TAXONOMY OF MAJOR PLANT PARASITIC NEMATODES IN HILLY ZONES OF TAMILNADU

Thesis submitted in part fulfilment of the requirements for the

Degree of MASTER OF SCIENCE (Agriculture) in PLANT NEMATOLOGY

to the Tamil Nadu Agricultural University, Coimbatore

By

MANOJ KUMAR DEHURY, B.Sc (Ag.)

I.D.No. 99-613-001

DEPARTMENT OF NEMATOLOGY

TAMIL NADU AGRICULTURAL UNIVERSITY

COIMBATORE –641003

2001

CERTIFICATE

This is to certify that the thesis entitled **"TAXONOMY OF MAJOR PLANT PARASITIC NEMATODES IN HILLY ZONES OF TAMILNADU"** submitted in part fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT NEMATOLOGY** to the Tamil Nadu Agricultural University , Coimbatore is a record of bonafide research work carried out by **Mr.MANOJ KUMAR DEHURY**, under my supervision and guidance and that no part of this thesis has been submitted for the award of any other Degree,Diploma,Fellowship or other similar titles of prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Place: Coimbatore

Date: 11.07.2001

11/7/01

(Dr.M.SIVAKUMAR)

Chairman

Approved by

Chairman: 2/8/01

(Dr.M.SIVAKUMAR)

Members:

(Dr.S.SUBRAMANIYAN)

2/8/01

(Dr.K.RAMARAJU)

Date: 2.08.2001

External Examiner

(Dr. K.KRISHNAPPA)

Acknowledgement

ACKNOWLEDGEMENT

With regardful memories.....

I thank almighty for all his choicest blessing showered for the success of this achievable saga.

Overwhelmed in silence , I express my gratitude beyond word.... for his immaculate, ingenious and ineffable manner in which my chairman **Dr.M.Sivakumar**, Associate Professor , Department of Nematology guided me.

May I convey the greatest privilege to record my deep sense of gratitude to the members of my advisory committee **Dr.S.Subramaniyan**,Assistant Professor, Department of Nematology and **Dr.K.Ramaraju** , Associate Professor, Department of Entomology for their valuable suggestions and able counselling throughout the period of study.

Words seem inadequate to express my sincere thanks to **Mrs.B.Anita**,Assistant Professor,Department of Nematology for her sustained interest and constant help throughout the course of my research study.

It is my great pleasure to express my heartful thanks to **Dr.G.Rajendran**,Professor and Head, Department of Nematology, **Dr. (Mrs). Rajeswari Sundarababu**, Professor, **Dr.S.Ramakrishnan**, Associate Professor and **Dr.(Mrs.) K.Poornima** , Assistant Professor for their instant help and constant encouragement.

On a pleasant note I wish to express my heartful thanks to friends **Dr.B.K.Das,Lala,Kalaiarasan,Jaikumar** and **Swarnakumari** for their incessant inspiration of untiring help.

I extend my special thanks to **ICAR , New Delhi** for providing the Junior Research Fellowship during my tenure at TNAU.

Last but not the least , I do not want to pen down some words to portray the laudable role and relentless efforts of my parents , brother and sister for whom I would like to keep the powerful feelings of love and affection to be nurtured in the deepest of my heart.

(MANOJ KUMAR DEHURY)

Abstract

ABSTRACT

TAXONOMY OF MAJOR PLANT PARASITIC NEMATODES IN HILLY ZONES OF TAMILNADU

BY

MANOJ KUMAR DEHURY

DEGREE : Master of Science (Agriculture) in Plant nematology

CHAIRMAN : **Dr. M.SIVAKUMAR**
Associate Professor
Department of Nematology
Tamil Nadu Agricultural University
Coimbatore – 641003

2001

A random survey conducted in hilly zones of TamilNadu viz., Udhagamandalam in the Nilgiris district, Kodaikanal in Dindigul district and Yercaud in Salem district, revealed the presence of ten major plant-parasitic nematodes viz., ***Globodera pallida*** (Stone, 1973) Behrens, 1975, ***G.rostochiensis*** (Wollenweber, 1923) Behrens, 1975, ***Helicotylenchus brassicae*** n.sp, ***H.conicephalus*** Siddiqi, 1972, ***H.dihystera*** (Cobb, 1890) Sher, 1961, ***Hoplolaimus indicus*** Sher, 1963, ***Meloidogyne hapla*** Chitwood, 1949, ***M.incognita*** (Kofoid and White, 1919) Chitwood, 1949, ***Pratylenchus coffeae*** (Zimmerman, 1898) Filipjev and Schuurmans Stekhoven,1941, ***Tylenchorhynchus shervroyi*** n.sp.

The species were identified by using the taxonomic keys, drawings and measurements were made, and the dimensions compared with the original descriptions. Differential diagnosis were given for the two new species identified.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

CHAPTER I
INTRODUCTION

The Western Ghat in Tamilnadu ranges from Nilgiris to Kanyakumari with the major stretch and adjoining regions being Yercaud in Shervroys and Javadhu hills.

The Plant parasitic nematode fauna in this region, have not been not fully studied , since most of this hilly zones are undisturbed and unexploited and have the nematode community intact. Keeping this in view, a study was conducted in this region to assess the major plant parasitic nematodes.

Three hill stations *viz.*,Udhagamandalam in Nilgiris ,Yercaud in Salem and Kodaikanal in Dindigul districts were surveyed for this purpose

The prime objectives of the present study are as follows:-

1. To survey the hilly zones at Tamilnadu for the major plant parasitic nematodes
2. To prepare permanent slides out of the collection and identify the important species of nematodes by making drawings and measurements, follwoings the taxonomy keys.
3. To describe new species encountered, if any
4. Maping the predominant species in the study.

Since most of the nematological surveys were concentrated in the area where intensive cultivation is followed, the present study in the undisturbed areas aims at possibilities of getting new species of plant parasitic nematodes with economic importance.

Since taxonomy forms the base on which the nematodes management strategies rest, the study was taken up. This preliminary investigation would help the future taxonomists to study the plant parasitic, predatory and entomophilic nematodes in the hilly zones of Tamil Nadu.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Phylum – Nemata (Diesing , 1861,Potts,1932) Maggenti , 1981

The nematodes have been placed within the kingdom Animalia and under the group invertebrate . Chitwood & Chitwood (1950) classified all the animals which are devoid of true body cavity but having bilateral symmetry under subkingdom Scolecida and proposed nine phyla. Nematodes were kept under the phylum Nematoda.

Hyman (1951) included six classes under phylum Aschelminthes *viz.*, Rotifera,Gastrotricha,Echinodera,Priapulida,Nematoda and Nematomorpha.

Borradiale *et al.* (1961) placed nematodes in a separate phylum Nematoda.

Thorne (1961) considered the group as phylum Nemata and divided into two classes *viz.*, the Secernentea and Adenophorea while Goodey (1963) suggested the group to have the status of the class Nematoda . The concept that nematodes belong to phylum Nemata was first proposed by Cobb which was later supported by Maggenti (1981).

Review of the major genera of plant parasitic nematodes , encountered in the present investigations are given.

The taxonomic position of the genus *Globodera* Skarbilovich , 1959 is as follows:

Phylum – Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981

Class – Secernentea (Von Linstow ,1905,Chitwood and Chitwood, 1958) Maggenti , 1981

Subclass – Diplogasteria (Von Linstow ,1905,Chitwood and Chitwood, 1958) Maggenti , 1981

Order – Tylenchida (Filipjev, 1934) Thorne , 1949

Suborder – Tylenchina (Filipjev, 1934) Geraert , 1966

Superfamily –Tylenchoidea (Filipjev, 1934) Chitwood and Chitwood ,1937

Family – Heteroderidae(Filipjev and Schuurmans Stekhven,1941)

Skarbilovich , 1947

Subfamily – Heteroderinae Filipjev and Schuurmans Stekhven,1941

Genus – *Globodera* Skarbilovich , 1959

= *Heterodera* (*Globodera*) Skarbilovich , 1959

Heterodera rostochiensis was first described by Wollenweber (1923) who recognised morphological differences of isolates of the beet cyst nematode *Heterodera schachtii.* However , the status of *H.rostochiensis* and its relationship to *H.schachtii* was unclear until Franklin (1940) published a detailed description and diagnosis of *H.rostochiensis.*

Thorne (1949) proposed Heteroderidae to include *Heterodera* and *Meloidogyne* Goeldi, 1892 on the basis of sexual dimorphism.

Chitwood and Chitwood (1950) ignored sexual dimorphism and placed the family Heteroderidae based on the heavy stylet, general characteristics of the head and the oesophagus of the adults. They recognised sub families *viz.*, Heteroderinae, Hoplolaiminae Filipjev, 1934 and a sub family Nacobbinae.

Skarbilovich (1959) reemphasized sexual dimorphism as a family character and she placed all groups of nematodes with swollen females, including Heteroderinae with *Heterodera* as the only genus, Tylenchulinae, Nacobbinae, Spheronematinae Raski and Sher, 1952 and the new sub family Meloidogyninae under the family Heteroderidae.

Paramonov (1967) accepted the Thorne's family concept, but recognised two different sub families *viz.*, Heteroderinae and Meloidogyninae.

Golden (1971) raised the family Heteroderidae to super family Heteroderoidae with two families Heteroderidae and Nacobbidae.

Mulvey and Stone (1976) placed *Heterodera rostochinesis* and *H.pallida* under the genus *Globodera* Skarbilovich, 1959.

Mulvey and Golden (1983) diagonised the cyst forming genera of Heteroderidae and gave morphometrics of 34 known cyst species along with an illustrated key for the identification of these genera and species.

Wouts (1984) described *Globodera zelandica* as a new species and also presented a key to the species of *Globodera*.

Wouts (1985) revised the family Heteroderidae and presented a phylogenetic classification of the family.

In their reappraisal, Luc *et al.*, (1988) placed the sub families *viz.*, Heteroderinae, Meloidogyninae and Nacobboderinae under single family Hetertoderidae.

Diagnosis of the genus *Globodera* Skarbilovich, 1959

Syn. *Heterodera (Globodera)* Skarbilovich, 1959

Female:

Cysts stage present, body globose, spheroidal with a short neck and no terminal cone. Cuticle thick, with superficial lace-like pattern; D-layer present. Vulva terminal of medium length. Vulval area circumferestrate; superficial tubercles near vulva. No anal fenestration, but anus and vulva lying both in a "Vulval Basin". Underbridge and bullae rarely present. All eggs retained in body (no egg mass)

Male:

Body twisted, lateral field with four lines. Spicules greater than 30 μm, distally pointed. No cloacal, tail short, hemispherical.

Second -stage juvenile:

Stylet < 30 μm. Lateral field with four lines. Oesophageal glands filling the body cavity. Tail conical, pointed with terminal half hyaline, Phasmid punctiform.

LIST OF VALID SPECIES OF *GLOBODERA* SKARBILOVICH ,1959

G.achillae (Golden & Klindic , 1973) Behrens , 1975

G.artemisiae (Eroshenko & Kazachenko , 1972) Behrens , 1975

G.chaubattia Gupta & Edward , 1973

G.hypolysi Ogawa , *et al.*, 1983

G.leptonepia (Cobb & Taylor , 1953) Behrens , 1975

G.millefolii (Kirjanova & Krall , 1965) Behrens , 1975

G.mirabilis (Kirijanova , 1971) Mulvey & Stone , 1976

G.pallida (Stone , 1973) Behrens , 1975

G.pseudorostochiensis (Kirijanova , 1963) Mulvey & Stone , 1976

G.rostochiensis (Wollenweber , 1923) Behrens , 1975

G.tabacum solanacearum (Miller & Gray , 1972) Behrens , 1975

G.tabacum tabacum (Lownsbery & Lownsbery , 1954) Behrens , 1975

G.tabacum virginiae (Miller & Gray , 1968) Behrens , 1975

G.zelandica Wouts , 1984

The taxonomic position of the genus *Helicotylenchus* Steiner,1945 is as follows :

Phylum	– Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981
Class	– Secernentea (Von Linstow ,1905, Chitwood & Chitwood,1958) Maggenti , 1981
Subclass	– Diplogasteria (Von Linstow ,1905,Chitwood & Chitwood,1958) Maggenti , 1981
Order	– Tylenchida (Filipjev, 1934) Thorne , 1949
Suborder	– Tylenchina (Filipjev, 1934) Geraert , 1966
Superfamily	– Tylenchoidea (Filipjev, 1934) Chitwood & Chitwood , 1937
Family	– Hoplolaimidae (Filipjev, 1934) Wieser , 1953
Subfamily	- Hoplolaiminae Golden , 1971
Genus	– *Helicotylenchus* Steiner , 1945

Steiner (1945) suggested the genus *Helicotylenchus* under the subfamily Tylenchinae, Filipjev, 1934 include the nematodes having a modified terminal oesophagus with indistinctly set-off bulb and with enlarged , protruding oesophageal glands under the genus.

Thorne (1949) include the genera *Hoplolaimus* Daday, 1905, *Rotylenchus* Filipjev,1936 and *Helicotylenchus* under the subfamily Hoplolaimidae and separated the genera *Helicotylenchus* from *Rotylenchus* on the basis of amphidial aperture position.

Goodey (1951) in his revised classification of Hoplolaimidae synonymised the genera *Helicotylenchus* and *Rotylenchus* and included *Hoplolaimus* under the subfamily Hoplolaiminae .

Golden (1956) revised the genus *Rotylenchus* and removed *Helicotylenchus* from synonymy. He distinguished it from *Rotylenchus* based on the distance of dorsal oesophageal gland orifice (DGO) from the stylet base.

Andrassy (1958) in his revision of Hoplolaiminae accepted the basic classification of Golden (1956) for separating *Helicotylenchus* and *Rotylenchus* .Two more genera *Scutellonema* and *Gottholdsteineria* were proposed and included *Helicotylenchus* ,

Rotylenchus and *Gottholdsteineria* in one group and *Scutellonema* and *Hoplolaimus* in the another.

Perry *et al.* (1959)revised the genus *Helicotylenchus* and synonymised *Gottholdsteineria* Andrassy , 1958 with *Helicotylenchus* and proposed that all species of spiral nematodes except those with a large phasmid, be placed in the genus *Helicotylenchus* without mentioning the status of the genus *Rotylenchus* .

Skarbilovich (1959) reclassified the order Tylenchida Thorne,1949 and diagnosed the subfamily Hoplolaiminae and included the genera *Hoplolaimus*, *Rotylenchus* and *Helicotylenchus*.

Chitwood (1958) described the family Hoplolaimidae to include the subfamilies Heteroderinae Skarbilovich, 1947, Hoplolaiminae Filipjev, 1934, Pratylenchinae Thorne, 1949 and Naccobinae Chitwood and Chitwood, 1950. Heteroderidae Skarbilovich, 1947 was considered a synonym of Hoplolaimidae.

Perry (1960) separated the genera *Rotylenchus* and *Helicotylenchus* based on the shape of lip region, cephalic framework and shape of the female body in relaxation.

Sher (1961)synonymised the genus *Gottholdsteineria* with *Rotylenchus*. He diagnosed *Helicotylenchus* as having a ventral overlap of oesophageal gland and '0' value of 25 percent or more and *Rotylenchus* as having a dorsal overlap of the oesophageal glands and ' 0 ' value of 25 percent or less.

Based on the size, shape and position of phasmid, Golden (1971) separated *Rotylenchus* and *Helicotylenchus* from Hoplolaiminae and proposed a new subfamily Rotylenchinae to include these two genera. The subfamily Rotylenchinae was diagnosed as having small phasmids, pore like, situated in anal region in contrast Hoplolaiminae having larger phasmids (scutellae) occupying variable positions in body.

Fotedar and Kaul (1985) gave a revised and comprehensive key to the species of genus *Helicotylenchus* Steiner 1945, and synonymised *H.teres* Gaur and Prasad 1973 with *H.insignis* Basir and Khan, 1964 and *H.oscephalus* Anderson , 1979 and *H.teleductus* Anderson , 1974.

Fortuner (1987) revised the family Hoplolaimidae and synonymised the family Nemonchidae, Aphasmatylenchidae and Rotylenchidae with Hoplolaimidae. A tabular key for the identification of valid genera was presented.

Diagnosis of *Helicotylenchus* Steiner , 1945

=*Rotylenchoides* Whitehead , 1958

= *Zimmermannia* Shamsi , 1973

Female:

Body vermiform , spiral to straight. Labial region continuous to slightly offset , rounded or anteriorly flattened , generally annulated but never longitudinally striated ; anterior lip annulus generally not divided into sectors , with elongate amphid apertures . Rarely faint or marked lip sectors are present. Lateral field with four lines . Phasmids small, near anus; cephalids and caudalids present. Tail 1 to 2 1/2 body diameters long , typically more curved dorsally , with or without a terminal ventral process , sometimes rounded . Stylet and labial framework average sized. DGO from 6-16 mm from stylet base. Median bulb rounded with average sized valve. Glands overlap intestine dorsally and ventrally , all three glands of about the same length. Two genital branches, the posterior one sometimes degenerated or reduced to a post uterine sac (PUS). Epiptygma present but folded inwards, into the vagina. Vulval flaps present, inconspicuous.

Male:

Slight sexual dimorphism seen in smaller anterior end . Caudal alae enveloping tail end.

