



Research Article

Description of Ten New Species Including Two New Genera of Nematodes (Nematoda) Associated with Economically Important Crops of Kashmir Valley, Jammu and Kashmir

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Abstract | During the survey of soil and plant-parasitic nematodes of vegetable and fruit crops of Kashmir valley, Jammu and Kashmir, ten new species including two new genera of following were recovered: *Fotedaronema kashmiriensis* gen. n. sp. nov., from soil around roots of *Pyrus communis* L. from Sonamarg, *Parasicagutter chitwoodi* gen. n. sp. nov., from soil around roots of *Pyrus malus* L. in Pattan, *Kochinema pahalgamiensis* sp. nov., from soil around roots of *Brassica oleraceae* from Pahalgam, *Kochinema kanganiensis* sp. nov., from soil around roots of *Lycopersicon esculentum* Miller, in Kangan, *Tylencholaimellus brassicus* sp. nov., from the roots of *Brassica oleraceae* var. *capitata* L. in Pulwama, *Tylencholaimus orientalis* sp. nov., from soil around roots of *Glycine max* (L.) Miller, in Handwara, *Longidorus goldeni* sp. nov., from soil around roots of *Prunus persica* in Sopore, *Mylonchulus shamimi* sp. nov., from soil around roots of *Pyrus communis* L. from Sonamarg, *Chronogaster anantnagiensis* sp. nov., from soil around roots of *Pyrus malus* L. in Anantnag, and *Chronogaster mustafaensis* sp. nov., from soil around roots of *Juglans regia* L. in Tral, Kashmir. Morphological and morphometric details, line drawings along with description, characteristics, and relationships of each new genus and species with its closely related genera and species are given.

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Introduction

Soil and root samples were collected and analyzed during a survey of soil and plant-parasitic nematodes of vegetable and fruit crops in Kashmir valley, Jammu and Kashmir to study the nematode fauna belonging to orders Dorylaimida, Plectida and Mononchida. During the surveys, several new species of these orders were encountered and are described and illustrated herein. The Dorylaimida order

includes several species that act as vectors and are responsible for transmitting soil born plant viruses, ultimately causing severe damage to crop of economic importance all over the world thus resulted in creating interest in the study of this group. The classification of this order was revised by several scientists (Siddiqi, 1969; Jairajpuri, 1969; Andr assy, 1976; Fotedar and Handoo, 1978) including the keys and additional reports recently provided by (Jairajpuri and Ahmad, 1992; Shah *et al.*, 2015, 2018; Esquivel *et al.*, 2011).

The following genera and species from Kashmir valley are described as follows: *Fotedaronema kashmiriensis* gen.n. sp. nov., recovered from soil around roots of *Pyrus communis* L. from Sonamarg, *Parasicagutter chitwoodi* gen. n. sp. nov., from soil around roots of *Pyrus malus* L. in Pattan, *Kochinema pahalgamiensis* from soil around roots of *Brassica oleraceae* from Pahalgam, *Kochinema kanganiensis* gen. n. sp. nov., from soil around roots of *Lycopersicum esculentum* Miller, in Kangan, *Tylencholaimellus brassicus* sp. nov., from the roots of *Brassica oleraceae* var. *capitata* L. in Pulwama, *Tylencholaimus orientalis* sp. nov., from soil around roots of *Glycine max* (L.) Miller, in Handwara, *Longidorus goldeni* sp. nov., from soil around roots of *Prunus persica* in Sopore, *Mylonchulus shamimi* sp. nov., from soil around roots of *Pyrus communis* L. from Sonamarg, *Chronogaster anantnagiensis* sp. nov., from soil around roots of *Pyrus malus* L. in Anantnag, and *Chronogaster mustafaensis* sp. nov., from soil around roots of *Juglans regia* L. in Tral, Kashmir.

This is one of the extensive report on nematodes known to be associated with several economically important vegetables and fruit crops of Kashmir valley, Jammu and Kashmir. A few earlier reports of nematodes in region dealt primarily with individual species (Fotedar and Handoo, 1974, 1977a, b, 1978, 1979a, b, 1980a; Fotedar and Kaul, 1986; Handoo, 1980a, b, 1983; Handoo and Shahin, 1980; Jairajpuri, 1964a, 1965; Waliullah, 1989). The objectives of this study were (1) to arrange a survey so as to more fully characterize, identify and describe nematodes associated with vegetable and fruit crops in Kashmir valley; (2) provide more extensive distribution of genera and species of nematodes, and (3) document their presence to establish their pest status that may have a significant impact on agriculture in the region.

