pigueti, Aulodrilus 194, 217, **220**, 221, 225
Planorbis 66
Plumatella 79, 89, 144
plumaseta, Pristina 24, 26, 27, 28, 160
plumosa, Dero 6, 102, **118,** 119
pluriseta, Aulodrilus 217, **222,** 224
pluriseta, Naidium 222
Polypedium 93, 107
Polyzoa 133, 179
Potamodrilidae 34, 35
?Potamodrilus 35
Potamothrix 186
Pristina 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 23, 24, 25, 26, 27, 28, 32, 33, 82, **159**, 177
Pristinella 15, 16, 27, 159, **179**
Pristininae 52, 53, **159**
Pristinis, Rhabdostyla 185
proboscidea, Pristina 160, **173,** 174
Procladius 107
Procladinum 98
Propappus 232
Protruberodrilus 200

Protozoa 74, 107, 113, 137, 147, 153, 225
Psammoryctides 186
pseudobtusa, Nais 7, 68, **83**
pseudobtusa, Nais obtusa var. 83
punjabensis, Chaetogaster 59
punjabensis, Nais communis 76
punjabensis, Nais variabilis var. 76
punjabensis, Slavina 88
puytoraci, Radiophryoides 47
Quistadrilus 186
raabei, Aurantiactinomyxon 194
radiatum, Echinoactinomyxon 190
rangoonensis, Enchytraeus 239
rangoonensis, Hemienchytraeus 239
raviensis, Dero 102, **120**, 121
raviensis, Dero (Dero) 121
raviensis, Nais 102, **120**
rayalaseemensis, Allonais 145, **154**, 155
rectilatrum, Limnaeae gedrosiana 64
remex, Aulodrilus 220
repens, Jussiae 1
Rhabdostyla 113
Rheomorpha 35, 36
Rhizodrilus 30, 200, 203
Rhopalonais 66
Rhyacodrilinae 186, **200**
Rhyacodrilus 6, 29, **200**
Rhynchelmis 3
Ripistes 6, 7, 9, 16, 24, 25, 27, 66
rosea, Pristinella 7, 15, 16, 179
rubroniveus, Monopylephorus 253
saffronensis, Glyphidrilus 256
Salvinia 6, 9, 16, 129
sawayai, Dero 3, 102, **122**, 123
Schizodrilus 229
semperi, Branchiodrilus 94, **99**, 100, 194, 222
semperi, Chaetobranchus 99
serpentina, Ophidonais 16
setosa, Homochaeta 25, 27
setosus, Chaetogaster 7
silvani, Limnodrilus 189, 193, 194
sima, Pristinella 179
simplex, Nais 11, 68, **84**, 85
simplex, Nais variabilis var. 84
simplex. Paranais 27
Siolidrilus 6, 216
Sketodrilus 216
Slavina 6, 9, 23, 24, 25, 27, 31, 66, 67, **88**
socialis, Limnodrilus 192
sowerbyi, Branchiura 3, 17, 18, 111, 194, 197, **231**, 214, 222
Specaria 9, 16, 24, 25, 27, 66
spelaeotes, Glyphidrilus 255, **260**
sperberae, Pristina 160, **175**, 176, 177
Spirochona 79, 171, 211
Spirogyra 93
Spongilla 89, 90
Spongilla, Chaetogaster 61
stephensoni, Aulodrilus 220
stephensoni, Hemienchytraeus **239**, 240
stephensoni, Rhyacodrilus **201**, 202
Stephensonia 156
Stephensoniana 6, 10, 15, 16, 23, 24, 25, **156**
Stephensonianinae 52, 53, **156**
Stephensoniella 232, **246**
Stercutus 232
stewarti, Fridericia 243
stewarti, Michaelseniella 243