Type species – *Helicotylenchus dihystera* (Cobb , 1893) Sher , 1961

LIST OF VALID SPECIES OF *HELICOTYLENCHUS* STEINER,1945

Helicotylenchus abuharazi Zeidan & Geraert, 1990

H.abunaami Siddiqi, 1972

H.acutus Teben'kova, 1983

H.aerolatus Berg &Heyns, 1975

H.africanus (Micoletzky, 1916) Andrassy, 1958

H.agricola Elmigly, 1970

H.amabilis Volkova, 1987

H.angularis Mulk & Siddiqi, 1982

H.anhelicus Sher, 1966

H.annobonensis (Gadea, 1960) Siddiqi, 1972

H.aqulii Khan & Nanjappa, 1972

H.arachisi Mulk & Jairajpuri, 1975

H.areolatus Fortuner, 1984

H.astriatus Khan &Nanjappa, 1972

H.australis Siddiqi, 1972

H.babikeri Zeidan & Geraert, 1990

H.belli Sher, 1966

H.belurensis Singh & Khera, 1979

H.bembasae Elmigly, 1970

H.bihari Mulk & Jairajpuri, 1974

H.borinquensis Roman, 1965

H.bradys Thorne & Malek, 1968

H.brevis (Whitehead, 1958) Fortuner, 1984

=*Rotylenchoides brevis* Whitehead , 1958

H.caipora Monteiro & Mendonca, 1972

H.californicus Sher, 1966

H.canadiensis Waseem, 1961

H.canalis Sher, 1966

H.caribensis Roman, 1965

H.caroliniensis Sher, 1966

H.caudatus Sultan, 1985

H.cavenessi Sher, 1966

H.cedreus Volkova, 1987

H.certus Eroshenka & Nguent Vu Tkhan, 1981

H.clarkei Sher, 1966

H.concavus Roman, 1961

H.conicephalus Siddiqi,1972

H.coomansi Ali & Loof, 1975

H.cornurus Anderson, 1979

H.craigi Khoblock & Laughlin, 1973

H.crassatus Anderson, 1973

H.crenacauda Sher, 1966

H.curvatus Roman, 1965

H.delanus Marais, 1998

H.delhiensis Khan & Nanjappa, 1972

H.dolichodoryhorus Sher, 1966

H.densibullatus Siddiqi, 1972

H.depressus Yeats, 1967

H.digitatus Siddiqi & Hussain, 1964

H.digitiformis Ivanova, 1967

H.digonicus Perry *et al.*, 1959

H.dihystera (Cobb, 1890) Sher, 1961

H.distinctus Mohilal *et al.*, 1998

H.egyptiensis Tarjan, 1964

H.elegans Roman, 1965

H.erythrinae (Zinnermann, 1904) Golden, 1956

H.essykkulensis Sultanalieva, 1983

H.exallus Sher, 1966

H.excallus Sher, 1966

H.flatus Roman, 1965

H.girus Saha *et al.*, 1974

H.glissus Thorne & Malek, 1968

H.goodi Tikyani, *et al.*, 1966

H.graminophilus Fotedar & Mahajan, 1974

H.gratus Patil & Khan, 1982

H.haki Fotedar & Mahajan, 1974

H.hazratbalensis Fotedar & Handoo, 1974

H.hoplocaudus Manjreder, 1972

H.hydrophilus Sher, 1966

H.imperialis Rashid & Khan , 1974

H.incisus Darekar & Khan, 1978

H.indenticaudatus Mulk & Jairajpuri, 1974

H.incisus Darekar & Khan, 1978

H.indicus Siddiqi, 1963

H.insignis Khan & Basir, 1964

H.interrogativus Eroshenko, 1981

H.issykkulensis Sultanalieva ,1983

H.jammuensis Fotedar & Mahajan , 1974

H.jojutlensis Zavaleta-Mejia & Sosa Moss, 1979

H.kashmirensis Fotedar & Handoo, 1974

H.kermarreci Marais *et al.*, 1999

H.khani Fortuner, 1984

H.kherai Kumar, 1982

H.krugeri Berg & Heyns, 1975

H.labiatus Roman, 1965

H.labiodiscinus Sher, 1966

H.laevicaudatus Eroshenko& Nguent Vu Tkhan, 1981

H.leiocephalus Sher, 1966

H.lemoni Firoza & Maqbool, 1996

H.limarius Eroshenko *et al.*, 1985

H.lobus Sher, 1966

H.longicaudatus Sher, 1966

H.macronatus Mulk & Jairajpuri, 1974

H.magnicephalus Phukan & Sanwal, 1981

H.magniferensis Elmigly, 1970

H.martini Sher , 1966

H.microcephalus Sher, 1966

H.microdorus Prasad *et al.*, 1965

H.minutus Berg *et al.*, 1991

H.minzi Sher , 1966

H.monstruosus Eroshenko, 1984

H.montanus Teben'kobva, 1983

H.mucronatus Siddiqi, 1963

H.multicinctus (Cobb, 1893) Golden, 1956

H.neopaxilli Inserra *et al.*, 1979

H.nigeriensis Sher, 1966

H.notabilis Eroshenko& Nguent Vu Tkhan, 1981

H.obliquus Maqbool & Shahina, 1986

H.obtusicaudatus Darekar & Khan, 1978

H.oleae Inssera *et al.*, 1979

H.orientalis (Siddiqi & Hassain, 1964) Geraert, 1976

H.orthosomaticus Siddiqi, 1972

H.oscephalus Anderson, 1975

H.parabelli Volkova, 1987

H.paracanalis Sauer& Winoto, 1975

H.paraconcavus Rashid & Khan, 1974

H.paradihysteroides Darekar & Khan, 1978

H.paragirus Saha *et al.*, 1973

H.paraplatyurus Siddiqi, 1972

H.pasohi Sauer & Winoto, 1975

H.paxilli Yuen, 1964

H.persici Saxena *et al.* 1972

H.phalerus Anderson, 1979

H.pisi Swarup & Sethi, 1968

H.planquettei Marais & Queneherve, 1999

H.platyurus Perry *et al.* 1959

H.plumariae Khan & Basir, 1964

H.pseudodigonicus Szezygil, 1970

H.pseudorobustus (Steiner, 1914) Golden, 1956

H.pteracercus Singh, 1971

H.pteracercusoides Fotedar & Kaul, 1985

H.regularis Philips, 1971

H.retusus Siddiqi & Brown, 1964

H.reversus Sultan , 1985

H.reynosus Razjivin *et al.*, 1973

H.rohtaangus Jairajpuri & Baqri, 1973

H.rotundicauda Sher, 1966

H.ryzhikovi Kulinich, 1985

H.sacchari Razjivin *et al.* 1973

H.sandersae Ali & Loof, 1971

H.scoticus Boag & Jairajpuri, 1985

H.serenus Siddiqi, 1963

H.seshadrii Singh & Khera, 1979

H.sharafati Mulk & Jairajpuri, 1974

H.sieversii Razjivin, 1971

H.silvaticus Lal & Khan, 1989

H.solani Rashid, 1972

H.spitsbergensis Loof, 1971

H.steineri Fotedar & Mahajan, 1974

H.stylocercus Siddiqi & Pinochet, 1979

H.teleductus Anderson, 1975

H.teres Gaur & Prasad, 1973

H.thornei Gupta & Chhabra, 1966

H.thornei Roman, 1965

H.trapezoidicaudatus Fotedar & Kaul , 1985

H.trivandranus Mohandas, 1976

H.tropicus Roman, 1965

H.truncatus Roman, 1965

H.tumidicaudatus Philips, 1971

H.tunisiensis Siddiqi, 1963

H.urobelus Anderson, 1978

H.ussuriensis Eroshenko, 1981

H.variabilis Philips, 1971

H.varicaudatus Yuen, 1964

H.ventroprojectus Patil & Khan, 1982

H.ventroprojectus Patil & Khan, 1982

H.verecundus Zarina & Maqbool, 1991

H.vietnamiensis Eroshenko *et al.* 1985

H.vulgaris Yuen, 1964

H.willomottae Siddiqi, 1972

The taxonomic position of the genus *Hoplolaimus* Daday , 1905 is as follows

Phylum	– Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981
Class	– Secernentea(Von Linstow ,1905,Chitwood & Chitwood,1958) Maggenti , 1981
Subclass	– Diplogasteria(Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981
Order	– Tylenchida (Filipjev, 1934) Thorne , 1949
Suborder	– Tylenchina (Filipjev, 1934) Geraert , 1966
Superfamily	– Tylenchoidea (Filipjev, 1934)Chitwood & Chitwood, 1937
Family	– Hoplolaimidae (Filipjev, 1934) Wiser , 1933
Subfamily	– Hoplolaiminae (Filipjev, 1934)
Genus	- *Hoplolaimus* Daday , 1905
Type Species	– *H.tylenchiformis* Daday ,1905

Daday (1905) established the genus *Hoplolaimus* with the description of a single species under the family. Menzel (1917) , Cobb (1923) , Filipjev (1934) contributed further on the taxonomy of the genus *Hoplolaimus.*

Filipjev (1934) reported the subfamily Hoplolaiminae, where in he included the genera with peculiar ring-like and scale-like structures on the cuticle *viz.*, *Hoplolaimus.*

Filipjev (1936) included *Hoplolaimus* in the subfamily Tylenchinae which also contained *Rotylenchus* Filipjev ,1936 pointing out the similarities between the two genera.

Thorne (1949) recognised the genera *Hoplolaimus*, *Rotylenchus* and *Helicotylenchus* under Hoplolaiminae.

Chitwood and Chitwood (1950) included under Hoplolaiminae the genera *Hoplolaimus* , *Helicotylenchus* , *Tylenchorhynchus* , *Radopholus* and *Pratylenchus* which was later changed by Goodey (1951) who included only two genera *viz.*, *Hoplolaimus* and *Rotylenchus* under the sub-family Hoplolaiminae.

Andrassy (1958) revised the sub-family Hoplolaiminae . The genera *Scutellonema* and *Gottholdsteineria* were added to this group. The genera *Hoplolaimus* and *Scutellonema* were placed in one group and *Helicotylenchus*, *Rotylenchus* and

The taxonomic position of the genus *Hoplolaimus* Daday , 1905 is as follows

Phylum	– Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981
Class	– Secernentea(Von Linstow ,1905,Chitwood & Chitwood,1958) Maggenti , 1981
Subclass	– Diplogasteria(Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981
Order	– Tylenchida (Filipjev, 1934) Thorne , 1949
Suborder	– Tylenchina (Filipjev, 1934) Geraert , 1966
Superfamily	– Tylenchoidea (Filipjev, 1934)Chitwood & Chitwood, 1937
Family	– Hoplolaimidae (Filipjev, 1934) Wiser , 1933
Subfamily	– Hoplolaiminae (Filipjev, 1934)
Genus	- *Hoplolaimus* Daday , 1905
Type Species	– *H.tylenchiformis* Daday ,1905

Daday (1905) established the genus *Hoplolaimus* with the description of a single species under the family. Menzel (1917) , Cobb (1923) , Filipjev (1934) contributed further on the taxonomy of the genus *Hoplolaimus*.

Filipjev (1934) reported the subfamily Hoplolaiminae, where in he included the genera with peculiar ring-like and scale-like structures on the cuticle *viz.*, *Hoplolaimus*.

Filipjev (1936) included *Hoplolaimus* in the subfamily Tylenchinae which also contained *Rotylenchus* Filipjev ,1936 pointing out the similarities between the two genera.

Thorne (1949) recognised the genera *Hoplolaimus*, *Rotylenchus* and *Helicotylenchus* under Hoplolaiminae.

Chitwood and Chitwood (1950) included under Hoplolaiminae the genera *Hoplolaimus* , *Helicotylenchus* , *Tylenchorhynchus* , *Radopholus* and *Pratylenchus* which was later changed by Goodey (1951) who included only two genera *viz.*, *Hoplolaimus* and *Rotylenchus* under the sub-family Hoplolaiminae.

Andrassy (1958) revised the sub-family Hoplolaiminae . The genera *Scutellonema* and *Gottholdsteineria* were added to this group. The genera *Hoplolaimus* and *Scutellonema* were placed in one group and *Helicotylenchus*, *Rotylenchus* and

(except *H.cephalus*). Lateral field with four lines or less , generally aerolated at level of phasmids and anteriorly , sometimes with striae irregularly scattered over entire field , rarely not areolated. Cephalic framework massive , basal annule divided into squares. Stylet is massive , 31-61 µm with compact tulip shaped basal knobs bearing anterior like projections (except *H.aorolaimoides* with poorly developed anterior projections). DGO near base of spear knobs (25 % or less spear length) . Oesophageal glands overlap intestine dorasally and laterally; sometimes gland nuclei duplicated to a total branches and stretched, equally developed. Excretory pore posterior to the hemizonid in species with four lines in lateral field (except *H.sacchari*) anterior to hemizonid in species with no or fewer than four incisures. Epiptygma present, distinct or indistinct, single or double,Vulva median with two outstretched genital branches. Tail short, terminus hemispherical to bluntly rounded, annulated. Phasmids enlarged to scutella erratically situated on body, one prevulval, one postvulval , not opposite to each other.

Male:

Rare. Tail short. Spicules well developed, arcuate with distal flanges, variable in size. Bursa extending to tail tip. Gubernaculum large, protrusible, with titillae and telamon.

Type Species – *H.tylenchiformis* Daday , 1905.

LIST OF VALID SPECIES OF *HOPLOLAIMUS* DADAY,1905

Type species:

Hoplolaimus tylenchiformis Daday, 1905

= *Criconema tylenchiformis* (Daday) Micoletzky, 1917

Other species:

Hoplolaimus abelmoschi Tandon & Singh, 1973

= *Basirolaimus abelmoschi* (Tandon & Singh, 1973) Siddiqi,1986

H.aegypti Shafiee & Koura , 1969

= *B.aegypti* (Shafiee & Koura, 1969) Shamsi, 1979

= *H.aegypti* Luc, 1981

= *B.aegypti* Siddiqi, 1986

H.aorolaimoides Siddiqi, 1972

H.californicus Sher, 1963

= *Holplolaimoides californicus* (Sher, 1963) Shakil, 1973

= *Hoplolaimus californicus* (Sher, 1963) Siddiqi, 1986

H.capensis Van den Berg & Heyns, 1970

= *H.pararobustus* Siddiqi, 1986

H.casparus Van den Berg & Heyns, 1970

= *H.pararobustus* by Siddiqi, 1986

H.cephalus Mulk & Jairajpuri, 1976

= *B.cephalus* (Mulk & Jairajpuri, 1976) Shamsi, 1979

= *H.cephalus* (Mulk & Jairajpuri, 1976) Luc, 1981

= *B.cephalus* Siddiqi, 1986

H.chambus Jairajpuri & Baqri, 1973

= *B.chambus* (Jairajpuri & Baqri, 1973) Shamsi, 1979

= *H.chambus* (Jairajpuri & Baqri, 1973) Luc, 1981

= *H.columbus* Khan, 1978

H.citri (Khan & Khan, 1985) n.comb.

= *B.citri* Khan & H.Khan, 1985

H.clarissimus Fortuner , 1973

= *B.clarissimus* (Fortuner , 1973) Shamsi , 1979

= *H.clarissimus* Luc , 1981

= *B.clarissimus* Siddiqi , 1986

H.columbus Sher , 1963

= *B. columbus* (Sher , 1963) Shamsi , 1979

= *H. columbus* Luc , 1981

= *B. columbus* Siddiqi , 1986

H.concaudajuvencus Golden & Minton , 1970

H.dimorphicus Mulk & Jairajpuri , 1976

= *B. dimorphicus* (Mulk & Jairajpuri , 1976)Shamsi,1979

= *H. dimorphicus* Luc , 1981

= *B. dimorphicus* Siddiqi , 1986

H.dubius Chaturvedi *et al.*, 1979

= *B. dubius* (Chaturvedi *et al.*, 1979) Siddiqi , 1986

H.galeatus (Cobb, 1913)Thorne , 1935

= *Nemonchus galeatus* Cobb , 1913

= *Hoplolaimus coronatus* Cobb , 1923

H.imphalensis Khan & Khan , 1985

H.indicus Sher , 1963

= *B.indicus* (Sher , 1963) Shamsi , 1979

= *H.indicus* Luc , 1981

= *H.arachidis* (Maharaju & Das , 1982) Siddiqi , 1986

= *B.arachidis* (Maharaju & Das , 1982) Siddiqi , 1986

= *B.indicus* Siddiqi , 1986

H.jalalabadiensis (Khan & Khan , 1985) n.comb.

= *B. jalalabadiensis* Khan & Khan , 1985

H.magnistylus Robbins , 1982

H.pararobustus (Schuurmans Stekhoven & Teunissen , 1938) Sher ,1963

= *Tylenchorhynchus robustus* Schuurmans Stekhoven , 1936

= *Rotylenchus pararobustus* (Schuurmans Stekhoven & Teunissen)
Filipjev & Schuurmans Stekhoven , 1941

= *Hoplolaimus proporicus* Goodey , 1957

= *Gottholdsteineria paraobusta* (Schuurmans Stekhoven & Teunissen)Andrassy , 1958

= *Hoplolaimus angustalatus* Whitehead , 1959

= *Hoplolaimus kittenbergeri* Andrassy , 1961

H.puertoricensis Ramirez , 1964

= *B.puertoricensis* (Ramirez , 1964) Siddiqi , 1986

H.sacchari (Shamsi , 1979) Luc , 1981

= *B.sacchari* Siddiqi , 1986

H.seinhorsti Luc , 1958

= *B.seinhorsti* (Luc , 1958) Shamsi , 1979

= *H.seinhorsti* (Luc, 1958) Luc , 1981

= *B.seinhorsti* Siddiqi , 1986

H.seshadrii Mulk & Jairajpuri , 1976

= *B. seshadrii* (Mulk & Jairajpuri , 1976) Shamsi , 1979

= *H.seshadrii* Luc , 1981

= *B.seshadrii* Siddiqi , 1986

H.sheri Suryawanshi , 1971

= *B.sheri* (Suryawanshi , 1971) Siddiqi , 1986

= *H.seinhorsti* Siddiqi , 1986

H.singhi Das & Shivaswamy , 1977

= *B.singhi* (Das & Shivaswamy , 1977) siddiqi , 1986

H.stephanus Sher , 1963

H.tabacum Firoza *et al.*, 1990

The taxonomic position of genus *Meloidogyne* Goeldi, 1887 is as follows.

Phylum	-Nemata (Diesing,1861,Potts,1932) Maggenti, 1981
Class	-Secernentae (Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti,1981
Subclass	- Diplogasteria (Von Listow , 1905,Chitwood & Chitwood, 1958) Maggenti, 1981
Order	-Tylenchida (Filipjev, !934 ,Thorne, 1949, Maggenti, 1981) Siddiqi, 1985
Super family	-Tylenchoidae (Filipjev,1934) Chitwood & Chitwood,1937)
Family	- Meloidogynidae Skarbilovich, 1959.
Subfamily	– *Meloidogyninae* Skarbilovich , 1959 (Wouts , 1973)
Genus	- *Meloidogyne* Goeldi, 1887

Cornu (1879) first named the root knot nematodes as *Anguillula marioni*, on Sainforn (*Onobrychis* sp.) in France.

Goeldi (1887) recognised the nematodes, causing root galls in coffee trees in Brazil under the name *Meloidogyne exigua* as new genus and species.

Cobb (1924) placed the root knot nematodes in a new genus *Caconema*. This generic name was later synonymised with *Heterodera* Schmidt 1871 and later with Meloidogyne Goeldi, 1887.

Filipjev (1934) placed the root knot nematodes and cyst nematodes under the family Heteroderidae Filipjev, 1934

Skarbilovich (1947) included the two sub families Heteroderinae and Tylenchulinae under the family Heteroderidae. But Thorne (1949) reviewed the family and recognised Heteroderinae as the only sub family with the genera *Heterodera*, *Meloidogyne* and *Meloidodera*.

Chitwood (1949) re-erected the genus *Meloidogyne* Goeldi, 1887 to include all the root knot nematodes and synonymized Cobb's genus *Caconema* and also presented a key for *Meloidogyne* species.

Chitwood and Chitwood (1950) included three sub-families *viz.*, Heteroderinae, Hoplolaiminae and Nacobbinae under the family Heteroderidae.

Skarbilovich (1959) redefined Heteroderidae by its sexual dimorphism and included in it five sub-families *viz.*, Heteroderinae, Tylenchulinae, Sphaeronematinae, Nacobbinae and Meloidogyninae.

Whitehead (1968) redefined the genus and confirmed the morphological distinctness of 23 species of *Meloidogyne*.

Wouts and Sher (1971) amended the family Heteroderidae and redefined the two sub-families Meloidogyninae and Heteroderinae. They also proposed *Meloidogyne* as the only genus in Meloidogyninae.

Golden (1971) raised the family Heteroderidae to super family Heteroderoidae with the families Heteroderidae and Nacobbidae and in addition to the sub family Heteroderinae and Meloidoderinae.

Franklin (1972) included 32 species and described the most recent development of the systematics of *Meloidogyne* with emphasis on the important characters of the various life stages.

In addition to *Meloidogyne*, Wouts (1973) transferred *Meloidoderita* as a valid genus to the family Meloidogynidae.

Esser *et al.* (1976) in their diagnostic compendium to the genus *Meloidogyne*, presented morphometric and morphological data with illustrations to facilitate the identification of 32 species of the genus.

Eisenback, *et al.* (1981) gave illustrated key for the four economically most important species of root knot nematodes *viz.*, *M.incognita, M.javanica, M.arenaria and M.hapla.*

Ebsary and Eveleigh (1983) described *Meloidogyne aquatilis* and presented a key to the Canadian species of *Meloidogyne*.

Jepson (1983) made general assessment on quantitative characters for identification of *Meloidogyne* species based on qualitative morphology of head and stylet.

Zhang and Weng (1991) identified 23 species in Fujian country including two new species and also provided a key to the species.

Karssen and Hoenselaar (1998) revised the genus *Meloidogyne* Goeldi, 1892 in Europe and developed a key for the 14 European species.

Diagnosis of genus *Meloidogyne* Goeldi, 1887

Syn. *Caconema* Cobb, 1924

Females:

Adults swollen, saccate, body remains soft walled. Lateral lips larger than others; amphid opening slit-like, larger than in *Heterodera*; a cap-like structure on the head. The head protrudes anteriorly; Excretory pore opening anteriorly to median bulb. The vulva and the anus are located terminally, cuticle forming a "finger print" pattern in perineal region; eggs not retained in the body but laid as an egg-mass within a gelastinous matrix. The oesophagus has a large muscular median but with conspicuous valve plates and three ventrally overlapping oesphageal glands. Females are didelphic and the two gonads are very long and greatly convoluted and occupying a major part of the toal body content.

Male:

Vermiform, lip region with or without distinct annulations, with head cap. Head skeleton well developed. Lateral lips larger than others, each about equal in size to the dorsal or ventral pairs; amphid openings similarly larger, slit like and leading to broad pouches when viewed laterally. Spear well developed with rounded basal knobs, length– (18-24) µm.The oesphagus has a slender procorpus and oval shaped median bulb with distinct valve plates. One gonad is present in normal males, whereas sex-reversed males have two gonads. Tail very short, without bursa spicules length ranges from 19 to 40 µm among the species. Lateral field with incisures passing round tail tip. Body twists through up to 180 degrees or more passing head to tail.

LIST OF VALID SPECIES OF *MELOIDOGYNE* GOELDI,1887

GENUS

Meloidogyne Goeldi , 1889

= *Caconema* Cobb , 1924

= *Hypsoperine* Sledge & Golden , 1964

= *Hypsoperine (Hypsoperine)* Siddiqi , 1985

= *Hypsoperine (Spartonema)* Siddiqi , 1985

TYPE SPECIES

M.exigua Goeldi , 1889

= *Heterodera exigua* (Goeldi , 1889)Marcinwski , 1909

SPECIES

M.actinidiae Li & Yu , 1991

M.arabicada Lopez & Salazar,1989

M.acronea Coetzee , 1956

= *Hypsoperine acronea* (Coetzee,1956)Sledge & Golden, 1964

=*Hypsoperine (Hypsoperine) acronea* (Coetzee , 1956)Siddiqi , 1985

M.africana Whitehead , 1960

M.aquatilis Ebsary and Eveleigh , 1983

M.ardenesis Santos , 1968

M.arenaria (Neal , 1889) Chitwood , 1949

= *Anguillula arenaria* Neal , 1889

= *Tylenchus arenarius* (Neal , 1889) Cobb , 1890

=*Heterodera arenaria* (Neal , 1889) Marcinowski , 1909

=*M.thamesi* (Chitwood *et al.* 1952) Goodey, 1963

M.artiellia Franklin , 1961

M.brevicauda Loos , 1953

M.californiensis Abdel-Rahman & Maggenti , 1987

M.camelliae Golden, 1979

M.caraganae Shagalina *et al.* 1985

M.carolinensis Eisenback , 1982

M.chitwoodi Golden *et al.* 1980

M. christiei Golden & Kaplan , 1986

M.cirricauda Zhang *et al.* 1990

M.citri Zhang *et al.* 1990

M.coffeicola Lordello & Zamith , 1960

= *Meloidodera coffeicola*(Lordello& Zamith,1960) Kirjanova , 1963

M.cruciani Garcia Martinez *et al.* 1982

M.decalineata Whitehead ,1968

M.deconincki Flmiligy , 1968

M.duytsi Karssen *et al.* 1998

M.elegans Jepson , 1987

M.enterolobii Yang & Eisenback , 1983

M.ethiopica Whitehead , 1968

M.exigua Chitwood , 1949

M.fallax Karssen , 1996

M.fanzhiensis Chen *et al.* 1990

M.fujianensis Pan , 1985

M.graminicola Golden & Birchfield , 1965

M.graminis (Sledge & Golden , 1964) Whitehead , 1968

= *Hypsoperine graminis* Sledge & Golden , 1964

=*Hypsoperine (Hypsoperine) graminis* Sledge & Golden,1964

M.hapla Chitwood , 1949

M.hispanica Hirschmann , 1986

M.hissarica Krall & Ivanova , 1992

M.ichinohei Araki , 1992

M.incognita (Kofoid & White , 1919) Chitwood , 1949

= *Oxyuris incognita* Kofoid & White , 1919

= *Heterodera incognita* Kofoid & White ,1919

= *M.incognita incognita*(Kofoid & White,1919)Chitwood,1949

= *M.incognita acrita* Chitwood , 1949

= *M.acrita* (Chitwood , 1949) Esser *et al.* 1976

= *M.incognita inornata* Lordello , 1956

=*M.elegan* da Ponte, 1977

=*M.grahami* Golden & Slana , 1978

= *M.incognita wartellei* Golden & Birchfield ,1978

= *M.inornata* Lordello , 1956

M.indica Whitehead , 1968

M.javanica (Treub , 1885) Chitwood , 1949

=*Heterodera javanica* (Treub, 1885) Cobb , 1890

=*Anguillula javanica* (Trueb ,1885) Lavergne , 1901

=*M. javanica javanica* (Treub,1885) Chitwood , 1949

=*M. javanica bauruensis* Lordello , 1956

=*M.baurensis* (Lordello , 1956) Esser *et al.* 1976

=*M.lucknowica* Singh , 1969

=*M.lordelloi* da Ponte , 1969

M.jianyangensis Zhu *et al.* 1991

M.jinanensis Zhang & Su , 1986

M.kikuyensis de Grisse , 1961

M.kirjanovae Terenteva , 196

M.kongi Yang *et al.* 1988

M.kralli Jepson , 1984

M.lini Yang *et al.* 1988

M.litoralis Elmiligy , 1968

M.lusitanica Abrantes & Santos , 1991

M.mali Itoh *et al.*, 1969

M.maritima Jepson , 1987

M.marylandi Jepson & Golden , 1987

M.mayaguensis Rammah & Hirshmann , 1988

M.megadora Whitehead , 1968

M.megatyla Baldwin & Sasser , 1979

M.mersa Siddiqi & Booth , 1991

M.microcephala Cliff & Hirschmann , 1984

M.microtyla Mulvey *et al.* 1975

M.morocciensis Rammah & Hirschmann , 1988

M.naasi Franklin , 1965

M.nataliei Golden *et al.* 1981

M.oryzae Naas *et al.* 1978

M.oteifae Elmiligy , 1968

M.ottersoni (Thorne , 1969) Franklin , 1971

=*Hypsoperine ottersoni* Thorne , 1969

=*Hypsoperine (Hypsoperine) ottersoni* (Thorne ,1969) Siddiqi , 1987

M.ovalis Riffle , 1963

M.paranaensis Carneiro *et al.* 1996

M.partityla Kleyhans , 1986

M.petuniae Charchar *et al.* 1999

M.pini Eisenback *et al.* 1985

M.piperi Sahoo *et al.* 2000

M.plantani Hirschmann , 1982

M.propora Spaull , 1977

=Hypsoperine (Hypsoperine*) propora* (Spaull , 1967), Siddiqi ,1985

M.querciana Golden , 1979

M.salasi Lopez, 1984

M.sewelli Mulvey & Anderson , 1980

M.sinensis Zhang , 1983

M.spartinae (Rau & Fassuliotis , 1965) Whitehead , 1968

=*Hypsoperine (Spartonema)sparti*(Rau & Fassulioits ,1965) Siddiqi,1985

M.subartica Bernard , 1981

M.suginamiensis Toida & Yaegashi, 1984

M.tadshistanica Kirjanova & Ivanova , 1965

M.triticorzae Gaur *et al.* 1993

M.turkestanica Shagalina *et al.* 1985

M.vandervegtei Kleynhans , 1988

The taxonomic position of genus *Pratylenchus* Filipjev , 1936 is as follows:

Phylum	– Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981
Class	– Secernentea (Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981
Subclass	– Diplogasteria(Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981
Order	– Tylenchida (Filipjev, 1934) Thorne , 1949
Suborder	– Tylenchina (Filipjev, 1934) Geraert , 1966
Superfamily	– Tylenchoidea (Filipjev, 1934) Chitwood & Chitwood , 1937
Family	-Pratylenchidae (Thorne , 1949) Siddiqi , 1963
Subfamily	– Pratylenchinae Thorne , 1949
Genus	– *Pratylenchus* Filipjev , 1936

The root lesion nematodes were once a part of the genus *Tylenchus* Bastian, 1865 with large number of species. Micoletzsky (1922) kept them on a new subgenus, *Chitinotylenchus*, with other members of *Tylenchus* that had conspicuous sclerotization in the lip region. The generic name *Tylenchus* was synonymised with *Anguillulina* Gervias and Van Benden by Baylis and Daubney (1926).

Filipjev (1934) described *Chitinotylenchus* as a distinct genus excluding the root-lesion nematodes for which he proposed a new genus *Pratylenchus* in 1936 and designated *Tylenchus pratensis* de Man , 1880 as the type species by Filipjev (1936).

Thorne (1949) proposed the subfamily Pratylenchinae under the family Tylenchidae Filpjev,1934 based on wide low and flattened lip region , basal portion of the oesophageal glands lobe-like extending back over anterior end of intestine ventrally and phasmids located well behind the latitude of tail. He classified the genera *Pratylenchus* Filipjev,1936, *Naccobus* Thorne and Allen,1944 , *Radopholus* Thorne,1949 and *Rotylenchulus* Linford and Oliveira,1940 under Pratylenchinae .

Chitwood & Chitwood (1950) transferred the genus *Pratylenchus* Filipjev,1936 to the family Hoplolaimidae. Later Chitwood (1958) classified the subfamilies Heteroderinae Skarbilovich, 1947, Hoplolaiminae Filipjev, 1934, Pratylenchinae Thorne,1949 and Naccobbinae Chitwood,1950 in the family Hoplolaimidae.

Siddiqi (1963) reported the family Pratylenchidae and included the genera *Hirschmanniella* Luc and Goodey, 1963, *Hoplotylus* S'Jacob, 1959, *Pratylenchus* Filipjev,1936, *Pratylechoides* Winslow,1958 and *Radopholus* Thorne , 1949.

Sher and Allen (1953) revised the genus *Pratylenchus* and recognised ten species, three of which described as new.

Loof (1960) recognised nineteen species , three of which were described as new and three left under species *inquirendae.*

Allen and Sher (1967) did not recognise pratylenchids at family level and placed the genera with vermiform females having only one genital branch (*Pratylenchus* , *Hoplotylus*) under Pratylenchinae.

Loof (1978) reviewed the genus *Pratylenchus* and recognised 29 valid species . A key based on females was also given for identification of species.

Luc (1987) revised the family Pratylenchidae and included the genera *Pratylenchus, Apratylenchoides*, *Radopholus* and *Zygotylenchus.*

Handoo and Golden (1989) revised the genus *Pratylenchus* and recognised and also gave an identification key for 63 species.

Frederick and Tarjan (1989) revised the genus *Pratylenchus* and recognised 49 valid species . The author also gave a key to the species of *Pratylenchus.*

Filho and Huang (1989) gave an actualised key to the genus *Pratylenchus* including 54 species validated till 1986 and described a new species *P.pseudofallax.*

Diagnosis of the genus *Pratylenchus* , Filipjev , 1936 :

Body length under 0.8 mm . No sexual dimorphism in the anterior part of the body. Deirids absent. Lip area low , flattened anteriorly , not or weakly set – off ; lip area characteritised by fusion of labial disc with submedial lip sectors; Lateral lip sector not reduced . Oesophageal glands overlapping ventral intestine for a medium distance. Oesophago-intestinal valve not well developed. Female genital tract with posterior branch reduced to post vulval sac. Female tail 2-3 times the anal body diameter, terminus rounded (rarely pointed). Phasmids situated at mid–tail or slightly posterior.Gubernaculum plain , not protruding . Caudal alae enveloping tail.

Type Species

P.pratensis (de Man ,1880) Filipjev , 1936

= *Tylenchus pratensis* de Man , 1880

=*Anguillulina pratensis* (de man ,1880) Goodey , 1929

=*P.heliophilus* Seinhorst , 1959

=*P.irregularis* Loof , 1960

LIST OF VALID SPECIES OF *PRATYLENCHUS* FILIPJEV,1936

Type Species :

Pratylenchus pratensis (de Man , 1880) Filipjev , 1936

Other species :

Pratylenchus agilis Thorne & Malek, 1968

P.acuticaudatus Braarch &Decker , 1989

P.alleni Ferris , 1961

P.andinus Lordello *et al.* 1961

P.australis Valenzuela & Raski , 1985

P.bachyurus (Godfery , 1929) Filipjev & Schuurmans Stekhoven , 1941

P.barkati Das & Sultana , 1979

P.bhatti Siddiqi *et al.* 1991

P.bolivianus Corbett , 1983

P.brachyurus (Godfrey,1929) Filipjev & Schuurmans Stekhoven, 1941

P.cerealis Haque , 1966

P.clavicauda Geraert *et al.*, 1990

P.codiaei Singh & Jain , 1984

P.coffeae (Zimmerman ,1898) Filipjev & Schuurmans Stekhoven , 1941

P.convallariae Seinhorst , 1959

P.crassi Das & Sultana , 1979

P.crenatus Loof , 1960

P.crossandrae Subramaniyan & Sivakumar , 1991

P.cruciferus Bajaj & Bhatti , 1984

P.curvicauda Siddiqi *et al.* 1991

P.dasi Fortuner , 1985

= *P.capitatus* (Das & Sultana , 1979) Ivanova , 1960

= *P.hyderbadensis* Singh & Gill , 1986

P.delattrei Luc , 1958

P.ekrami Bajaj & Bhatti , 1984

P.elamini Zeidan and Geraert , 1991

P.emarginatus Eroshenko , 1978

P.estoninensis Ryss , 1982

P.exilis Das & Sultana , 1979

P.fallax Seinhorst , 1968

P.flakkensis Seinhorst , 1968

P.gibbicaudatus Minagawa , 1982

P.goodeyi Sher & Allen , 1953

P.graminis Subramanian & Sivakumar , 1991

P.gutierrezi Golden *et al.* 1992

P.hexincisus Taylor & Jenkins ,1957

P.impar Khan & Singh , 1975

P.jordanensis Hashim , 1983

P.kasari Ryss , 1982

P.kralli Ryss , 1982

P.kumaoensis Lal & Khan , 1989

P.loofi Singh & Jain , 1984

P.loosi Loof,1960

P.macrostylus Wu , 1971

P.manaliensis Khan & Shama , 1991

P.manohari Quraishi , 1982

P.mediterraneus Corbett , 1983

P.microstylus Bajaj & Bhatti , 1984

P.morettai Luc *et al.* 1986

P.mulchandi Nandkumar & Khera , 1970

P.neglectus (Rensch , 1924) Filipjev & Schuurmans Stekhoven 1941

P.neocapitatus Khan & Singh , 1975

P.nizamabadensis Maharaju & Das , 1981

P.obtusicaudatus Romaniko , 1977

P.panamaensis Siddiqi *et al.* 1991

P.penetrans (Cobb , 1917) Filipjev & Schuurmans Stekhoven1941

P.pinguicaudatus Corbett , 1969

P.pratensisobrinus Bernard, 1984

P.pseudofallax Café Filho & Huang , 1989

P.pseudopratensis Seinhorst, 1968

P.ranjani Khan & Singh , 1975

P.scribneri steiner , 1943

P.sefaensis Fortuner , 1973

P.sensillatus Anderson & Townshend , 1985

P.similis Khan & Singh , 1975

P.singhi Das & Sultana , 1979

P.stupidus Romaniko , 1977

P.subpenetrans Taylor & Jenkins , 1957

P.subranjani Mizukubo *et al.* 1990

P.sudanensis Loof & Yassin , 1971

P.tenuis Thorne & Malek , 1968

P.teres Khan & Singh , 1975

P.thornei Sher & Allen , 1953

P.typicus Rashid , 1976

P.uralensis Romaniko , 1966

P.variacaudatus Romaniko , 1977

P.ventroprojectus Bernard , 1984

P.vulnus Allen & Jensen , 1951

P.wescolagricus Corbett , 1985

P.yassini Zeidan & Geraert , 1991

P.zeae Graham , 1951

The taxonomic position of genus *Tylenchorhynchus* Cobb , 1913 is as follows:

Phylum – Nemata (Diesing , 1861 , Potts , 1932) Maggenti , 1981

Class - Secernentea (Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981

Subclass – Diplogasteria (Von Linstow ,1905,Chitwood & Chitwood, 1958) Maggenti , 1981

Order – Tylenchida (Filipjev , 1934) Thorne , 1949 Maggenti ,1981 Siddiqi , 1985

Suborder – Tylenchina (Filipjev , 1934) Geraert , 1966

Superfamily - Tylenchoidea (Filipjev , 1934) Chitwood & Chitwood , 1937

Family – Belonolaimidae Whitehead , 1960

Subfamily – Telotylenchinae

Genus – *Tylenchorhynchus* Cobb , 1913

The genus *Tylenchorhynchus* was established by Cobb in 1913 with *T.cylindricus* as type species.

Allen (1955) reviewed the genus *Tylenchorhynchus* and recognised 37 valid species.

Baker (1962) and de Guiran (1967) listed 55 and 71 valid species respectively.

Sturhan (1966) described four new species of *Tylenchorhynchus* and recognised 73 valid species and 10 species as species *inquirendae.*

Siddiqi (1970) reviewed ninety six species of *Tylenchorhynchus* under the family Belonolaimidae n.rank.

Golden (1971) raised the subfamily Tylenchorhynchinae Eliva , 1964 to family rank as Tylenchorhynchidae and provided a key to the six genera.

The synopsis of the species and genera within Tylenchorhynchidae by Tarjan (1943), clarified the status of certain genera and species within this group.

Hooper (1978) added many new species and made the genus *Tylenchorhynchus* to undergo some taxonomic reappraisal after his publication of the Manual on Tylenchorhynchidae.

Jairajpuri (1982) gave a key to sixteen species of the subgenus *Bitylenchus*.

Lewis and Golden (1981) transferred *T.divitattus, T.triglyphus* and *T.sculptus* to *Trilineellus* and gave a key to the species.

Mulk and Siddiqi (1982) transferred *T. judithae , T.gladiolatus , T.microphasmis , T.lamelliferus* and *T.sulcatus* the species without recurved bursa to the genus *Dolichorhynchus* . But Jairajpuri and Hunt (1984) rejected this amendment and proposed a new genus *Neodolichorhynchus* and included the above species , except *T.lamelliferus* under this. They also proposed another genus *Tessellus* to include *T.claytoni* as the type species and *T.pachys* as the other species in it.

Jairajpuri (1984) considered *T.divitattus, T.triglyphus, T.sculptus* distinct by restricting *Trilineellus* to the type species *T.clathrocutis* and placed the above three species in *Divittus* and also added *T.obscurisulcatus* and *T.pruni* to it.

Mahajan and Bello (1986) added *T.impar* to this genus and transferred *T.djungaricus* to the genus *Merlinius*. Meanwhile, *Merlinius obscuriculcatus* was placed in *Tylenchorhynchus* by Siddiqi (1979) but subsequently Jairajpuri (1984) transferred this species to the genus *Divittus*.

Siddiqi (1986) regarded seventy one species in *Tylenchorhynchus*.

Fortuner and Luc (1987) in their reappraisal of Tylenchina, included *Tylenchorhynchus* under the family Belonolaimidae, subfamily Telotylenchinae and recognised 129 valid species, defining *Tylenchorhynchus* as having 2 to 5 lines in the lateral field , which was sometimes areolated.

Mahajan (1988) gave a diagnostic compendium to species of *Tylenchorhynchus* and included 89 valid species in the genus.

Esser (1991) listed 257 nominal species in his checklist of this genus.

Brzseki and Dolinski (1998) compiled a compendium containing 177 species with 2 to 5 lines in the lateral field.

Handoo (2000) gave a key and diagnostic compendium to the species of the genus T*ylenchorhynchus* by amending the diagnosis of *Tylenchorhynchus* Cobb, 1913 and also gave a list of all 111 valid species.

Diagnosis of the genus *Tylenchorhynchus* Cobb, 1913

Females:

Body small to medium-sized (0.36-1.6mm long), cuticle fine to distinctly annulated, sometimes with longitudinal striae, lateral field marked by four incisures, generally not areolated behind oesophageal region; outer incisures sometimes areolated. Stylet well developed (10-31 μm long), with prominent basal knobs, cone about as long as shaft. Head continuous, off-set or sunken from body, annulated or smooth;cephalic framework lightly to heavily sclerotised. Deirids usually inconspicuous. Phasmids near middle of tail. Median bulb round or oval, with distinct valve plates, usually demarcated by constrictions from procorpus and isthmus. Basal oesophageal bulb present , offset from intestine,its base sometimes slightly extending over intestine.Cardia prominent. Vulva generally near middle of body V=47-64%. Ovaries paired, outstretched, tail cylindrical to sub-cylindrical, conoid with blunt tip, pointed–conoid, conical to almost funnel-shaped, clavate to sub–clavate, or bluntly rounded; tail hemispherical to sub hemispherical, acutely pointed or bluntly pointed to bluntly rounded, conoid or rounded; tail tip smooth or annulated. Males generally present, similar to females but slightly smaller. Tail short. Bursa nearly always extending to tail tip; phasmids near middle of tail ; spicule distally flanged with well-developed velum , terminus narrow , indented or pointed . Gubernaculum well developed, about half the length of spicule, generally rod like or sometimes variously hooked at anterior end , protrusible.

Type species :

Tylenchorhynchus cylindricus Cobb , 1913

LIST OF VALID SPECIES OF *TYLENCHORHYNCHUS* COBB,1913

Type species :

Tylenchorhynchus cylindricus Cobb , 1913

Other species :

T. aduncus de Guiran , 1967

T.aerolatus Tobar Jimenez , 1970

T.agri Ferris , 1963

T.allii Khurma & Mahajan , 1987

T.alami Shaw & Khan , 1996

T.amgi Kumar , 1981

T.ancorastyletus Ivanova , 1983

T.annulatus (Cassidy , 1930) Golden , 1971

T.antarcticus Wouts & Sher , 1981

T.aspericutis Knobloch , 1975

T.badliensis Saha & Khan , 1982

T.bicaudatus Khakimov , 1973

T.bohrrensis Gupta & Uma ,1980

T.brassicae Siddiqi , 1961

T.brevilineatus Williams , 1960

T.bryobius Sturhan , 1966

T.canalis Thorne & Malek , 1968

T.clarus Allen ,1955

T.clavicaudatus Seinhorst , 1963

T.clavus Khan , 1990

T.claytoni Steiner , 1937

T.coffeae Siddiqi & Basir , 1959

T.contractus Loof , 1964

T.crassicaudatus Williams , 1969

T.cristatus Ivanova , 1983

T.crotoni Pathak & Siddiqi ,1997

T.cuticaudatus Ray &Das , 1983

T.cynodoni Kumar , 1981

T.delhiensis Chawla , Bhamburkar , Khan & Prasad , 1968

T.depressus Jairajpuri , 1982

T.dewaeli Kleynhans , 1992

T.dubius (Butschli , 1873) Filipjev , 1936

T.ebriensis Seinhorst , 1963

T.elegans Siddiqi , 1961

T.eremicolus Allen , 1955

T.eroshenkoi Siddiqi ,1986

T.estherae Kleynhans , 1992

T.ewingi Hopper , 1959

T.georgiensis Eliashvili , 1971

T.goffarti Sturhan , 1966

T.goldeni Rashid & Singh, 1982

T.gossypii Nasira & Maqbool , 1996

T.graciliformis Siddiqi & Siddiqi , 1983

T.haki Fotedar & Mahajan , 1971

T.hordei Khan , 1972

T.huesingi Paetzold , 1958

T.ibericus Mahajan & Nombela , 1986

T.iphilus (Minagawa , 1955)

= *Bitylenchus iphilus* Minagawa , 1995

T.irregularis Wu , 1969

T.ismaili Azmi & Ahmad , 1989

T.kamalae Shaw & Khan ,1996

T.kashmirensis Mahajan , 1974

T.kegasawai Minagawa , 1995

T.kegenicus Litvinova , 1946

T.kidwaii Rashid & Heyns ,1990

T.lamilliferus (de Man ,1880) Filipjev,1936

T.latus Allen , 1955

T.leucaenus Azmi , 1991

T.leviterminalis (Siddiqi *et al.* 1982) Siddiqi , 1986

T.malinus Lin , 1992

T.manubriatus Litvinova , 1946

T.mashhoodi Siddiqi & Basir , 1959

T.maximus Allen , 1955

T.mexicanus Knobloch & Laughlin , 1973

T.microcephalus Siddiqi & Patel , 1990

T.microconus Siddiqi *et al.* 1982

T.musae Kumar ,1981

T.namibiensis Rashid & Heyns , 1990

T.natalensis Kleynhans , 1984

T.neoclavicaudatus Mathur *et al.* 1979

T.nordiensis Khan & Nanjappa ,1974

T.novenus Nobbs , 1989

T.nudus Allen , 1955

T.olereaceae Gupta & Uma , 1981

T.pachys Thorne & Malek , 1968

T.paracanalis Khan , 1991

T.paranudus Phukan & Sanwal , 1982

T.paratriversus Brzseki , 1991

T.parvus Allen , 1955

T.paulettae Bloemers & Wanless , 1998

T.penniseti Gupta & Uma ,1980

T.projectus Khan , 1990

T.punensis Khan & Darekar , 1979

T.quaidi Golden ,Maqbool & Handoo ,1987

T.queirozi Monteiro & Lordello , 1976

T.robustus Thorne & Malek , 1968

T.rosei Zarina & Maqbool , 1991

T.sabourensis Shaw & Khan , 1997

T.sacchari Sivakumar & Muthukrishnan , 1983

T.sanwali Kumar , 1982

T.siccus Nobbs , 1989

T.silvaticus Ferris , 1963

T.solani Gupta & Uma , 1982

T.spinaceae singh , 1976

T.striatus Allen , 1955

T.swarupi Singh & Khera , 1978

T.tarjani Andrassy , 1969

T.teeni Hashim , 1984

T.tenuicaudatus Wouts & Sher , 1981

T.thermophilus Golden *et al.* 1995

T.tobari Sauer & Annells , 1981

T.tritici Golden *et al.* 1987

T.tuberosus Zarina & Maqbool , 1994

T.usmanensis Khurma & Mahajan ,1987

T.variacaudatus Singh , 1971

T.velatus Sauer & Annells , 1981

T.ventrosignatus Tobar Jimenez , 1969

T.vishwanathensis Pathak & Siddiqi , 1996

T.vulgaris Upadhyay *et al.* 1972

T.wilskii Kornobis , 1980

T.zambiensis Venditti & Noel , 1995

Material and Methods

CHAPTER III

MATERIAL AND METHODS

Sample Collection:

A random survey was conducted for the presence of plant parasitic nematodes in different cultivated crops of Western Ghat of Tamil Nadu *viz.*, Udhagamandalam, Kodaikanal, Yercaud and adjoining areas of hill slopes. One hundred and eighty samples from the rhizosphere of cultivated plant species grwon in different location at an altitude ranging from 600 to 2500m MSL were collected The samples were mixed thoroughly and a representative sample of 200cc was drawn. Root samples (5g) were also collected along with the soil. The soil and root samples were placed in polythene bags and stored in a refrigerator at 5 °C, to avoid drying of samples.