Materials and Methods

Three-inch core soil and root samples were collected and analyzed during a survey of soil and plant-parasitic nematodes of vegetable and fruit crops in Kashmir valley, Jammu and Kashmir. Soil samples were collected from time to time from around the roots of fruit trees and vegetable crops. Samples from superficial layers were collected with the help of a borer having one inch bore. Usually, 3 to 4 inches deep samples from the field were combined and processed in the laboratory. Soil samples from deeper layers particularly in case of fruit trees were

collected by digging the ground with the help of a spade and soil collected with the trowel. Each sample consisted of 5-6 sub samples and the selection of samples was mainly from around the roots. A high number of nematode fauna was separated from soil by sieving and Baermann funnel extraction, fixed in 3% formaldehyde and processed to glycerin by the formalin glycerin method (Hooper, 1970). Line drawings were drawn while looking the specimens on a compound microscope with prism attached to 10x eye piece drawn at 100x objective. All measurements are in micrometers, unless otherwise mentioned.

Fotedaronema gen. nov.

Diagnosis: Belonidirinae. Body long and slender taking a strong ventral curvature. Cuticle thin, transversally striated. Head set off from the body by a deep constriction, disc like. Stylet short and thin measuring about one head width, lumen and stylet aperture fine. Basal extension of stylet symmetrical rod like. Amphid stirrup shaped. Anterior part of oesophagus thin and non-muscular, no swelling present at base of stylet extension. Posterior part of oesophagus bulbous, set off by deep constriction from the anterior tubular part. Cardia complex with three distinct cells (like the members of Nygolaimidae). A loose spiral sheath of muscles surrounds the basal bulbous part of the oesophagus. Intestine polycytic. Gonads amphidelphic symmetrical. Rectum about 1 anal body width in length. Tail dorsally convex-conoid with a sub-acute end.

Type and only species: *Fotedaronema kashmiriensis* gen. nov. sp. nov.

***Fotedaronema kashmiriensis* gen. n. sp. nov.** (Figure 1A-H)

Measurements

Female (Holotype): L= 0.90 mm, a= 49.5; b= 4.7; c= 29.1; c'= 2.8; V= 47%; stylet= 7 μ m, stylet extension= 5 μ m.

Female (8 paratypes): L= 0.77-0.90 mm; a= 38.5-49.5; b= 4.7-5.7; c=28.9-29.9; c'=2.1-3.1; V= 46-49 %; stylet = 7-8 μ m; stylet extension= 5-6 μ m.

Description

Female: When killed by hot water body assumes an open "C" shape. The arcuature of the body is more in the posterior third of body. Body slender, cylindrical

tapering at both the ends anteriorly from neck base to a set off head measuring about half the body width at base. Body cuticle thick interrupted by fine transverse striations. Lateral hypodermal chord arising as a thin streak in region of anterior tubular part of oesophagus which assumes a maximum width of $1/3^{\text{rd}}$ of body at mid body. Lateral hypodermal glands well developed measuring about $25\ \mu\text{m}$ posterior to vulva. Lip region set off by a deep constriction, cap like and measures $8 \times 4\ \mu\text{m}$ in dimension. Labial papillae very prominent projecting beyond the labial contour. Stoma with cuticularized inverted funnel. Guiding ring single and anteriorly located. Stylet symmetrical, short $7\ \mu\text{m}$ in length, its lumen about $1\ \mu\text{m}$ broad with a small aperture measuring about $1/6^{\text{th}}$ of stylet length. Stylet extension small rod like measuring $5\ \mu\text{m}$ in length, being slightly shorter than stylet. Anterior tubular part of oesophagus swollen in form of spindle behind base of extension. Oesophagus composed of an anterior tubular part and basal bulbous part, the former measuring $100\ \mu\text{m}$ in length, non-muscular and cylindrical. Nerve ring located at about $60\ \mu\text{m}$ from anterior end. Basal oesophageal bulb muscular, cylindrical and set off from anterior tubular part by a sudden deep constriction. There is a small isthmus like region which represents the modified distal part of the tubular oesophageal region. Small cuticularized plates present at the junction between 2 parts of oesophagus. Basal oesophageal bulb measures $75\ \mu\text{m}$ in length \times $11\ \mu\text{m}$ wide ($70\text{--}75 \times 11\text{--}13\ \mu\text{m}$ in paratypes) and is surrounded by a sheath. Five oesophageal gland nuclei are visible, unpaired dorsal and two pairs of sub-ventral gland nuclei lodged in the bulb along with their openings. Cardia complexed with distinct cells. Gonads didelphic opposed symmetrical, ovaries reflexed at oviduct.