stratioides, Pistia 1
Stylaria 3, 6, 7, 9, 10, 11, 13, 16, 19, 22, 23, 24, 25, 26, 27, 28, 29, 32, 33, 66, **91**
Styloscolex 31
subterranea, Marionina **246**, 247
subterranea, Michaelsena 246
synclites, Pristina 7, 160, **177**, 178
tanganykia, Plumatella (Afridenella) 79
Telmatodrilinae 186, **225**
Telmatodrilus 29, **225**
tentaculata, Bithynia 66
ternaria, Pleurophleps 50
ternarium, Aeolosoma **50**
Tetractinomyxida 107
Thalassodrilus 216
tomentosa, Lymnaea 66
tonkinensis, Aulophorus 25, 29, 127, **142**, 143
tonkinensis, Dero 142
tonkinensis, Dero (Aulophorus) 142
travancorense, Aeolosoma 36, **45**, 48
Triactinimyxon 79, 171
Tribelos 93
Trichodrilus 3
Tritogenia 254
trivandrana, Stephensonia 156
trivandrana, Stephensoniana 27, **156,** 158
trivandranum, Naidium 156
trivandranus, Aulodrilus 222
tuberosus, Glyphidrilus 187, 255, **261**
Tubifex 3, 4, 22, 26, 29, 145, 186, **187**, 203, 206
tubifex, Lumbriculus 187
tubifex, Tubifex 4, 5, **187,** 188, 195
tubifex, Tubifex (Tubifex) 187
Tubificida 34, 51
Tubificidae 1, 4, 5, 6, 8, 9, 17, 19, **20, 21,** 22, 26, 29, 30, 31, 34, 51, 185
Tubificidarum 186
Tubificinae **136,** 187, 217
typica, Pristina longiseta f. 168
typica, Pristina proboscidea f. 173, 174
udekemianus, Limnodrilus 190, **197**, 198
Uncinais 6, 9, 16, 24, 25, 27, 66
unciniate, Uncinais 16, 24
vagus, Aulophorus 21
variabilis, Nais 11, 14, 68, 70, 71, **86**, 87
Variechaetodrilus 186
variegatus, Lumbriculus 3, 4, 8, 30, 31, **251,** 252
variegatus, Lumbricus 251
variegatus, Peloscolex 3
vejdovskyella, Bothrioneurum 208, **211,** 212
Vejdovskyella 6, 7, 9, 24, 25, 26, 27, 66
Vejdovskyi, Telumatodrilus 225
ventriculosa, Enchytraeus 243
ventriculosa, Henlea 242, **243**, 244
Vermiculus 203
vericillata, Hydrilla 1
viride, Aeolosoma 33, 36, **49**, 50
visakapatnamensis, Radiophryoides 43
waldvogeli, Haemonais 27, **94**, 95
Waspa 66
weberi, Glyphidrilus 255
zeylanica, Dero 102, **124**, 125
zeylanica, Dero (Dero) 124
zeylanicus, Hespirodrilus 230
zeylanicus, Phreodriloides **230,** 231
zeylanicus, Phreodrilus 230
zeylanicus, Phreodrilus (Phreodriloides) 230

Sri K. Vanamala Naidu was born on 5th June 1923 at Bellary, Karnataka. He had schooling at Bellary and Adoni, under graduation at Anantapur and graduation and post graduation in Presidency College, Chennai. He started teaching in Presidency College, Chennai and taught in two other degree Colleges in old Madras Presidency and nine Government Degree Colleges in Andhra Pradesh. In 1952 started doing research in his spare time as hobby on fresh water Oligochaeta from Bugga stream in Cuddapah town. He published over 30 research papers in Indian and foreign journals on fresh water oligochaetes of India, Singapore and Australia, protozoan parasites of Oligochaeta, Ciliophora, Euglenoidina, Thecamoebae, Gastrotricha, Rotifera and Nematoda. He helped in identifying oligochate material sent to him by Indian and foreign researchers and institutions. When denied the laboratory facilities and use of binocular reserach microscope outside the college hours and holidays by the college authorities, from 1959-1960, he turned his attention to the flora of Cuddapah and Chittoor districts and published 6 papers on flora of Cuddapah and Tirupati hills. He is currently working on the manuscript on the Acanthocephala of Indian subcontinent and in collaboration with Dr. S. Z. Siddiqi on the manuscript of Rotifera of Indian subcontinent.