Processing the Samples:

Soil samples of 200cc were processed by Cobb's decanting and sieving method (Cobb, 1918) followed by modified Baermann's funnel method (Schindler, 1961) for extraction of nematodes.

The roots were cut into pieces of 1cm macerated in a blender with 100 ml of water for 45 sec and then filtered through facial tissue paper, the nematodes present in the residues were extracted by Modified Baermann's funnel method.

Globodera cysts form dried soil, were extracted by modified Fenwick can method or conical flask method.

Processing of Nematode specimens:

The extracted nematodes, were fixed in hot triethanol amine formaline (TAF) by adding equal volume of the fixative to the nematode suspensions. (Courtney 1955).

The fixed specimens were then processed by slow method to glycerine through the following steps.

1. The nematodes were hand picked and put in 5 ml of seinhorst –1 solution in a cavity block and kept in closed chamber containing 95% ethanol.

2. After 24 hours, the excess ethanol filled in the cavity block were sucked out along with Seinhorst-I solution with a fine pipette, retaining only nematodes.

3. Few drops of Seinhorst- II solution containing ethanol and glycerine (95:5) were added to the block and kept half lid opened condition in a desicator containing calcium Chloride until preparation of slides.

4. Whole mounts of nematodes specimens were prepared in anhydrous glycerine medium on Cobb's aluminum slides with double coverslip. (Cobb, 1917)

Measurements and Drawings:

Nematode drawings were made with prism type camera lucida and measurements were taken with the help of filar micrometer. The following body dimensions and ratios according to de Man's formulae (de Man, 1880) were recorded.

L = Total length of nematode body (in mm)

$$a = \frac{\text{Body Length}}{\text{Greatest body width}}$$

$$b = \frac{\text{Body Length}}{\text{Distance from anterior end to basal gland of oesophagus (Abutting)}}$$

$$b' = \frac{\text{Body Length}}{\text{Distance from anterior end to posterior of oesophageal glands}} \times 100$$

$$c = \frac{\text{Body Length}}{\text{Tail Length}}$$

$$c' = \frac{\text{Tail Length}}{\text{Body width at anus}}$$

$$V\% = \frac{\text{Distance from Anterior end to vulva}}{\text{Body length}} \times 100$$

O = Distance between stylet base and orifice of dorsal oesophageal gland as percentage of stylet length

Ran = Number of annules on tail

The classification proposed by Maggenti (1981) was followed for grouping the species. Tabular compendium and dichotomous taxonomic keys were used for species identification.

Position of the excretory pore and posterior cuticular pattern of adult females were used as taxonomic key for identification of *Meloidogyne* spp (Eisenback *et al.* 1980).

The species of *Meloidogyne* was identified by making PCP (Post Cuticular Pattern). PCP were prepared by dissecting out the adult females from the galled roots and the perenial regions were cut by using a scalpel under stereo zoom microscope, the inner tissues were removed and mounted in glycerine.

The keys provided by Eisenback et al,. (1980) were followed for identification of species of *Meloidogyne*.

Results

CHAPTER IV

RESULTS

The results of the species identified in the study are presented in this chapter.

Globodera pallida **Stone , 1973**

Description:

Female : Body sub-spherical with a projecting neck. Head with amalgamated lips with one or two prominent annules. Lateral incisures absent. Head skeleton weakly developed, hexaradiate , length of spear ranges 26.9-30.1 μ.Spear knobs backward sloping. Very large median oesophageal bulb. Mean diameter of the median bulb ranges from 29.1-37.5 μ. Excretory pore is prominent and situated at base of neck. Vulva a transverse slit at the opposite pole of body to neck, in a slight circular depression, the vulval basin. The cysts are dark brown in colour (Fig. 2).

Male: Not found.

Juvenile: Vermiform. Tail tapering uniformly with a finely rounded tip. Lateral field with four incisures at the oesophageal region and terminating with three incisures at the tail.The head rounded and slightly offset with 4-6 annules.Stylet well developed, basal knobs having forward projection on anterior face in lateral view, Excretory pore at 20% of body length behind head (Fig. 2).

The measurements of cysts and juveniles are furnished in Table 1 & 2.

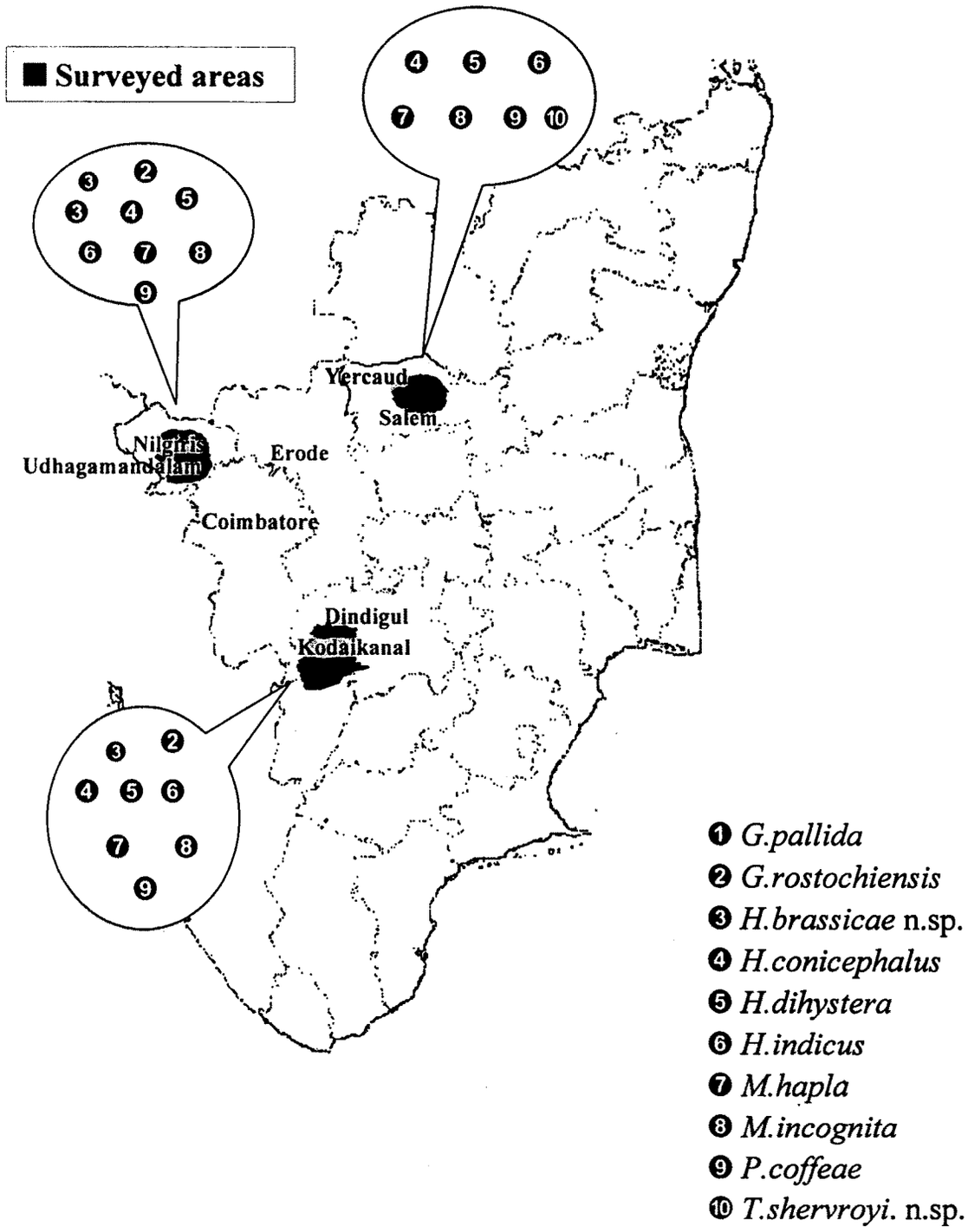

Fig. 1 Map showing the location of surveyed areas and distribution of plant parasitic nematodes

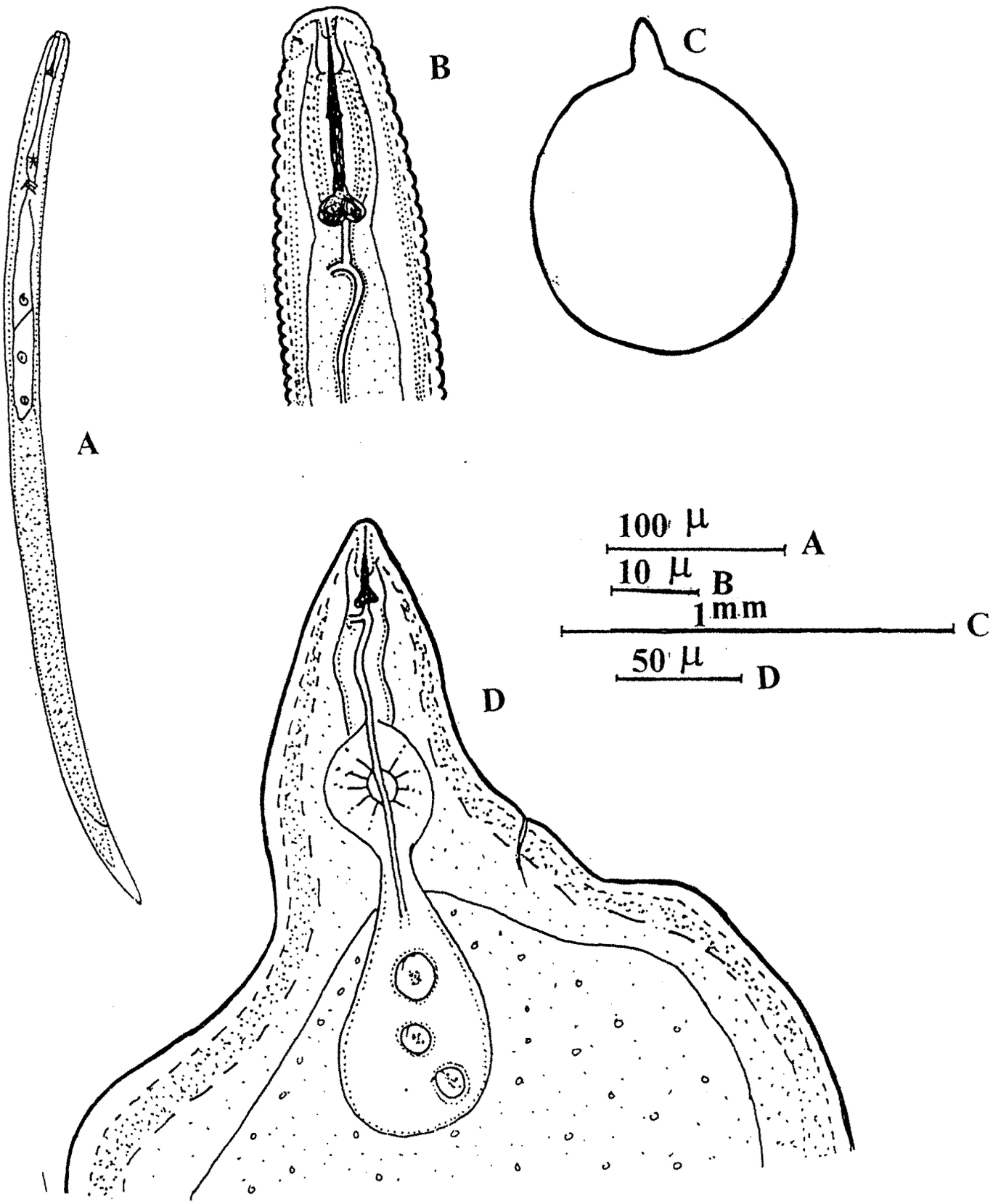

Fig.2 *Globodera pallida*
A) Entire larva
B)Head region of second stage larva
C) Entire cyst
D) Head and neck of female

Table 1:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Globodera pallida* Stone , 1973 (CYSTS)

Dimensions (μ)	Epworth Lincolnshire, England (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **
Stylet length	27.4 (26.3-28.5)	28.1 (26.9-29.4)	28.6 (27.1-30.1)
Head width at base	5.2 (4.7-5.7)	5.5 (4.9-6.1)	5.3 (4.8-5.9)
Stylet base to dorsal gland duct entry	5.2 (4.3-6.5)	5.7 (4.5-6.9)	5.8 (4.6-7.0)
Head tip to median bulb valve	67.2 (48.5-85.9)	68.4 (49.8-87.1)	68.7 (49.2-88.2)
Median bulb valve to level of excretory pore	71.2 (49.3-93.1)	72.7 (51.2-94.2)	71.7 (50.8-92.6)
Head tip to level of excretory pore	139.7 (124.2-155.2)	141.3 (125.5-157.1)	142.2 (126.6-158.3)
Mean diameter of median bulb	32.5 (28.2-36.8)	32.6 (29.1-36.1)	33.8 (30.1-37.5)
Length of vulval slit	11.5 (10.2-12.8)	11.8 (10.5-13.2)	12.2 (10.6-13.9)

(a) – Original description after Stone , 1973

** - Author's measurement

Value in parentheses indicate the range

Table:2

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Globodera pallida* Stone , 1973. (Second stage larvae)

Dimensions	Epworth Lincolnshire, England (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **
Body length (μ)	486 (463-509)	486.5 (463-510)	488 (464-512)
Stylet length (μ)	23.8 (22.8-24.8)	24.2 (23.1-25.3)	24.4 (23.2-25.6)
Stylet base to dorsal oesophageal gland duct (μ)	2.7 (1.8-3.6)	3.1 (2.3-3.9)	2.8 (2.2-3.4)
Head tip to median bulb valve (μ)	68.7 (66-71.4)	69.55 (67-72.1)	70 (67-73)
Head tip to excretory pore (μ)	108.6 (104.5-112.7)	109.1 (105.1-113.1)	109.7 (105.6-113.8)
Tail length (μ)	51.1 (48.3-53.9)	51.55 (48.9-54.2)	51.95 (49.1-54.8)

(a) Original description after Stone, 1973

** - Author's measurement

Value in parantheses indicate the range

Globodera rostochiensis **(Wollenweber , 1923) Behrens , 1975**

Description:

Female: Body sub-spherical with projecting neck. Head with 1-2 prominent annules merging into deep irregular annulations on the neck. Stylet length ranges from 21.8-25.5 μm with the knobs rounded with posterior slope.Median oesophageal bulb large with well developed crescentic valvular apparatus. Excretory pore prominent, near base of neck.Vulva a transverse slit situated between finely papillated crescentic areas. Anus outside vulval basin lying in a direction at right angle to the axis of vulval slit. The colour of the cysts ranges from golden yellow to dark brown (Fig. 3).

Male: Not found.

Juvenile: Vermiform, tail tapering uniformily to a finely rounded terminus. Cuticular annulation distinct, lateral field with four incisures at the oesophageal region and three incisures at the posterior end. Head slightly offset , rounded , with 4-6 annules. Stylet well developed with the knobs rounded with slight backward slope. Excretory pore at 20% of body length behind head (Fig. 3).

The data on the measurements of *Globodera* cysts and the juveniles are presented in Table 3 and 4.

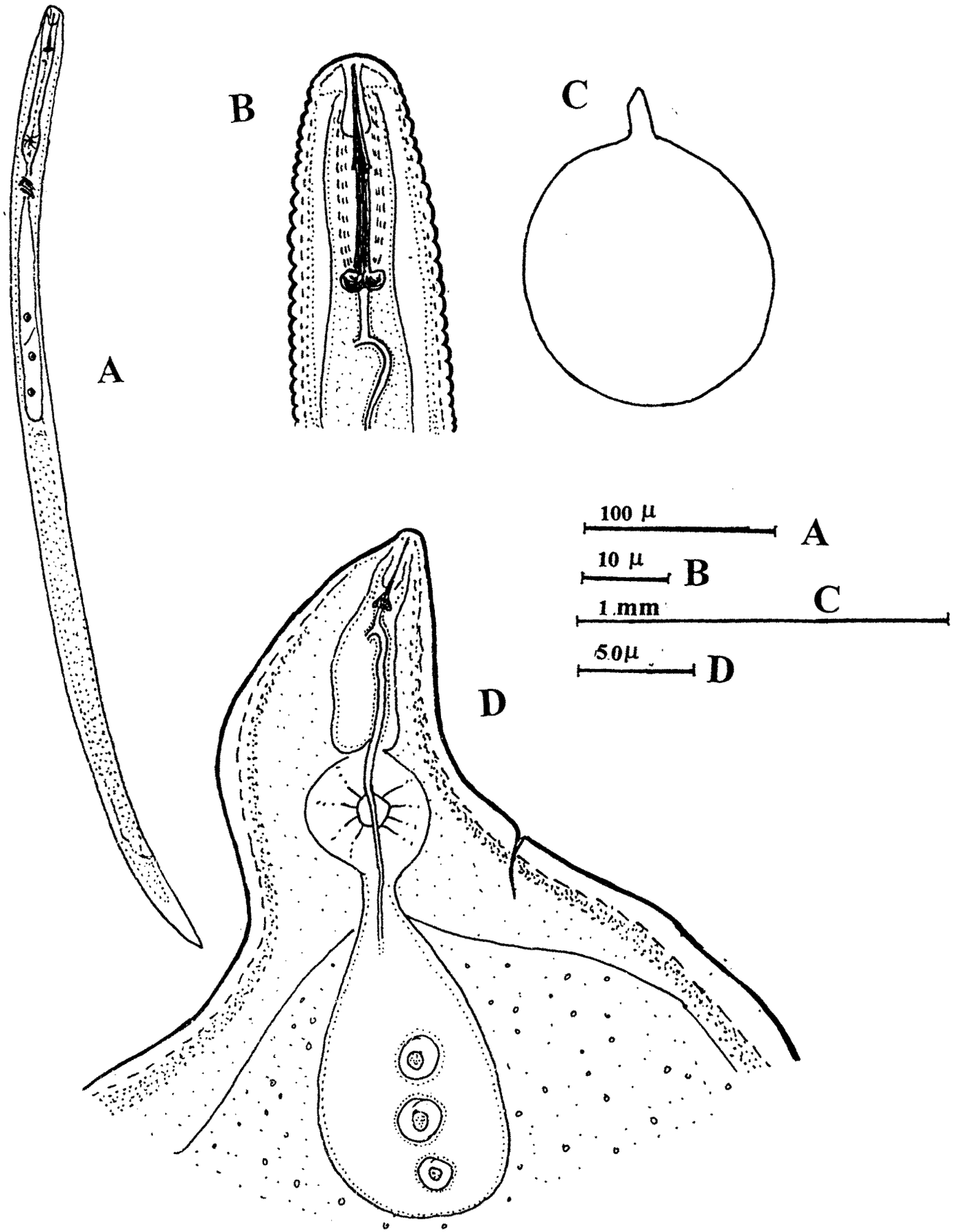

Fig.3 *Globodera rostochiensis*

A)Entire larva B)Head region of second stage larva

Table:3

COMPARISON OF DIFFERENT POPULATIONS OF *Globodera rostochiensis* Wollenweber , 1923. (Adult Females)

Dimensions	Tessin Mecklenbury Rostock,East Germany (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **
Stylet length (μ)	23.75 (22.3-25.2)	24.15 (21.8-26.5)	24.9 (23.9-25.9)
Stylet base to dorsal oesophageal gland orifice (μ)	5.3 (4.5-6.2)	5.6 (4.4-6.8)	5.9 (4.7-7.1)
Head width at base (μ)	5.4 (4.7-6.1)	5.6 (4.8-6.4)	5.5 (4.9-6.2)
Length of median bulb valve (μ)	70.3 (57.2-83.4)	73.2 (59.2-87.3)	73.3 (60.2-86.5)
Median bulb valve to excretory pore (μ)	67.2 (47.1-87.3)	69.2 (48.8-89.7)	69.2 (49.9-88.6)
Head tip to excretory pore (μ)	146.3 (129.2-163.4)	147.3 (130.2-164.5)	147.6 (129.9-165.3)
Mean diameter of median bulb (μ)	31.2 (29.1-33.4)	31.2 (28.7-33.8)	31.95 (30.1-33.8)
Length of vulval slit (μ)	10 (8.2-11.8)	10.2 (7.9-12.5)	10.6 (8.9-12.3)

(a) – Original description after Stone , 1973

** - Author's measurement

Value in parentheses indicate the range

Table:4

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Globodera rostochiensis* Wollenweber , 1923.(Second stage larvae)

Dimensions	Rostock Germany (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **
Body length (μ)	468 (448-488)	469.5 (450-489)	469.5 (449-490)
Stylet length (μ)	21.8 (21.1-22.5)	23.15 (22.5-23.8)	22.9 (22.2-23.6)
Stylet base to dorsal oesophageal gland duct (μ)	2.6 (2.0-3.2)	3.05 (2.5-3.6)	3.35 (2.8-3.9)
Head tip to median bulb valve (μ)	69.2 (67.3-71.1)	69.95 (67.8-72.1)	69.65 (67.5-71.8)
Head tip to excretory pore (μ)	100.5 (98.1-102.9)	100.9 (98.6-103.2)	101.1 (98.8-103.4)
Tail length (μ)	43.9 (32.3-55.5)	44.4 (32.7-56.1)	44.95 (32.9-57.0)

(a) Original description after , Stone , 1973

** - Author's measurement

Value in parentheses indicate the range

Helicotylenchus brassicae **n.sp.**

Measurement:

Female (holotype): L=0.63 mm, a = 26.52 , b = 5.36, b' = 5.24, c = 50, c'=0.83, V=67% O=51

Female(paratype): L=0.70(0.62-0.75)mm, a = 31.1(29.1-35), b = 4.7(4.2-5.3) , b' = 4.98(4.97-5.0) , c =49(47-52) , c' = 0.95(0.82-1.1), V=64(61-67)% , O=52(50-54).

Male: Not found.