Vulva a transverse slit. Vagina at right angles to body axis, extending to about $1/3^{\text{rd}}$ of body width across. Rectum about one anal body width in length. Pre-rectum not very much differentiated measuring about 2 rectal length from anus. Tail strongly dorsally curved measuring about 3 anal-body-width in length ending with a sub-acute rounded terminus.

Male: Not found.

Type specimens: Holotype (Female) on slide No. PN/FOT/3 in authors collection and paratype females on slide No: PN/ FOT/1-2 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Specimens were collected from soil around roots of *Pyrus communis* L. from Sonamarg, Kashmir.

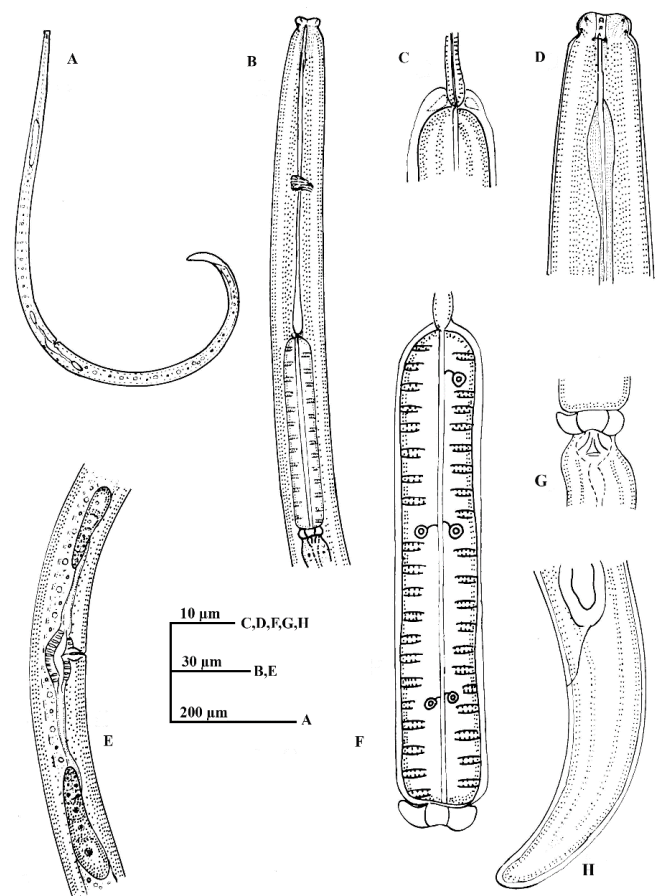


Figure 1: (A-H). *Fotedaronema kashmirensis* gen. n. sp. nov. Female. A: Entire body; B: Oesophageal region; C: Neck region showing junction between the two parts of oesophagus; D: Anterior region; E: Vulval region showing didelphic gonad, reflexed at oviduct; F: Basal oesophagus bulb; G: Complex nature of cardia with distinct cells; H: Tail region.

Diagnosis and relationship

Fotedaronema kashmiriensis gen. n. sp. nov. is distinctive by having a disc like set off head by deep constriction, presence of small isthmus like region, complex nature of cardia with three distinct cells and by the shape of tail ending into a subacute rounded terminus. However, it comes close to *Belondirella* Thorne 1964, *Yunqueus* Thorne 1964, *Durinema* Jairajpuri, 1966, *Bullaenema* Sauer, 1968 and *Axonchooides* Thorne, 1967, but differs from all the above genera by having a constriction between the anterior and posterior portion of oesophagus. It also comes close to *Axonchium* Cobb, 1920 and *Anchobelondira* Nair and Coomans, 1971. From *Axonchium* the n. gen. differs by the presence of isthmus like region between the two parts of oesophagus and by having two female gonads, while from *Anchobelondira* it differs by the shape of lip

region which is disc like set off by deep constriction, the presence of isthmus like region between two parts of oesophagus and shape of female tail.