Description:

Body cylindrical; assume spiral shape when killed with gentle heat; cuticle with fine transverse striations. Lip region hemispherical with 4-5 faint striations. A slight sunken area noticed at the lip region. Lip region with moderate sclerotization. Spear 28.98 μm long with anteriorly projected knobs. Cephalids indistinct. Lateral field with four incisures covering 1/3rd of the body and prominent. The outer and inner incisures are crenated. Lateral field extends upto tail tip. Excretory pore at 115.62 μm from anterior end and hemizonid and hemizonions are inconspicuous at the level of excretory pore. Dorsal oesophageal gland orifice (DGO) at 12.48 μm from the stylet base. Procorpus cylindrical in shape bearing a slight constriction at base. Median bulb spheroid to oval measuring 13.34 X 9.66 μm. Oesophageal gland overlaps intestine dorsally and ventrally. Isthmus is long and nerve ring encircle the same at about 11.25 μm from median bulb.Vulva is at 67 % of the body length with slightly depressed slit. The vagina , at the right angle to the body axis more than ½ the body width deep. Paired ovaries opposite to each other. Spermatheca spherical to elongate without sperm. Tail bluntly rounded with 14 distinct annules. The annules at the tail tip are prominent. Tail length is equal or shorter than the anal body width. The annules at the tail tip are slightly wider than others. Phasmid is prominent and located at twelveth annule anterior to anus. The lateral lines extend upto tail tip and outer incisures are crenate and fused at the tail tip. (Fig .4)

Male : Not found.

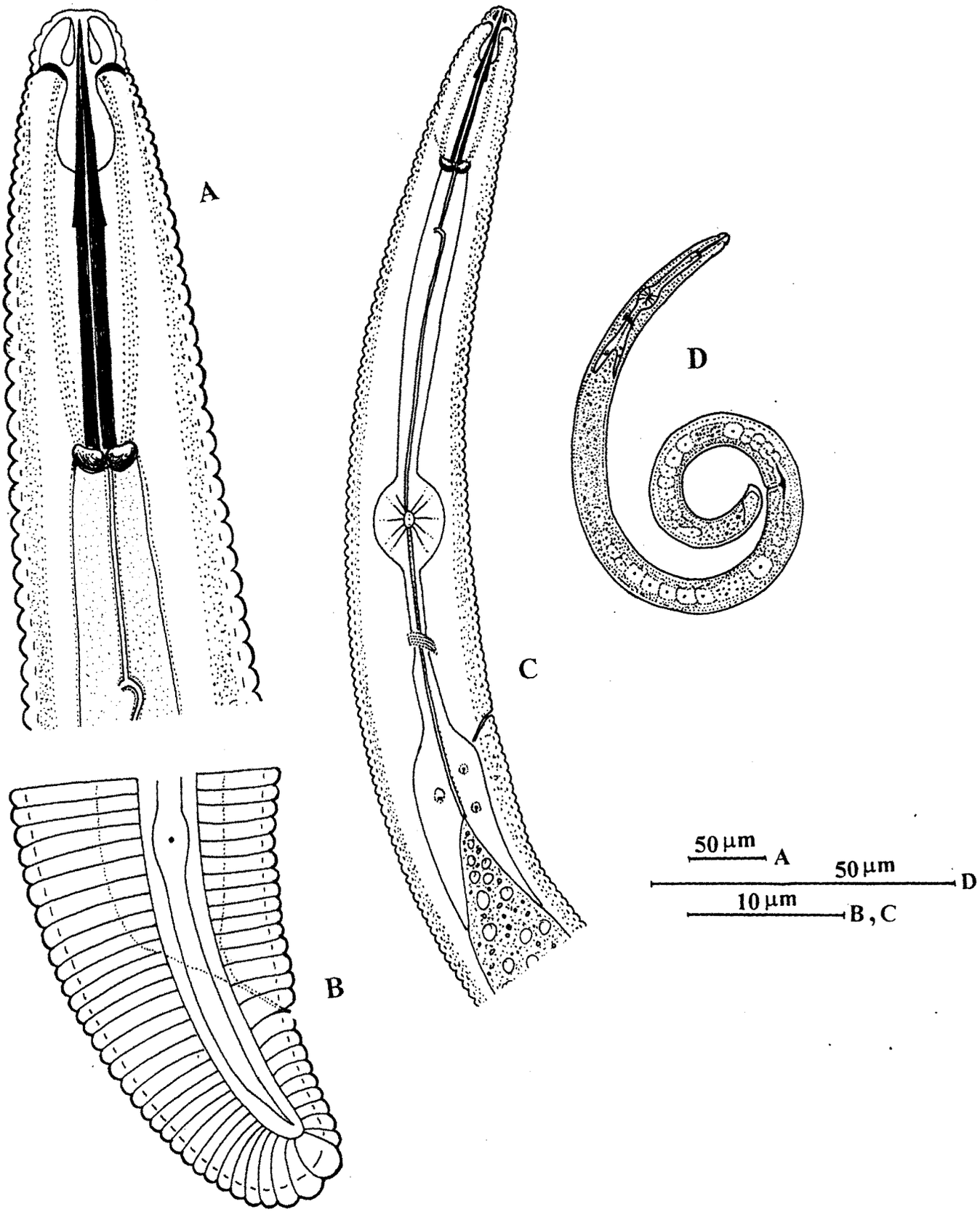

Fig.4 *Helicotylenchus brassicae* n.sp.
A) Head region
B)Female tail
C)Oesophageal region
D) Whole body

Diagnosis and relationship:

H.brassicae n.sp. is closely related to *H.retusus* Siddiqi and Brown , 1964 but can be identified by its spiral shaped body , lip annules , body length, shape of stylet knobs, length of stylet, tail annules and tail length. The lip region in *H.brassicae* n.sp. has 5 faint annules but in case of *H.retusus*, without any lip annules. The body length in *H.brassicae* n.sp. range from 0.62-0.74 µm while it was 0.78-0.83 µm in *H.retusus*. Stylet knobs were slightly sloping inward and indented in *H.brassicae* n.sp. but slight indentation in *H.retusus* without slope. The shape in stylet knobs of *H.brassicae* n.sp. resembled that of *H.paraconcarus* Rashid & Khan , 1972. The stylet in *H.brassicae* n.sp. was 28-31 µm long but 23.9-26.1 µm long in *H.retusus*. The number of tail annules were 9 in *H.brassicae* n.sp whereas in *H.retusus* it ranged from 13-17. The tail in *H.brassicae* n.sp is equal or shorter in length than anal body width but it is longer than anal body width in *H.retusus*.

Type locality:

Kuruthukuli village near Udhagamandalam, Nilgiris District, Tamilnadu.

Type Host : Cabbage (*Brassica oleracea* L.var.capitata)

Type specimen:

Holotype TNAU/101 , deposited at Department of Nematology , TNAU, Coimbatore –3. Paratype TNAU /102 – TNAU/307 with 8 nematodes and paratype TNAU/308 with 2 ♀ nematodes deposited at National Nematode Collection , IARI,New Delhi.

Helicotylenchus conicephalus **Siddiqi , 1972**

Female:

Body short , thin with a loose spiral shape when heat relaxed. Lip region with small labial disc, with 4-5 annules. Cephalids indistinct. Stylet robust, 21-27 μm long with rounded , anteriorly indented knobs, 3.5-4.5μ wide. Dorsal oesophageal gland orifice at 10-15 μm posterior to basal knobs. Oesophagus long, 120-141 μm with large rounded median bulb, long isthmus and oesophageal glands overlapping intestine ventrally and dorsally. Nerve ring surrounds isthmus at 75-82 μm from anterior body end. Hemizonid about 2 annules wide and situated at 0-3 annules anterior to excretory pore which is at 85-98 μm from anterior body end. Lateral field occupies one fourth of corresponding body diameter and the inner two incisures fuse distally. Phasmid pore like situated at 6-11 annules anterior to anus level. Female reproductive system didelphic, amphidelphic, vagina at 60-67% of the body length and vulva a transverse slit. Tail rounded to conical with 12-17 annules; terminal annule finer than the rest and provided with a ventral non-annulated projection (Fig. 5).

Male: Not found.

The dimensions of Udhagamandalam , Yercaud and Kodaikanal populations are furnished in Table 5.

Host – Cabbage (*Brassica oleracea* L.var. capitata)

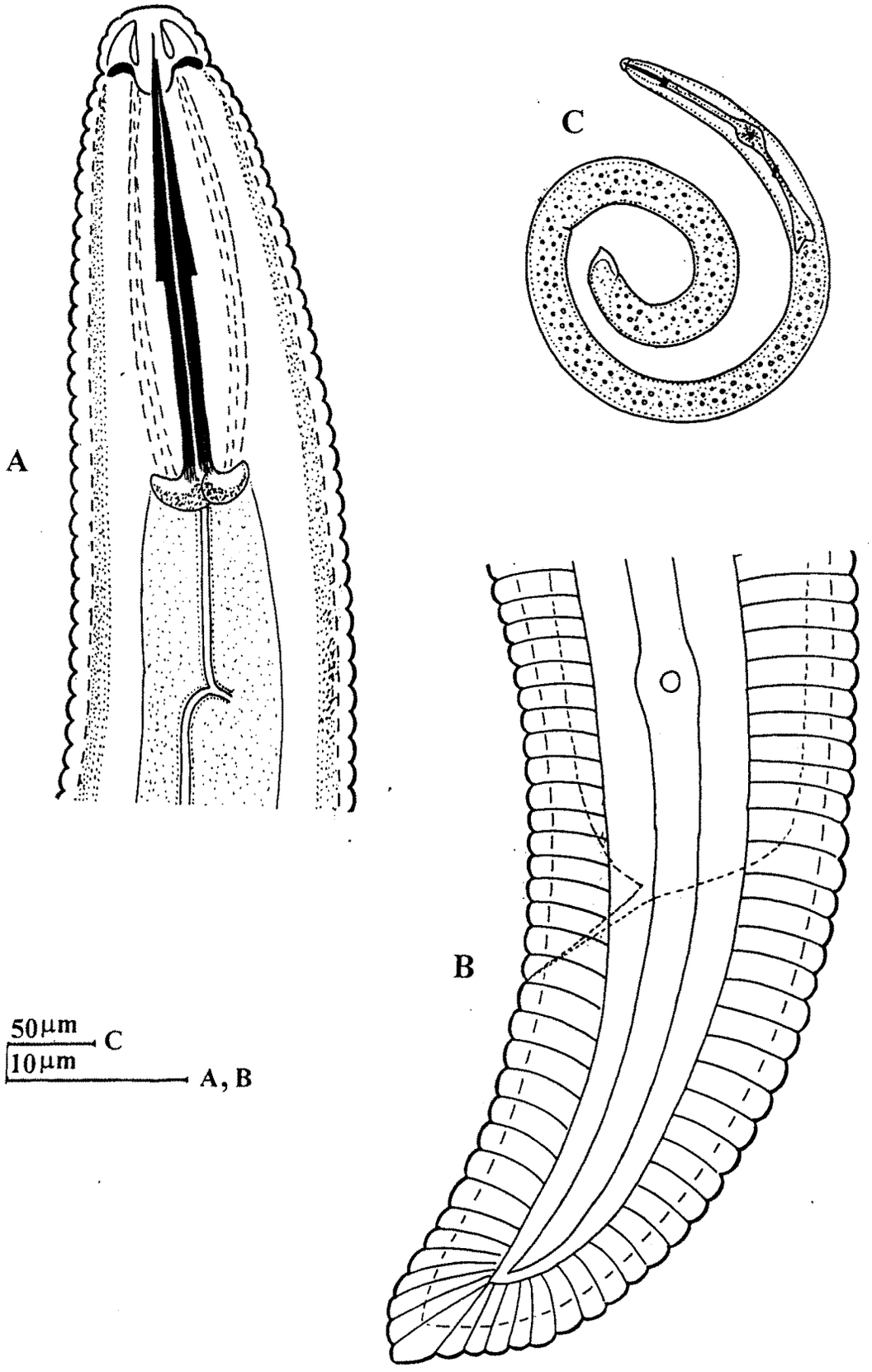

Fig.5 *Helicotylenchus conicephalus*
A)Head region
C) Whole body
B) Female tail

Table 5:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Helicotylenchus conicephalus* Siddiqi , 1972

Dimensions	Mzuzu Malawi, Sudan (a)	Udhagamandalam Tamilnadu **	Yercaud Tamilnadu **	Kodaikanal Tamilnadu **
L(mm)	0.54 (0.46-.64)	0.59 (0.51-0.68)	0.625 (0.52-0.73)	0.63 (0.52-0.74)
a	29 (28-32)	30.5 (28-33)	32 (29-35)	32.5 (29-36)
b	5.4 (4.9-7.0)	6.35 (5.2-7.5)	6.5 (5.3-7.8)	6.05 (4.9-7.2)
b'	4.4 (4.0-5.5)	5.1 (4.3-5.9)	5 (4.2-5.8)	4.8 (3.9-5.7)
c	47 (36-51)	45.5 (37-54)	44.5 (37-52)	44.5 (36-53)
c'	1.1 (0.7-1.4)	1.0 (0.7-1.3)	1.1 (0.8-1.5)	1.2 (0.8-1.6)
V %	61.5 (60-63)	63.5 (60-67)	63 (60-66)	63 (60-66)
O	54 (50-57)	53 (49-57)	50.5 (45-56)	55 (51-59)
Spear (µm)	22 (21-24)	24.5 (22-27)	24 (22-26)	24 (22-26)
No of ventral Annules	7-9	9-15	10-15	10-15

(a) - Original description by Siddiqi , 1972

** - Author's measurements

Value in parentheses indicate the range

Helicotylenchus dihystera **(Cobb , 1893) Sher,1961**

Description:

Female:

Body spiral when heat relaxed. Lip region hemispherical with 4 or 5 annules; outer margins of labial frame work extending 2-3 body annules. Body annules distinct, marked by 1.5-1.7 μm wide annules at the mid body. Stylet 24-27.5 μm long , conical part of the spear 11.0-12.5 μm long and basal knobs about 4.5 μm wide with concave anterior surfaces. Orifice of dorsal oesophageal gland located 11.5 μm below the stylet knobs. Procorpus tubular, median bulb oval. Excretory pore near the oesophageo-intestinal junction. Oesophageal gland partially surrounding anterior end of the intestine. Sub-ventral lobe slightly longer than the dorsal lobe. Ovaries paired outstretched with oocytes arranged in a single row. Spermatheca offset, without sperms. Tail 12-16 μm long , dorsally convex conoid , 9-13 annules ventrally. Phasmids 6-12 annules above anal level (Fig. 6).

Male: Not found.

The dimensions of the Udhagamandalam, Kodaikanal and Yercaud populations are furnished in Table 6.

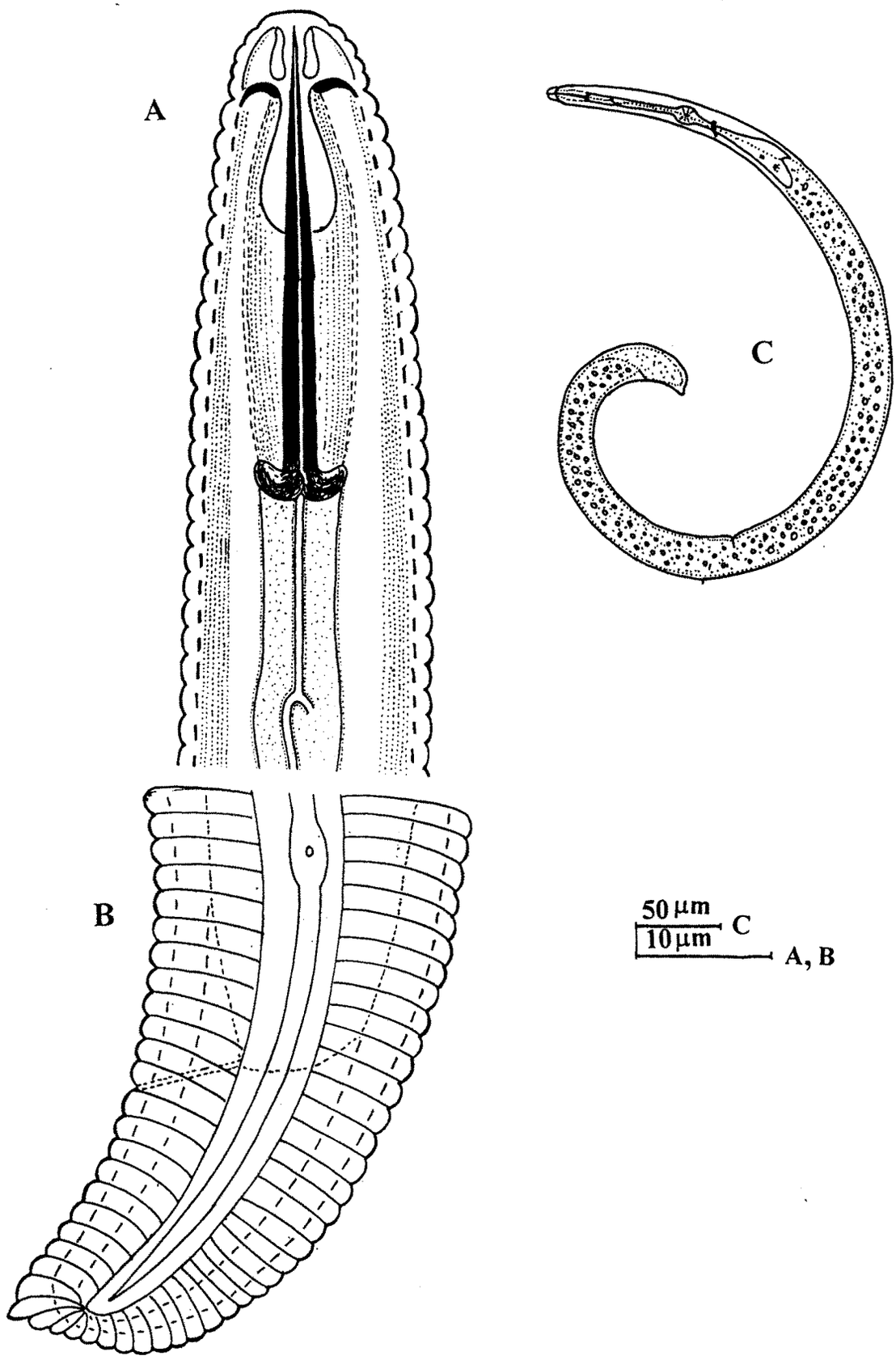

Fig.6 *Helicotylenchus dihystera*
A)Head region
B) Female tail
C) Whole body

Table 6:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *H.dihystera* (Cobb,1893) Sher, 1961

Dimensions	Harwood Australia (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **	Yercaud Tamilnadu **
L (mm)	0.69 (0.59-0.79)	0.66 (0.57-0.76)	0.65 (0.58-0.73)	0.63 (0.56-0.71)
a	31 (27-35)	30.5 (26-35)	29.5 (25-34)	28.5 (25-32)
b	6.35 (5.8-6.9)	5.3 (4.2-6.4)	5.6 (4.5-6.7)	5.8 (4.9-6.8)
b'	5.15 (4.4-5.9)	5 (4.3-5.7)	4.8 (4.2-5.50	4.85 (4.0-5.7)
c	42 (35-49)	41 (32-50)	40 (33-47)	43 (35-51)
c'	1 (0.8-1.2)	1.05 (0.7-1.4)	0.95 (0.6-1.3)	0.8 (0.5-1.1)
V %	62.5 (60-65)	63.5 (61-66)	64 (61-67)	62 (60-64)
Spear (μm)	26.5 (25-28)	25 (24-26)	25.2 (24-26.5)	26.2 (25-27.5
O	41.5 (37-46)	43 (39-47)	41.5 (38-45)	43.5 (40-47)
Ventral annules	6-12	7-11	7-12	8-12

(a)- Original description after Sher , 1961

** Author's measurement

Value in parentheses indicate the range

Hoplolaimus indicus **Sher , 1963**

Female:

Body open 'C' shaped on heat relaxation. Lip region slightly conical with 3-4 annules. Basal labial annule with 15-16 longitudinal striations. Labial frame-work well sclerotised, spear knobs with anterior projections. Conus almost half of spear length.Spear knobs 6-7 μm wide. The dorsal oesophageal gland orifice 3-7 μm behind spear base. Procorpus cylindrical , median bulb spheroid with a distinct valve. The dorsally overlapping gland has six nuclei. Excretory pore 110-135 μm from the anterior end located above the level of oesophageo-intestinal valve. Hemizonid 5-8 annules behind the excretory pore , extending over 2 annules. Phasmids located asymmetrically. Lateral field has a single incisure. Median vulva, ovaries outstretched. Spermatheca filled with sperms. The intestine slightly overlaps the rectum. Tail rounded with 12-15 annules (Fig. 7).

Male:

Similar to female except for the reproductive system. Testis single, outstretched. Spicule 39.21 μm and gubernaculum 20.85 μm long. Tail conoid enveloped by bursa. (Fig . 7)

The mesurements of Udhagamandalam , Kodaikanal and Yercaud populations are furnished in Table 7 .