In view of the above differences the present form is placed in a new genus for which the name *Fotedaronema* is proposed.

Etymology

The genus name is given in honor of Late Prof. Dr. D.N. Fotedar, former Head, Department of Zoology and Dean Faculty of Sciences, University of Jammu and Kashmir, for both his outstanding contributions to Parasitology and guidance as supervisor of the senior author's Ph. D work. The species name refers to the type locality Kashmir.

***Kochinema pahalgamensis* sp. nov. (Figure 2A-F)**

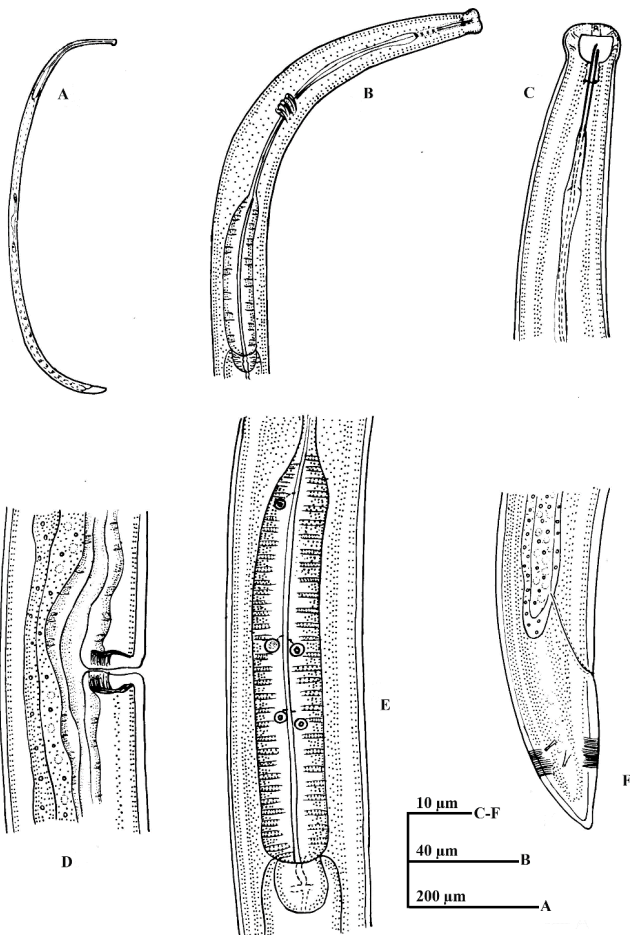


Figure 2: (A-F). *Kochinema pahalgamensis* sp. nov. Female: A: Entire body; B: Oesophageal region; C: Anterior region showing amphid; D: Vulval region; E: Posterior part of oesophagus showing basal bulb and cardia; F: Tail region.

Measurements

Female (Holotype): L= 0.65 mm; a= 32.5; b= 4.1; c=

29.5; stylet= 13 µm, stylet extension=9 µm;

Female (6 paratypes): L= 0.62-0.67 mm, a= 31.1 to 32.9; b= 4-4.8; c= 28.1-29.5; V = 47-49%, stylet=13-15 µm; stylet extension= 9-11 µm.

Description

Female: Nematodes, when killed body assumes an open “C” shape. Body slender, cylindrical tapering at both the ends, anteriorly from neck base to a knob like head which measures 2/3rd of body at neck base. Body cuticle interrupted by transverse striations. Amphid stirrup shaped, its aperture measuring 5 µm across i.e., about 55% of head width. Stoma weakly sclerotized, tubular, forming a stylet guide located at 10 µm from anterior end. Stylet slender measuring 13 µm in length, its lumen measuring 1 µm in width. Stylet extension simple rod like, measuring 9 µm in length. Oesophagus made up of two parts an anterior tubular slender part, measuring 84 µm in length which proximally in the region of stylet extension forms a spindle like swelling and distally expanding to form the basal oesophageal bulb which measures 60 µm in length, and having maximum width of 12 µm. Nerve ring located at 50 µm from anterior end. The five oesophageal gland nuclei and their openings are lodged in the basal oesophageal bulb. The unpaired dorsal oesophageal nuclei located at 7 µm whereas 1st pair of sub-ventral gland nuclei at 28 and 29 µm (right and left) and 2nd pair of sub-ventral gland nuclei at 37 and 39 µm from where the basal oesophageal bulb starts expanding. Cardia hemispherical measuring 8x8 µm in dimension.