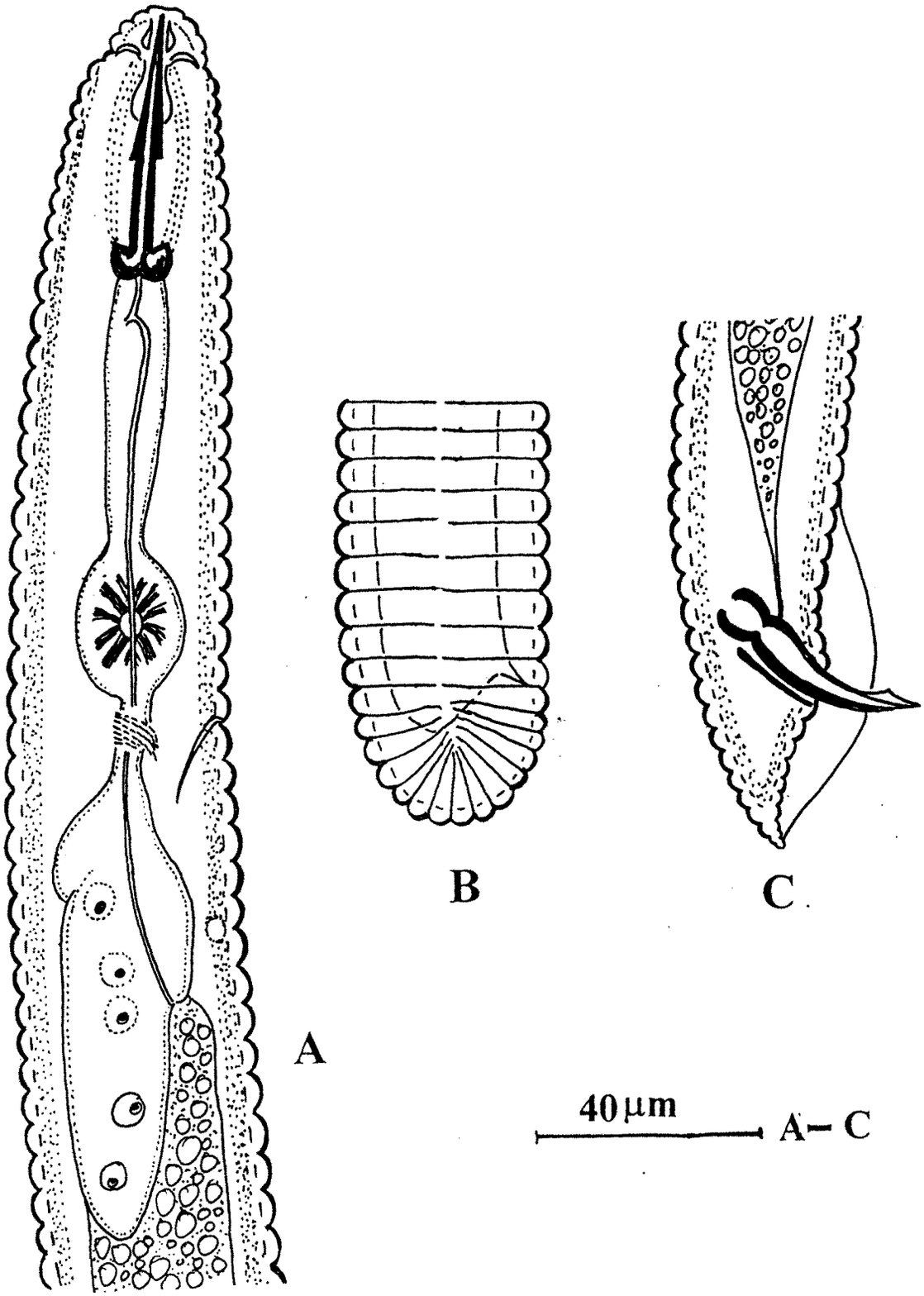

Fig.7 *Hoplolaimus indicus*

A) Oesophageal region B) Female tail
C) Male tail

Table 7

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Hoplolaimus indicus* Sher, 1963.

Dimensions	Karnal,Punjab (a)	Udhagamandalam Tamilnadu **	Yercaud Tamilnadu **	Kodaikanal Tamilnadu **
L (mm) ♀	1.17	1.22	1.14	1.23
	(0.95-1.5)	(0.95-1.5)	(0.88-1.4)	(0.97-1.5)
♂	1.1	1.06	0.98	1.22
	(0.90-1.3)	(0.92-1.2)	(0.87-1.1)	(0.92-1.3)
a ♀	31	30	31	32.5
	(26-36)	(25-35)	(27-35)	(28-37)
♂	29.5	30	31	29.5
	(26-33)	(26-34)	(27-35)	(26-33)
b ♀	10.85	9.55	10.25	11.25
	(9.1-12.6)	(8.9-10.2)	(9.2-11.3)	(9.4-13.1)
♂	10.7	9.3	9.8	11
	(9.4-12.0)	(8.5-10.1)	(8.8-10.8)	(9.2-12.8)
b' ♀	8.05	8.05	8.35	8.65
	(7.0-9.1)	(7.2-8.9)	(7.5-9.2)	(7.8-9.5)
♂	7.6	7.7	7.65	7.6
	(6.2-9.0)	(6.8-8.6)	(6.5-8.8)	(6.7-8.5)
c ♀	59.5	49.5	54	58
	(45-74)	(40-59)	(43-65)	(45-71)
♂	35	33	33	34.5
	(32-38)	(30-36)	(31-35)	(32-37)

Dimensions	Karnal, Punjab (a)	Udhagamandalam Tamilnadu **	Yercaud Tamilnadu **	Kodaikanal Tamilnadu **
V %	54.5 (50-59)	57 (55-59)	56 (54-58)	55.5 (53-58)
O % ♀	14 (10-18)	12.02 (8.95-15.1)	11.75 (9.00-14.5)	12 (9.00-15)
♂	13 (10-16)	12 (9.00-15)	11.9 (9.50-14.3)	12.85 (9.7-16)
Spear(μm) ♀	36.5 (33-40)	37.4 (33.8-41)	38.5 (34-43)	37.5 (33-42)
♂	35 (33-37)	36 (33-39)	38 (34-42)	37 (33-41)
Spicules (μm)	39.5 (37-42)	40 (37-43)	40.5 (37-44)	41.5 (38-45)
Anterior phasmid ♀	36 (28-44)	35.5 (29-42)	35.5 (28-43)	36.5 (29-44)
♂	36 (29-43)	36.5 (30-43)	36.5 (31-42)	36.5 (30-43)
Posterior phasmid ♀	81 (76-86)	82 (77-87)	83 (78-88)	81 (77-85)
♂	81 (74-88)	81.5 (75-88)	82.5 (76-89)	81.5 (76-87)

(a) – Original description by Sher , 1963

** - Author's measurement

Value in parentheses indicate the range

Meloidogyne hapla **Chitwood , 1949**

Female:

Body pyroid with short neck. Spear 11.5-13 µm long with 2.5-4 µm wide knob and not conspicuous. Hemizonid slightly posterior to excertory pore. Posterior cuticular pattern circular, comprising of closely spaced smooth or slightly wavy striae. Dorsal arch low. Lateral fields may be unmarked, may be marked only by slight irregularities in the striae, or dorsal and ventral striae may meet at a slight angle along the fields. Tail with few striae but distinct punctuations forming a stippled area between the anus and tail terminus. Phasmids widely spaced. The PCP shows winged pattern (Fig. 8).

Male: Not found.

Juvenile :

Head not set off , truncate. Spear knobs rounded. Lateral field with four incisures, outer bands irregularly cross striated. Tail tip variable (Fig. 8).

The dimensions of Udhagamandalam, Kodaikanal and Yercaud populations are furnished in Table 8 and 9.

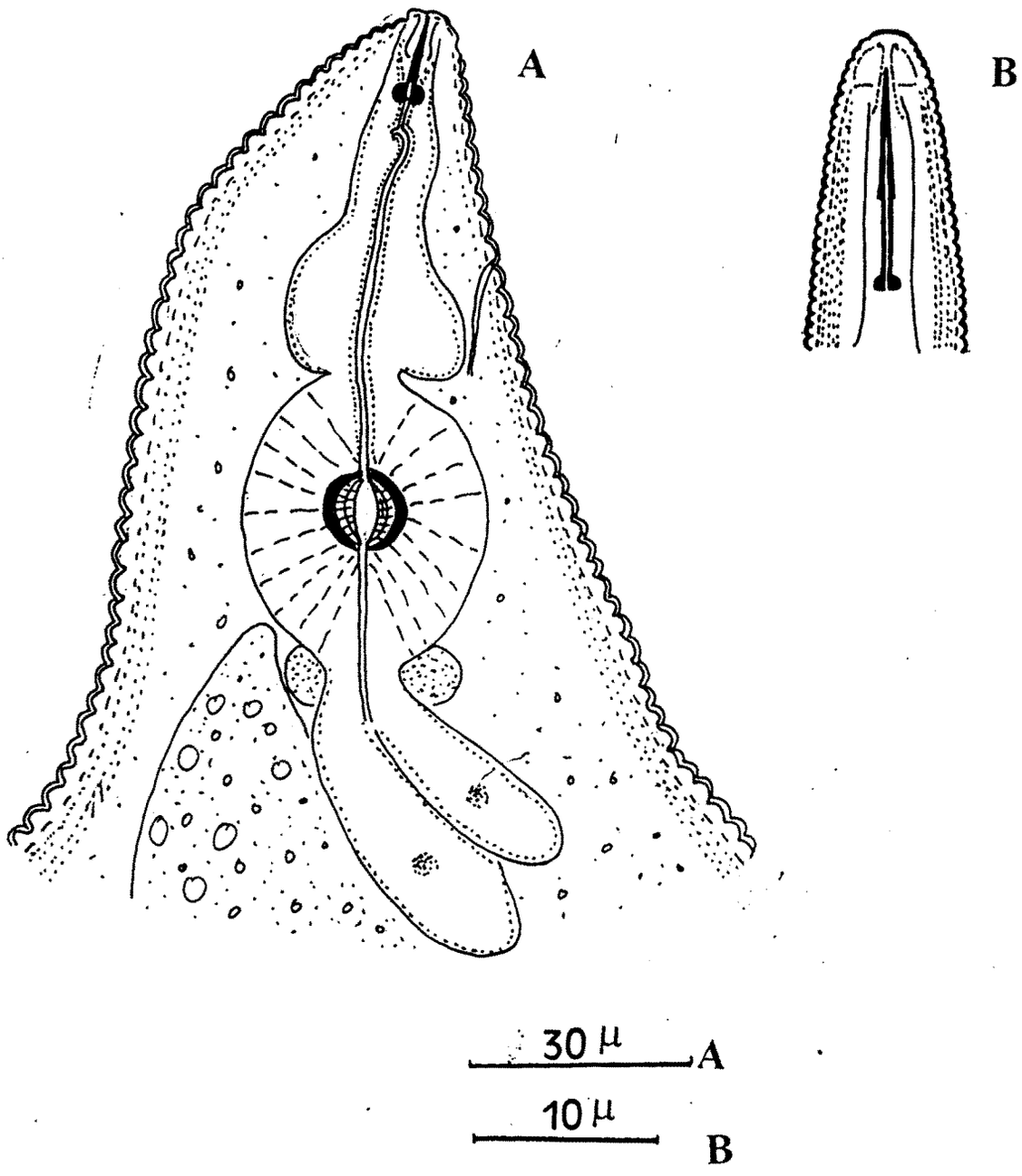

Fig.8 *Meloidogyne hapla*

A) Female oesophageal region B) Head region of second stage larva
C) Posterior cuticular pattern

Fig.8 *Meloidogyne hapla*
C) Posterior cuticular pattern

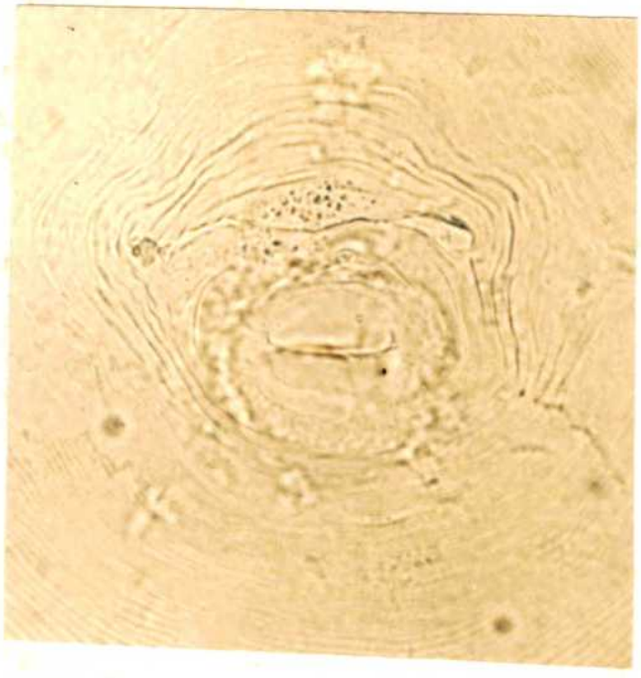

Table 8:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Meloidogyne hapla* Chitwood,1949 (♀)

Dimensions	Bridgehampton New York, USA (a)	Udhagamandalam, Tamilnadu **	Yercaud Tamilnadu **	Kodaikanal Tamilnadu **
Length (μ)	632 (419-845)	635 (420-850)	636.5 (418-855)	641 (422-860)
Width (μ)	436 (311-561)	437.5 (310-565)	442 (314-570)	438.5 (317-560)
Spear Length (μ)	11.5 (10-13)	12.5 (11-14)	13 (11-15)	12.5 (11-14)
Dorsal oesophageal gland orifice (μ)	5 (4-6)	6 (5-7)	5.5 (4-7)	5 (3-7)
Width spear base (μ)	2.5 (2-3)	2.5 (2-3)	4 (3-5)	3 (2-4)
Length of median bulb (μ)	37 (31-43)	39 (33-45)	37.5 (33-42)	37.5 (32-43)
Width of median bulb (μ)	31.5 (26-37)	33.5 (29-38)	31.5 (28-35)	33.5 (27-40)
Length of median bulb valve (μ)	11.5 (10-13)	12.5 (10-15)	13 (12-14)	12 (9-15)
Width of median bulb valve (μ)	10 (9-11)	11 (10-12)	11.5 (10-13)	12.5 (11-14)

(a) – Original description after Whitehead , 1968
** - Author's measurement

Value in parentheses indicate the range

Table 9:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Meloidygyne hapla* Chitwood , 1949 (Second stage larvae)

Dimensions	Bridgehampton L.I.New York (a)	Udhagamandalam Tamilnadu **	Kodaikanal Tamilnadu **	Yercaud Tamilnadu **
L ((μ)	351.5 (331-372)	354.5 (334-375)	352.5 (332-373)	355 (334-376)
a	28 (25-31)	29 (26-32)	29.5 (27-32)	29 (25-33)
b	7 (6-8)	7.5 (6-9)	7 (6-8)	9 (7-9)
c	7.4 (6.8-8)	7.75 (7-8.5)	7.95 (7-8.9)	9 (8-10)
Stylet length (μ)	10	10.7 (9.6-11.8)	11.05 (10-12.1)	10.95 (10-11.9)
Distance of dorsal gland orifice behind stylet base (μ)	3.5 (3-4)	4.5 (4-5)	4.75 (4-5.5)	5.15 (4.5-5.8)

(a) Original description after Chitwood , 1949

** - Author's measurement

Value in parentheses indicate the range

Meloidogyne incognita **(Kofoid and White, 1919) Chitwood, 1949**

Female:

Body pyriform. Spear 14-14.7 µm long with 4-4.5 µm wide and rounded knobs having backward sloping. Dorsal oesophageal gland orifice 3.5-4.5 µm behind the spear base. Excretory pore at the posterior of spear knobs. Posterior cuticular pattern with dorsal arch high and squarish with striations closely spaced, very wavy to zig-zag on dorsal and lateral side. Dorsal arch high, rounded. Lateral field not clear. Much variations have been noticed in the posterior cuticular patterns especially with the dorsal arch (Fig. 9).

Juvenile:

Head not offset, truncate. Spear knobs prominent and rounded. Hemizonid three annules long just anterior to excretory pore. Lateral field with four incisures, outer bands cross striated. Tail tapering to subacute terminus striation crossing posteriorly (Fig. 9).

Male: Not found.

The dimensions of Udhagamandalam, Kodaikanal and Yercaud populations are furnished in Table 10 and 11

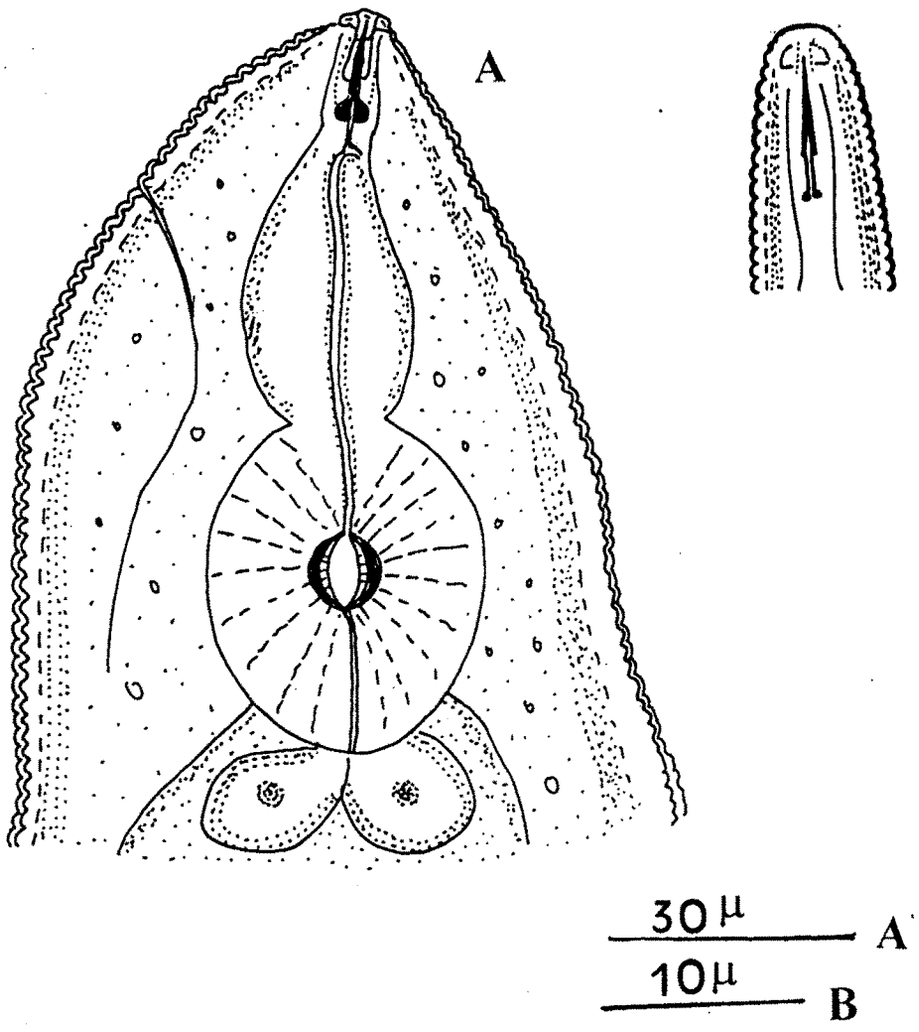

Fig.9 *Meloidogyne incognita*

A)Female oesophageal region B)Head region of second stage larva
C)Posterior cuticular pattern

Fig.9 *Meloidogyne incognita*
C)Posterior cuticular pattern

Table 10:

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood , 1949 (♀)

Dimensions	ElPaso,Texas, USA (a)	Udhagamandalam Tamilnadu **	Yercaud Tamilnadu **	Kodaikanal Tamilnadu **
Length (μ)	609 (500-723)	621 (530-712)	610 (520-700)	622.5 (525-720)
Width (μ)	415 (331-520)	425 (350-500)	426 (342-510)	427 (339-515)
Spear Length (μ)	14 (13-16)	14 (13-15)	14.5 (13-16)	14.7 (13.5-16)
Width spear base (μ)	4 (3-5)	4.5 (3-6)	4 (3-5)	4.5 (4-5)
Dorsal oesophageal gland orifice (μ)	3 (2-4)	4 (3-5)	3.5 (3-4)	4.5 (3-6)
Length of the median bulb ((μ)	46 (37-63)	49.5 (39-60)	50 (37-63)	51 (38-64)
Width of the median bulb (μ)	39 (31-49)	39.5 (33-46)	40.5 (31-50)	41.5 (32-51)
Length of the median bulb valve (μ)	14 (13-16)	15 (14-16)	14.5 (13-16)	15.5 (14-17)
Width of the median bulb valve (μ)	12 (11-13)	13 (12-14)	12.5 (11.5-13.5)	13.7 (12.5-15)

(a) – Original description after Whitehead , 1968

** - Author's measurement

Values in parentheses indicate the range.

Table :11

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS *OF* *Meloidogyne incognita* (Kofoid & White,1919) Chitwood , 1949 (Second stage larvae)

Dimensions	ElPaso Texas , USA (a)	Udhagamandalam Tamilnadu **	Kodaikanal, Tamilnadu **	Yercaud, Tamilnadu **
L (μ)	376.5 (360-393)	377.5 (360-395)	380 (362-398)	379 (361-397)
a	31 (29-33)	32.5 (30-35)	33 (30-36)	33.5 (31-36)
b	6 (5.6-6.4)	6.3 (5.8-6.8)	6.5 (6.1-6.9)	6.65 (6.2-7.1)
c	8.7 (8-9.4)	9.2 (8.5-9.9)	9.8 (8.4-11.2)	9.7 (8.3-11.1)
Stylet length (μ)	(10)	10.5 (10-11)	10.75 (10-11.5)	10.5 (10-11)
Distance of dorsal gland orifice behind stylet base (μ)	2.25 (2-2.50)	2 (3-3.8)	3.45 (3-3.9)	3.65 (3.2-4.1)

(a) – Original description after Chitwood , 1949

** - Author's measurement

Value in parentheses indiacate the range.

Pratylenchus coffeae **(Zimmermann,1898) Filipjev and Schuurmans Stekhoven ,1941**

Description:

Female: Body slender, ventrally curved when heat relaxed, cuticular annulation fairly conspicuous. Lip region slightly set off with two annules. Outer margins of the labial framework extend into one body annule. Spear 14.3-18.5 µm long with broadly rounded 3 µm high and 4.5 µm wide. Lateral field has four incisures. Dorsal oesophageal gland orifice about 2.6 µm behind the spear base. Excretory pore located at the level of oesophageo-intestinal junction, 75-90 µm from the anterior end. Hemizonid about two annules long , situated just anterior to the excretory pore. Median bulb oval in shape.Ovary single, outstretched. Spermatheca oval, filled with sperms. Post-uterine branch about 20-50µm long, differentiated. Phasmids slightly posterior to middle of the tail. Lateral lines extend beyond phasmids. Tail tapering slightly , consisting of 20-25 ventral annules. Tail terminus broadly rounded and smooth (Fig. 10).

Male:

Similar to female. Testis single , outstretched. Phasmids slightly posterior to middle of the tail, extend slightly into bursa. Spicule slender and ventrally concave , curved with bursa. (Fig .10)

The dimensions of the Udhagamandalam, Kodaikanal and Yercaud populations are furnished in Table 12.

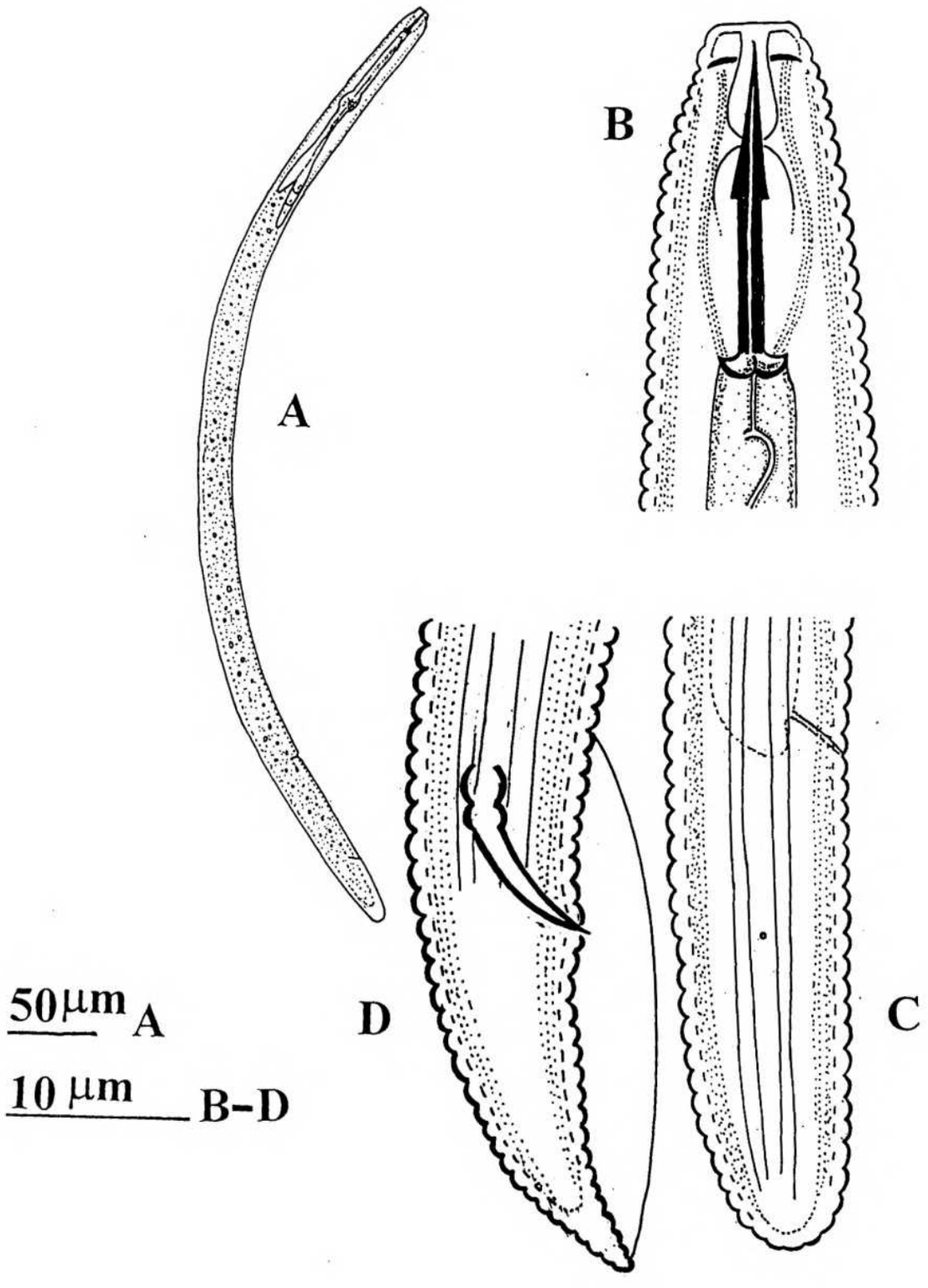

Fig.10 *Pratylenchus coffeae*

A) Whole body
B) Head region
C) Female Tail
D) Male tail

TABLE 12 :

COMPARISON OF DIMENSIONS OF DIFFERENT POPULATIONS OF *Pratylenchus coffeae* (Zimmermann, 1898) Filipjev and Schuurmans Stekhoven , 1941.

Dimensions	Bangor Indonesia (O) (a)	Udhagamandalam,Tamilnadu		Kodaikanal,Tamilnadu	
		Female (n=10) **	Male (n=7) **	Female (n=10) **	Male (n=8) **
L (mm)	0.57 (0.45-0.7)	0.53 (0.47-0.60)	0.5 (0.45-0.55)	0.53 (0.48-0.59)	0.52 (0.46-0.59)
a	30 (25-35)	22.45 (16.5-28.4)	25.54 (21.89-29.2)	22.2 (16.8-27.6)	25.28 (21.65-28.92)
b	6 (5-7)	6.6 (5.38-7.82)	6.72 (5.88-7.56)	6.01 (4.82-7.21)	6.91 (5.72-8.11)
b'	-	4.01 (3.35-4.68)	3.99 (3.14-4.85)	4.05 (3.35-4.75)	3.99 (3.16-4.83)
c	19.5 (17-22)	19.89 (17.28-22.5)	20.54 (17.91-23.18)	19.67 (17.52-21.83)	20.48 (17.85-23.12)
c'	-	2.24 (1.63-2.85)	-	2.32 (1.72-2.92)	_
V %	79.5 (76-83)	79.35 (76.21-82.5)	-	80 (77-83)	_
Spear (µm)	16.5 (15-18)	16.9 (15.3-18.5)	15.35 (14.3-16.4)	16.7 (15.1-18.3)	15.3 (14.4-16.2)
Spicule (µm)	-	-	50.3 (42.5-58.15)	-	51 (43.2-58.8)
Gubernaculum (µm)	-	-	18.16 (16.5-19.82)	-	18.24 (16.62-19.86)

(a) – Original description after Sher and Allen.1953
** - Author's measurement. - Data not available
Values in parentheses indicate the range.

Tylenchorhynchus shervroyi **n.sp.**

Measurements:

Female (holotype): L=0.76 mm, a = 33.8, b = 4.6, c = 16, c'=2.1,V = 54, Stylet = 20.24μm

Female (paratype): (10): L= 0.712 (0.695-0.757)mm, a = 28.65 (27-36), b = 5.2 (5.2 - 5.5), c = 17(15-19), c'= 2.2(2.1-2.3), V = 53 %(52-55), Stylet = 19.06 (17.94-21.24)μm.

Male: Not found

Description:

Specimen open 'C' shaped after killing by gentle heat; body cylindroid, tapering at both ends. Head region broadly rounded, set off from body by constriction, and bears 6-7 annules which are not clearly demarcated. Labial framework moderately sclerotized; stylet 20.24 μm in length with well-developed stylet knobs, slight inclination posteriorly. Median bulb oval to slightly rectangular in shape (16.10 X 12.42 μm); excretory pore located at a distance of 114.3 μm from head region and opens at 1/3rd the length of the base bulb. Orifice of the dorsal oesophageal gland (DGO) located 2.5μm behind stylet base. Oesophago-intestinal valve not conspicuous, lateral field more than 1/3rd of body diameter wide having four incisures and continue near the tail tip and the inner incisures are not united at the tail tip. Female reproductive system double, opposed; Spermatheca non-functional; Vulva at 54% of body length and it is slightly raised on the body contour. Vagina more than 1.5th of the body dip. Phasmid located 12 annules behind the anus and 30% the tail length. Tail short, ventrally curved, conoid with about 41 annules. The tail terminus with heart shaped projection without annules or striations (Fig. 11).

Diagnosis and relationship;

T.shervroyi n.sp. is closely related *to T.solani* Maqbool,1982 but can be differentiated by not having spiral body and slightly longer than *T.solani* (0.695-0.75 Vs 0.61-0.73). It has stylet length of 21.16 μm but in *T.solani* the stylet length is 18.4-19.5. The stylet knobs are

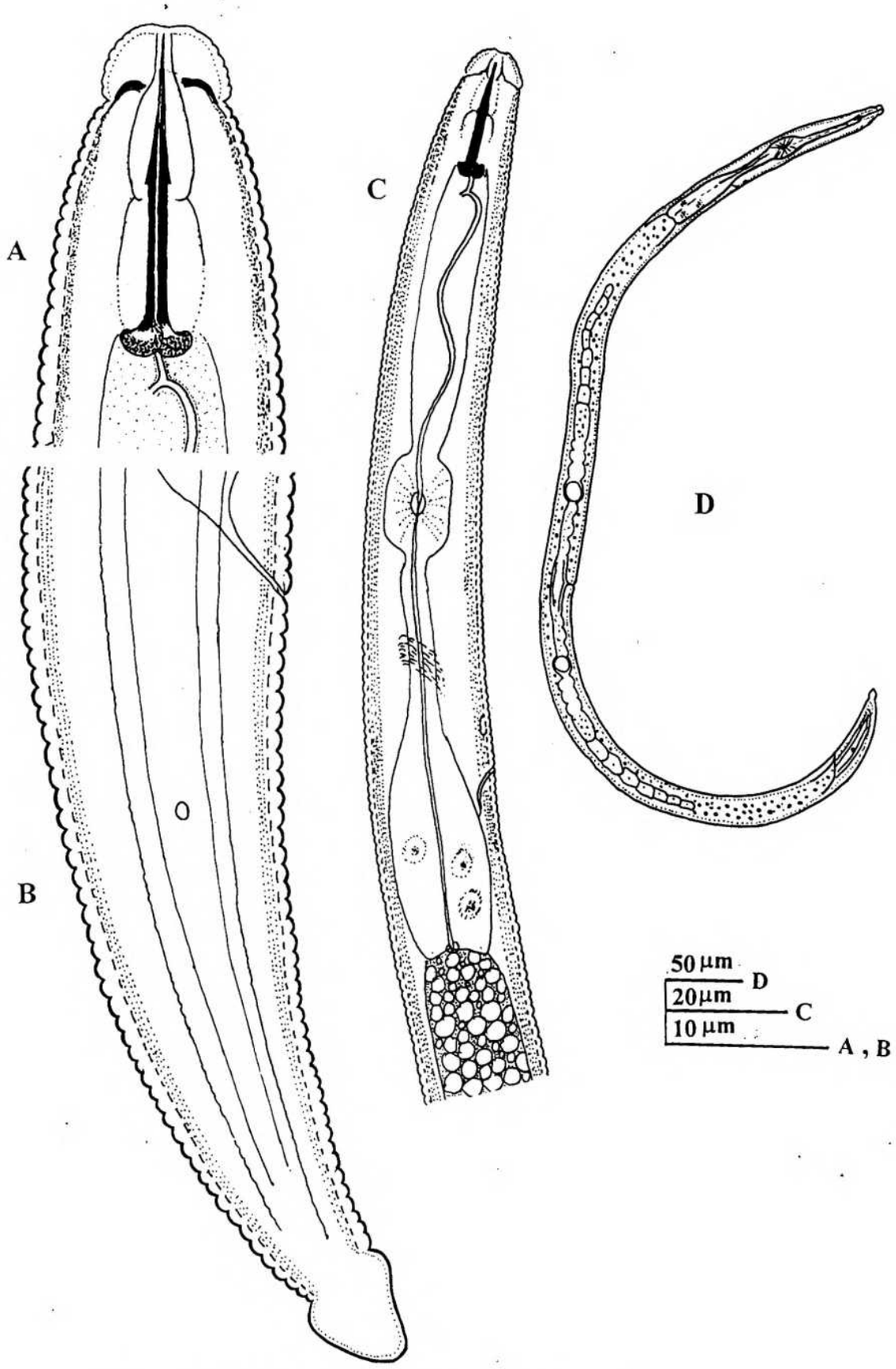

Fig.11 *Tylenchorhynchus shervroyi* n.sp.
A)Head region
B) Female tail
C) Oesophageal region
D) Entire body

rounded with slight inclination posteriorly but in *T.solani* , it is sloping posteriorly. Median bulb is oval to rectangular in *T.shervroyi* n.sp. but in *T.solani* it is oval in shape. Excretory pore is at 114.3 µm and DGO is at 2.5 µm . Lateral field has only four incisures in *T.shervroyi* n.sp. but five incisures in *T.solani*. Vagina is more than 1.5th of the body width deep but in *T.solani*, it is < 1.5th of the body width deep. The number of tail annules is 42-48 in *T.shervroyi* n.sp. whereas *T.solani* has upto 38 annules. The tail terminus in *T.solani* having heart shaped projection bluntly. The tail terminus bluntly pointed with heart shaped projection without any annulation in *T.shervroyi* n.sp.

Type locality:

Horticultural Research Station , Yercaud in Shervroy, Salem district , Tamilnadu.

Type host : Mandarin Orange (*Citrus reticulata* L.)

Type slides : TNAU/301 holotype deposited at department of Nematology , TNAU , Coimbatore –3.

Paratype TNAU/302 – TNAU/305 with five nematodes and paratype TNAU/306 with six ♀ deposited at National Nematode Collection at IARI,New Delhi.

Discussion

CHAPTER V

DISCUSSION

The measurements of the species recorded in the present investigation are compared with original measurement of the species.

***Globodera pallida* Stone , 1973**

***G.rostochiensis* (Wollenweber, 1923) Behrens , 1975**

Species of *G.pallida* and *G.rostochiensis* collected in the Potato (*Solanum tuberosum* L.) rhizosphere from Udhagamandalam , Nilgiris district and Vilpatty village in Kodaikanal , Dindigul district which are located in temperate region at an altitude of about 2000-2500 m MSL.

The body measurements of *G.pallida* and *G.rostochiensis* collected from above places mostly agrees with the original description given by Stone, (1973) and the dimensions did not deviate much from the range as reported by the author (Table 1,2,3 & 4)

It might be due to the reason that the nematodes are introduced from England through the seed potatoes and could be the same races of populations of *G.pallida* and *G.rostochiensis*. Further, the factors like climatic condition and altitude in which the nematodes prevail are almost similar which could influence on the body dimensions. But the second stage infective juveniles collected from the same places show some minimum variations in the biometric dimensions than that of the original description given by Stone, (1973) in respect of body length, stylet length, stylet base to dorsal oesophageal gland duct and tail length.

This might be due to the factors like host influence, altitude and the prevailing temperature. Possibilities of occurrence of pathotypes could also be one of the factors for the variation, Krishnaprasad (1992).

Subramanian *et al.* (1989) expected the presence of the pathotypes Ro 5 and Pa 3 or others, not yet identified which are infesting the resistant cultivar Kufri Swarna, might be one factor for the variation in biometric as against original description.

***Helicotylenchus brassicae* n.sp.**

It is very close to *H.retusus* Siddiqi and Brown, 1964 but can be differentiated from it, by having 5 lips annules in *H.brassicae* n.sp. where as *H.retusus* without any lip annules, shorter body measuring 0.62-0.75 mm as against 0.78-0.83 mm in *H.retusus* and slight sloping inward and indented stylet knobs, longer stylet length of 28-31 µm (23.9-26.1 in *H.retusus*) , less number of ventral annules of 9-10 (13-17 in *H.retusus*). The tail length is equal or shorter than anal body width in case of *H.brassicae* n.sp. whereas it is longer than anal body width in *H.retusus.*

The new species is named after the host *viz., Brassica oleraceae* L. var. *capitata.* Although it was encountered at Nilgiris, the population recorded at Yercaud and Kodaikanal resembles *H.brassicae* n.sp. could be the same species.

***Helicotylenchus conicephalus* Siddiqi , 1972**

It was described by Siddiqi (1972) from Mzuzu , Malawi. This species is closely related to *H.microcephalus* Sher , 1966 and differs in having 6-8 annules between anterior and posterior cephalids, a more slender spear with smaller knobs and a tail with a ventral projection with fine annules on terminus.

This species was collected from the rhizosphere of Cabbage (*Brassicae oleracea* L.var.*capitata*) from Kurthukuli , Udhagamandalam and Attuvampatti , Kodaikanal and HRS , Yercaud , Tamilnadu.

Variations in body dimensions have been observed in the individuals in the body length. The specimens from all the three locations were longer than the original description by Siddiqi (1972).

The individuals from Kodaikanal population are longer measuring 0.63 mm (0.52-0.74 mm) followed by Yercaud population 0.62 mm (0.52-0.73 mm) and Udhagamandalam population 0.59 mm (0.51-0.68 mm) as against [0.55mm (0.46-0.64 mm)] with the original measurement recorded by Siddiqi (1972).

Spear length in the Siddiqi's description was 22 μm and the specimens recorded at Udhagamandalam had a largest spear upto 27 μm .

The values of a,b and b' are higher with the specimens from all the three places than the original description, but the value of 'c' is much shorter than the original description.

The position of vulva in the specimens encountered in the present study were slightly posterior by 2% than the original measurement made by Siddiqi (1972).

The variation in dimension with the original description might be due to difference in host range, locality and altitudes.

Helicolylenchus dihystera **(Cobb, 1893) Sher, 1961**

It is the most widely distributed species occuring in tropical, sub-tropical as well as in temperate region.

The comparison of dimensions shows that there is variation in the individuals from description given by Sher (1961).

The specimens encountered in the present study had slightly shorter body (0.57-0.76 mm) than the original description (0.59-0.79 mm) by Sher (1961). The values of a, b, and b' are also lower than the original description. However values of c and c' more or less agree with the original description. Little variation was observed in vulval position within the populations of Udhagamandalam, Kodaikanal and Yercaud. Udhagamandalam and Kodaikanal populations had shorter spear length of 25 and 25.2 μm and the Yercaud population agrees with Sher's measurement of 26.2 μm . The value of 'O' is smaller (37-46) in case of original description as against the populations collected in the present study (38-47).

The variations in dimensions with the original description might be due the difference in host and altitude effect. Since the original measurements were based on the specimens collected from Harwood, Australia which differs in altitudes of Western Ghats in Tamil Nadu.

***Hoplolaimus indicus* Sher , 1963**

Sher (1963) described this species from soil around the roots of sugarcane from Karnal,Punjab. In India , this species has wide distribution and is found in tropical , sub-tropical as well as in temperate regions.

Hoplolaimus spp. are distributed in tropical and temperate region and more than fifteen species have been reported from India.

Among the species , *H.seinhorsti* is the most predominant one occuring on a wide variety of hosts in Tamil Nadu.

H.indicus varies with *H.seinhorsti* in many body dimensions *viz.*, *H.indicus* has three labial annules (four in *H.seinhorsti*), *H.indicus* has longer oesophageal gland lobe with the 'b' value (9.1-12.6) as against shorter lobe with 'b' value ranges from 5.2-7.5 in *H.seinhorsti*. *H.indicus* also differs with *H.seinhorsti* by having shorter spear of 33-40 μm (40-45 μm in *H.seinhorsti*).

Most of the body mesurements of the populations collected for study from Udhagamandalam, Kodaikanal and Yercaud agree with the measurements of Sher (1963) except for the longer body of 1.22-1.23 mm with population from Udhagamandalam and Kodaikanal than the original measurement of 1.17 mm by Sher, 1963. The value 'c' is lesser 40-71 with the population collected in the present study than the original measurement (45-74). The spear was longer (37.4-37.5 μm) in all the three populations than the Sher's measurement of 36.5 μm.

The males encountered in the present investigation had longer spicules measuring 40-41.5 μm than the Sher's record of 39.5 μm (1963).

***Meloidogyne hapla* Chitwood, 1949**

Chitwood (1949) described *M.hapla* from soil and roots of Green Mountain variety of Potato from Bridgehampton, New York. In India, this species has limited distribution in sub-tropical and temperate regions only. It is very much destructive to Carrot crop in Udhagamandalam, Nilgiris District. This species was found to cause forking symptom in Carrots.

M.hapla was collected from Udhagamandalam, Nilgiris District, Horticultural Research Station, Yercaud, Salem District and in VilPatty, Kodaikanal, Dindigul District.

Major differences have been found in the body length of the specimens collected in the present study where the length ranges from 418-860 μ as compared to the original description by Whitehead, 1968. The width of the spear base in the Yercaud population is larger (4 μ) than the original (2.5 μ). Minor differences have been found in the position of dorsal gland orifice, stylet length, length and width of median valve or bulb.

The temperate species *M.hapla* has been originally described from a temperate region viz., Bridgehampton, New York. The presently encountered specimens were also from the temperate region but in high altitude ranges. The minor differences in the dimension might be due to the host and altitude effects.

***Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949**

Chitwood (1949) described *M. incognita* from soil and roots of Carrot (*Daucus carota* L.) from El Paso, Texas. This species has a wide distribution in India and has an economic significance throughout the tropical and sub-tropical regions of the world due to the wide host range.

The present study yielded the species from Udhagamandalam, Kodaikanal and Yercaud regions. Major differences were noticed in the length and the width of body as well as length and width of the median bulb in the populations of Udhagamandalam, Kodaikanal and Yercaud as compared to the original discription by Whitehead, 1968. However the variations are minimum in the position of the dorsal oesophageal gland orifice and spear length.

M.incognita was originally described from Texas, a relatively warmer region than the sub-tropical and temeperate regions of Udhagamandalam, Kodaikanal and Yercaud. This might be the possible reason for the differences in the body dimensions.

Meloidogyne hapla **Chitwoodi, 1949**

M.incognita **(Kofoid and White) Chitwood, 1949**

Second stage juveniles:

The biometric dimensions of the second stage juveniles collected form Udhagamandalam, Kodaikanal and Yercaud are longer than that of original measurement given by Chitwood, 1949 in respect of body length, a, b, c values, sylet length and distance of the dorsal gland orifice behind stylet base.

Variations might be due to differences in geographical distributions, climatic factors and altitudes. The possibility of existence of races is also attributed for the variation.

***Pratylenchus coffeae* (Zimmermann, 1898) Filipjev and Schuurmans Stekhoven, 1941**

It is the most widely distributed species of lesion nematodes occuring in the tropical, sub-tropical as well as temperate region of world and this endoparasitic nematode has a major economic significance on Coffee and Banana.

The present investigation yielded the species from Coffee in Kodaikanal and Yercaud and Banana in Udhagamandalam.

All the three populations encountered had a shorter body measuring 0.45-0.6 mm than the original description by Sher and Allen, 1953 (0.45-0.7) mm. The 'a' value ranges from 16.5-29.2 as compared to the original description of 25-35.

In respect of all other dimensions no much variations are noted.

***Tylenchorhynchus shervroyi* n.sp.**

T. shervroyi n.sp. collected around the rhizosphere of Mandarin Orange, exhibit close relationship to *T.solani* Maqbool, 1982 but it can be distinguished from *T.solani* by its spiral body shape, longer body of 0.69-0.75 mm as against 0.61-0.72 mm, longer stylet of 17.94-21.24 µm (18.4-19.5 µm in *T.solani*) , shape of stylet knobs, oval to rectangular median bulb, *T.shervroyi* n.sp. has four lateral lines compared to 5 lines in *T.solani.*

The tail annules in the new species is more (42-48) as compared to *T.solani* (upto 38).

The populations of *Tylenchorhynchus* collected from Udhagamandalam and Kodaikanal were also close to *T.shervroyi* n.sp. in the body dimensions and could be the same species.

Summary

CHAPTER VI

SUMMARY

The investigation for plant parasitic nematodes carried out in three regions of Western Ghats *viz.*, Udhagamandalam, Kodaikanal and Yercaud revealed the predominance of ten plant parasitic nematodes under six genera *viz.*,

Globodera pallida Stone, 1973

G.rostochiensis (Wellenweber, 1923) Behrens, 1975

Helicotylenchus brassicae n.sp.

H.conicephalus Siddiqi, 1972

H.dihystera (Cobb, 1893) Sher, 1961

Hoplolaimus indicus Sher, 1963

Meloidogyne hapla Chitwoodi, 1949

M.incognita (Kofoid and White, 1919) Chitwood, 1949

Pratylenchus coffeae (Zimmermann, 1898) Filipjev and Schuurmans Stekhoven, 1941

Tylenchorhynchus shervroyi n.sp.

The measurements based on de man's formulae worked out, drawings were made and the body dimensions compared with the measurements given by the authors.

The new species viz., *Helicotylenchus brassicae* n.sp. and *T. shervroyi* n.sp. were encountered in the study for which drawings and measurements were made and the type slides submitted at the Nematode collection at the Department of Nematology, TNAU, Coimbatore.

The differential diagnosis of the new species with the closely related species were given.

The comparison of the measurements of the species recorded in the three locations studied, revealed some variations with the original description made by the author for the species. The possible reasons for this, might be due to the influence of hosts, altitude and the prevailing temperature conditions.

The possibility of the existence of the subspecies, biotypes or races can not be eliminated and the present study leaves these possibilities to the future work on these lines.

References

REFERENCES

*Allen, M.W. 1955. A review of the nematode genus Tylenchorhynchus. University of California Publications in Zoology 61: 129 –166.

Allen,M.W and Sher,S.A.1967.Taxonomic problems concerning the phytoparasitic nematodes. **Annual Review of Phytopathology, 5**: 247-267.

*Alton, M.W.1955. A review of the nematode genus *Tylenchorhyndus* **Univ. Publ. Calif.Zool., 6** : 129 – 166.

Andrassy,I.1958. *Hoplolaimus tylenchiformis* Daday, 1905.(syn. *H.coronatus* Cobb,1923) und die gattungen der unterfamilie Hoplolaiminae Filipjev , 1936. **Nematologica, 3**: 44 – 56.

*Baker,A.D.1962. Check lists of the nematode super-families Dorylaimidea, Rhabditoidea,Tylenchoidea .and Aphelenchoidea. **Leiden**, E.J.Brill , 261 pp.

*Baylis, H.A. and Daubney. R.1926. A synopsis of the families and genera of Nematoda. British Museum, London, 227 pp

*Borradiale,C.A., Eowthan, Potts. F.A. and Saunders, J.T. 1965. The invertebrate: **A Manual for use of students,** IV edn , Cambridge Univ, Press London and New York. 137 pp.

*Brzeski, M.W. and Dolinski, C.M. 1998. Compendium of the genus *Tylenchorchynchus* Cobb, 1913 sensu lato (Nematoda: Belonolaimidae). **Russian Journal of Nematology, 6**: 189-199.

Chitwood .B.G.1949. Root-knot nematodes – part I. A revision of the genus *Meloidogyne* Goeldi , 1887. **Proceedings of the Helminthological Society of Washington, 16** : 90-104

Chitwood, B.G. and Chitwood, M.B. 1950. **An introduction to Nematology**. Section I. Anatomy (Rev. Ecl.) 213 pp. Baltimore, Monumental printing co.

*Chitwood , B.G. 1958. The classification on plant parasitic nematodes and related forms. **Fifteenth International Cong. Of Zoology** , Sect.VIII , paper , 28, 1-2.

*Cobb , N.A.1913. New nematode genera found inhabitating fresh water and non brakish soils . **J.Wash . Acad. Sci., 3** : 432 –444

*Cobb , N.A.1917. A new parasitic nematode found infesting cotton & potatoes. **Jrur .Agr.Res., 11**: 27-33.

*Cobb , N.A.1918 . Estimating the nematode population of soil. U.S.Dep. **Agr.Bur. plant Ind.Agr.Tech. Cir., 1**: 1-48

*Cobb, N.A. 1919. New nematode genera found inhabiting fresh water and non brakish soils. **J. Wash. Acas. Sci., 3**:432-444.

*Cobb, N.A. 1923 .An amendation of *Hoplolaimus* Daday, 1905 nec autores. **Control Sci. Nematology, 13:** 363-370

Cobb, N.A. 1924. The amphids of *Caconema* (nom.nov.) and other nemas. **Journal of Parasitology,11**: 118-119.

*Cornu, M. 1879. Etides sur le *Phylloxera vastatrix*. **Mem. Acad. Sci,** Paris **26**:163-175, 328,339-341.

Courtney , W.D., Polley, D. and Miller, V.L. 1955. TAF, an improved fixative in nematode technique. **Plant Disease Reporter, 39**: 570 –571

*Daday,E. Von, 1905. Untersuchugen uber die susswasser Mikrofauna Paraguays. **Zoologica Stuttugart, 18**:1-349.

De Guiran,G.1967. Description de deux especes nouvelles du genre *Tylenchorhynchus* Cobb,1913 (Nematoda : Tylenchinae) accompagnea d'une cle de femella,et precisions sur *T.mamillatus* Tobar Jimenez , 1966. **Nematologica, 13** : 217 – 230

*de Man , J.G.1880. Die einheimidchen frei in derreinen Erde und im sussen Wasser lebende Nematoden , Tijdschr. **ned. Dierk . ver.** 5pp:104

Ebsary,B.A and Eveleigh. E.S. 1983. *Meloidogyne aquatilis* n.sp. (Nematoda: Meloidogynidae) from *Spartina pectinata* with a key to the Canadian species of *Meloidogyne*. **Journal of Nematology, 15**: 349-353.

Eisenback, J.D., Hirschmann, H and Triantaphyllou, A.C. 1980. Morphological comparison of *Meloidogyne* female head structure, perineal patterns and stylets . **Journal of Nematology, 12** : 300 –313

Eisenback , J.D., Hirshmann, H. , Sasser, J.N. and Triantaphyllou, A.C. 1981. A guide to the four most common species of root-knot nematodes (*Meloidogyne* species) , with a pictorial key. Coop. Publ.Deps. **Plant Pathology and Genetics,** North Carolina State Univ., and U.S. Agency Int.Dev. Raleigh , N.C.48 pp.

Esser , R.P., Perry.V.G. and Taylor .A.L. 1976. A diagnostic compendium of the genus *Meloidogyne* (Nematoda : Heteroderidae). **Proceedings of the Helminthological Society of Washington. 43**:138-150.

*Esser, R.P. 1991. A computer ready checklist of the genera and species of phytoparasitic nematodes, including a list of mnemonically coded subject categories. **Bulletin 13.** Florida Department of Agriculture and Consumer Service Division of Plant Industry, Contribution No. 387, Gainesville.

Filho, A.C.C. and Huang, C.S. (1989). Description of *Pratylenchus pseudofallax* n.sp. with a key to species of the genus *Pratylenchus* Filipjev, 1936 (Nematoda : Pratylenchidae) . **Revue de Nematology, 12** :7-15

*Filipjev, I.N. 1934. The classification of the free-living nematodes and their relation to the parasitic nematodes. **Smithson.Misc. collect. , 89**:1-63.

Filipjev,I.N.1936. On the classification of the Tylenchinae. **Proceedings of the Helminthological Society of Washington, 3**: 80-82.

Fortuner, R. 1987. A reappraisal of Tylenchina Nemata (Diesing , 1861,Potts , 1932) Maggenti, 1981. 8. The family Hoplolaimidae Filipjev, 1934. **Revue de Nematology, 10** :219 – 232.

Fortuner , R. 1991. The Hoplolaiminae . pp 669-719 in W.R.Nickle , (ed) . **Manual of Agricultural Nematology**. New York : Marcel Dekker.

Fortuner, R. and Luc, M.1987. A reappraisal of Tylenchina (Nemata). The family Belanolaimidae Whitehead, 1960. **Revue de Nematology, 10:** 183-202.

Fotedar , D.N and Kaul .V. 1985. A revised key to the species of Genus *Helicotylenchus* Steiner , 1945 (Nematoda : Rotylenchidinae). **Indian Journal of Nematology, 15**: 138 – 147

Franklin, M.T. 1940. On the specific status of the so-called biological strains of *Heterodera Schmidt*. **Journal of Helminthology, 18**: 193-208.

*Franklin, M.T. 1972. The present position in the systematics of *Meloidogyne*. **Eur. Mediterr. plant Prot. Organ. (OEPP/EPPO) Bull., 6**: 5-15

Frederick,J.J. and Tarjan, A.C. 1989. A compendium of the genus *Pratylenchus* Filipjev , 1936 (Nemata : Pratylenchidae). **Revue de Nematology, 12**:243-256

*Goeldi, E.A. 1887. Relatorio sobre a molestia do cafeeirs na provincia do Rio de Janeiro. Apparently and advance separate of : Arch. **Mus. Nacional Rio de Janeiro, 8**: 7-121, 1892.

*Golden,A.M. 1956.Taxonomy of the spiral nematode (*Rotylenchus* and *Helicotylenchus*) and the developmental stages and host parasite relationships of *R.buxophilus* n.sp., attacking boxwood. **Bull. Md. Agric. Exp. Stn. A,, 85** : 1-28.

Golden , A.M.1971 . Classification of the genera and higher categoies of the order Tylenchida (Nematoda) In : Zuckerman , B.M., Mai , W.F. and Rohde , R . A. (Eds) **Plant parasitic nematode** , Academic press , New York and London , 1 : pp :191 –232.

Goodey, G.B. 1963. **Soil and fresh water Nematodes** (revised by J.B.Goodey) Methuen and Co. Ltd., London, 544 pp.

Goodey , T.1951. **Soil and fresh water Nematodes** . London , methuen , 390 pp.

Handoo , Z.A. and Golden, A.M. 1989. A key and Diagnostic compendium to the species of the Genus *Pratylenchus* Filipjev,1936 (Lesion Nematodes). **Journal of Nematology, 21**: 202 –218.

Handoo , Z.A.and Golden, A.M. 1992. A key and Diagnostic compendium to the species of the Genus *Hoplolaimus* Daday , 1905 (Nematoda :Hoplolaimidae). **Journal of Nematology, 24** : 45-53

Handoo, Z.A. 2000. A key and Diagonistic Compendium to the species of the Genus *Tylenchorhynchus* Cobb, 1913 (Nematoda: Belonolaimidae). **Journal of Nematology, 32**:20-34

*Hooper, D.J. 1978. The identification and biology of stunt nematodes (Tylenchorhynchidae) especially those of western Europe.**Manual, Rothamsted Experimental Station, Harpenden , England , part 2** , 1 –72.

*Hyman ,L.H.1951.The invertebrates Acanthrocephala, Aschelminthes and Entroprocta , **The Pseudocoelomate Bilateris . Vol .III**, Mcgraw Hills , New York 472 p

*Jairajpuri, M.S. 1982. Some studies on Tylenchorchychinae: The subgenus *Bitylenchus* Filipjev, 1934 with description of *Tylenchorchynchus* (*Bitylenchus*) *depressus* n.sp. and a key to species of Bitylenchus. **MededelingenVanden Berg de Fakulteit Landbouwwetenschappen, Rijksuniversiteit Gent, 47**: 765-770.

Jairajpuri, M.S. 1984. Some studies on Tylenchorchynchinae: proposal of *Divittus* n.g. (Nematoda: Tylenchida). **Systematic Parasitology, 6**:107-112.

Jairajpuri, M.S.and Hunt, D.J.(1984). The taxonomy of Tylenchorhynchinae (Nematoda: Tylenchida) with longitudinal lines and ridges. **Systematic Parasitology, 6**: 261-268.

Jepson , S.B. 1983. Identification of *Meloidogyne* : A general assessment and a comparison of male morphology using light microscopy , with a key to 24 species . **Revue de Nematology, 6** :291 –309.

Karseen ,G. and Hoenselaar, T.V. 1998. Revision of the Genus *Meloidogyne* Goeldi ,1892 (Nematoda : Heteroderidae) in Europe.**Nematologica, 44** : 713 – 788

*Krall , E.L.1978. Root parasitic nematode. Family Hoplolaimidae. **Academy of science of USSR** . Leningrad: Nauda Publishers (English translation from Russian)

Krisnaprasad,K.S.1992. Nematode pests of potato,pp-99-108. In: **Nematode pests of crops** (Eds. Bhatti, D.S. and Walia, R.K.), CBS Publishers and Distributors, Delhi.

Lewis, S.A. and Golden, A.M. 1981. Description of *Trineellus clathrocutis* n.g., n.sp. (Tylenchorhynchinae : Tylenchidae Thorne , 1949) with a key to the species and observations on *Tylenchorhynchus* sensu stricto. **Journal of Nematology, 13** : 135 –141.

*Loof, P.A.A. 1960. Taxonomic studies on the genus *Pratylenchus* (Nematoda). **T. Plziekt. 66**: 29-90.

*Loof, P.A.A. 1978. The genus *Pratylenchus* Filipjev,1936(Nematoda : Pratylenchidae) : A review of its anatomy morphology , distribution , systematics and identification. **Swedish University of Agricultural Science Research Information Centre, Uppasal,** Sweden, 50pp.

Luc, M. 1987. A reappraisal of Tylenchina (Nemata). 7. The family Pratylenchidae Thorne, 1949. **Revue de Nematology** 10:203-218.

Luc, M., Maggenti. A.R. and Fortuner.R.1988. A reappraisal of Tylenchina (Nemata). 9. The family Heteroderidae Filipjev and Schuurmans Stekhoven, 1941. **Revue de Nematology, 11**: 159-176.

Maggenti , A.1981. **General Nematology** . Springer Verlay, New York , 372pp

Maggenti, A.R. 1983 . Nematode higher classification as influence by species and family concepts , In : A. Stone , H.Platt and L.Khalil , (Eds.). **Concepts in Nematode Systematics** . Academic press, London , 25 –40 pp.

Mahajan,R. 1988. A conspectus of the genus *Tylenchorhynchus* Cobb, 1913 (Nematoda: Tylenchorhynchinae). **Indian Journal of Nematology, 18:** 199-206.

Mahajan, R. and Bella, A. 1986. *Divittus impar* (Ray and Das, 1983) nov. comb. *Merilinius djungaricus* (Razzhivin, 1974) nov. comb. and *Tylenchorhynchus eroshenkoi* (Eroshenka, 1980) nom. nov. (Nemata (Diesing , 1861,Potts , 1932) Maggenti,1981(Diesing,1861,Potts,1932) Maggenti, 1981: Tylenchida). **Revue de Nematology, 9**: 652.

*Menzel,R.1917. Zur Kenntnis der reilebenden Nematoden gattung *Hoplolaimus* Daday. **Rev.Suisse Zool., 25**: 153-162.

*Micoletzky, H. 1922, Die freilchbenden Erd-Nematoden. **Archiv. F. Naturgesch, 87**: 1-650.

Mulk, M.M. and Siddiqi, M.R. 1982. Three new species of Hyplolaimid nematodes from South America. **Indian Journal of Nematology, 12**:124-131.

*Mulvey, R.H. and Stone, A.R. 1976. Description of *Punctodera matadorensis* n.gen., n.p. (Nematoda: Heteroderidae) from Saskatchewan with lists of species and generic diagnoses of *Globodera* (n.rank), *Heterodera* and S*arisodera.* **Canadian Journal of Nematology, 554**: 772-785.

*Paramonov, A.A. 1967. A critical review of the sub order Tylenchinae (Filipjev, 1934) Nematoda: Secernentea. **Trudy gel' mint. Lab, 18**: 78-101 (In Russian).

Perry,G.1960.The subfamily Hoplolaiminae in Nematology, **Fundamentals and recent advances with emphasis on plant parasitic and soil forms** (Eds. Sasser , J.N. and Jenlins , W.R.) Eurasia Publishing House (P) Ltd.,Ramnagar , New Delhi –110055 185 – 190 pp.

*Perry ,V.G., Darling, H.M. and Thorne, G. 1959. Anatomy, taxonomy and control of certain spiral nematodes attacking blue grass in Wisconsin . **Bull. Wis . agric. Exp. Stn., 201** : 1-24.

Schindler , A.F.1961. A simple substitute for a Baermann funnel. **Plant Disease Reporter, 45** : 747 – 748

Seinhorst , J.W.1959. A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. **Nematologica, 4**: 67 –69.

Sher , S.A.1961 . Revision of the Hoplolaiminae (Nematoda) classification of nominal genera and species. **Nematologica, 6** : 155 –169.

Sher,S.A.1963a. Revision of Hoplolaiminae (Nematoda) II.*Hoplaimus* Daday , 1905 and *Aorolaimus* n.gen. **Nematologica, 9:** 267-295

Sher,S.A.1963b. Revision of Hoplolaiminae (Nematoda) III. *Scutellonema* Andrassy, 1958. **Nematologica, 9**: 421-443.

Sher, S.A. 1963c. Revision of Hoplolaiminae (Nematoda) IV, *Peltamigratus* n.gen. **Nematologica, 9**: 455-467

*Sher, S.A and Allen, M.W. 1953. Revision of the genus *Pratylenchus* (Nematoda: Tylenchidae). **Univ. Calif. Publ. Zool., 57**:441-470

*Siddiqi, M.R. 1963. On the classification of the Pratylenchidae (Thorne , 1949) *nov.grad.* (Nematoda: Tylenchida) with a description of *Zygotylenchus browni* nov.gen.et nov.sp.**Z.Parasitkde, 23**:390-396

Siddiqi, M.R. 1970. On the plant parasitic nematode genera *Merlinius* gen.n. and *Tylenchorhynchus* Cobb and the classification of the families Dolichoderidae and Belonolaimidae n.rank. **Proceedings of the Helminthological Society of Washington, 37**: 68-77.

Siddiqi, M.R. 1979. Taxonomy of plant nematode sub-family Meriliniinae Siddiqi, 1970, with description of *Merlinus processus* n. sp., *M. loofi* n.sp. and *Amplimerlinius globigerus* n.sp. from Europe. **Systematic Parasitology, 1**:43-60.

Siddiqi, M.R. 1986. Tylenchida, Parasites of plants and insects. **Commonwealth Agricultural Bureau**, Slough, U.K. 645 pp.

Skarbilovich, T.S. 1947. On the reorganisation of the systematics of the nematodes belonging to the family Anguillulinidae. Baylis and Daubney, 1926. **Dokl. Akad. Nauk. SSSR, 57**: 307-308 (In Russian)

Skarbilovich, T.S. 1959. On the structure of the systematics of the nematode order Tylenchida Thorne, 1949. **Acta Parasitol. Pol., 7**: 117 – 132.

Steiner, G. 1945. *Helicotylenchus* a new genus of plant parasitic nematodes and its relationship to *Rotylenchus* (Filipjev). **Proceedings of the Helminthological Society of Washington, 12** : 34-38

*Sturhan, D. 1966. Uber Verbreitung, Pathologenitat and Taxonomie der Nemato-dengathung *Tylenchorhynchus*. Mitteilungen aus der Biologischen Bundensanstalt fur Land. **Und Forstwirtschaft Berlin Dahlem, 118** : 82-99.

Subramanian, S., Balasubramanian, P., Rajeswarisundarababu, Naganathan, T.G., Lakshmanan, P.L., Rajendran, G., Sivakumar, C.V. and Sivagami Vadivelu. 1989. Present status of the potato cyst nematodes in the Nilgiris, Tamilnadu. **Current Science. 58**: 701-702.

Tarjan, A.C. 1973. A synopsis of genera and species in the Tylenchorhynchinae (Tylenchoidea : Nematoda). **Proceedings of the Helminthological Society of Washington, 40**: 123 –144

Thorne, G. 1961. **Principles of Nematology** . McGraw Hill New York and London, 553pp.

Thorne, G. 1949. On the classification of the Tylenchida, New order (Nematoda: Phasmidia). **Proceedings of the Helminthological Society of Washington, 16**: 37-73.

*Whitehead, A. G. 1968. Taxonomy of *Meloidogyne* (Nematoda: Heteroderidae) with descriptions of four new species. **Trans. Zool. Soc. Lond., 31**: 263 – 401.

*Wollenweber, H.W. 1923. Krankheiten und Beschadigungen der Kartoffel. **Arbeit der Forschungi Institut Kartoffel Berlin,** 7: 1-56.

Wouts, W.M. and Sher, S.A. 1971.The genera of the subfamily Heteroderinae (Nematoda : Tylenchoidea) with a description of two new genera. **Journal of Nematology, 3**: 129 – 144.

Wouts,W.M. 1972. A revision of the family Heteroderidae (Nematoda: Tylenchoidea) 1. The family Heteroderidae and its subfamilies. **Nematologica, 18:** 439-446.

Wouts, W.M. 1973. A revision of the family Heteroderidae (Nematoda : Tylenchoidea). III. The subfamily Ataloderinae. **Nematologica, 19**:279-284

Wouts, W.M. 1984. *Globodera zelandica* n. sp. (Nematoda: Heteroderidae) from New Zealand, with a key to the species of the genus *Globodera.* **New Zealand Journal of Zoology, 11**: 129-135.

Wouts, W.M. 1985. Phylogenetic classification of the family Heteroderidae (Nematoda: Tylenchida). **Systematic Parasitology. 7**: 295-328.

Wouts, W.M. 1973. A revision of the family Heteroderidae (Nematoda : Tylenchoidea). III. The subfamily Ataloderinae. **Nematologica, 19**:279-284

*Zhang, S.S and Weng, Z.M. 1991. Identification of root knot nematode species in Fuji. **Journal of Fuji Agricultural College, 20** :158 –160 pp.

* Originals not seen.