Vulva, atransverse slit at 47%; vagina at right angles to body axis extending to 1/3rd of body across. Gonads didelphic and symmetrical. Ovaries reflexed at the oviduct and oocytes mostly arranged in single row except in zone of multiplication. Prerectum not differentiated. Rectum measuring about one anal body width in length. A small post-anal-blind sac present. Tail elongate conoid with a small protuberance at the tip, the former measuring a little less than 2 anal-body-widths in length. Two pairs of caudal pores present.

Male: Not found.

Type specimens: Holotype female on slide No.PN/KOC/3 in authors collection and paratype females on slide No: PN/KOC/1-2 deposited with the

Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around the roots of local cultivar (Hak) of *Brassica oleracea* from Pahalgam, Kashmir.

Diagnosis and relationship

Kochinema pahalgamiensis n. sp. is distinctive by having a knob like head, stirrup shaped amphid, hemispherical cardia, post anal blind sac and by the presence of an elongate conoid tail with a small protuberance. However, it comes close *K. proamphidium* Heyns, 1963, *K. tenue* Argor Van and den Berg, 1971 and *K. kanganiensis* n. sp. from *K. proamphidium* and *K. tenue*, the new species differs in the smaller body size and stylet, anteriorly located vulva (L= 0.82-0.98 mm; stylet= 25.8 µm; V= 56-59% in *K. proamphidium*; L=0.81-0.87. mm; stylet= 17 µm; V=55 % in *K. tenue*). From *K. kanganiensis*, the new species differs by having a smaller body and stylet, a posteriorly located and widely open vulva, and by the shape of cardia. In view of the above differences the present form is considered here to constitute the new species for which the name *K. pahalgamiensis* is proposed.

Etymology: The species name refers to the type locality Pahalgam.

***Kochinema kanganiensis* sp. nov. (Figure 3A-G)**

Measurements

Female (Holotype): L = 0.74 mm; a= 29.6, b= 4.7; c= 29.6; V= 44%; stylet= 20 µm; stylet extension= 16 µm.

Female (10 paratypes): L= 0.71-0.75 mm; a= 27.7-29.6; b= 4.3-5.1; c= 29.1-29.8; V= 43-45%; stylet= 20-23 µm; stylet extension=15-17 µm.

Description

Female: The body assumes an arc like shape on being killed by hot water. Body cuticle moderately thickened more so in the head and tail region. Body is cylindrical, tapering at both the ends anteriorly from neck base to form the head which is about 1/3rd body width at neck base, while posteriorly behind the vulva it has an elongated conoid tail. Cuticle finely transversally striated. Head expanded and knob like, set off by deep constriction from the adjacent body and measures 9x5 µm in dimension. Amphid funnel shaped located

anteriorly in the head region, its aperture measuring 4 µm across i.e., 44% of lip width. Stylet and its extension measuring 20 µm and 16 µm in length respectively, the latter being slightly smaller than the former, and rod like. Anterior part of oesophagus swelling in a spindle like shape, at the base of the extension, and thereafter becoming tubular measuring 120 µm in length being coiled distally and expands gradually to form the basal oesophageal bulb. The later measures 60 µm (55-70 µm in paratypes) long and 11 µm wide (10-14) µm in paratypes. Cardia well developed, elongate conoid (8-10 µm in paratypes). Five gland nuclei i.e., unpaired dorsal gland nucleus located at 13 µm from where the basal bulb starts expanding, the first pair of sub-ventral gland nuclei located at 36 and 37 µm, respectively (right and left) from where oesophagus starts expanding. Second pair of gland nuclei located at 54 µm where the oesophagus expands, their opening lie close to the gland nuclei.

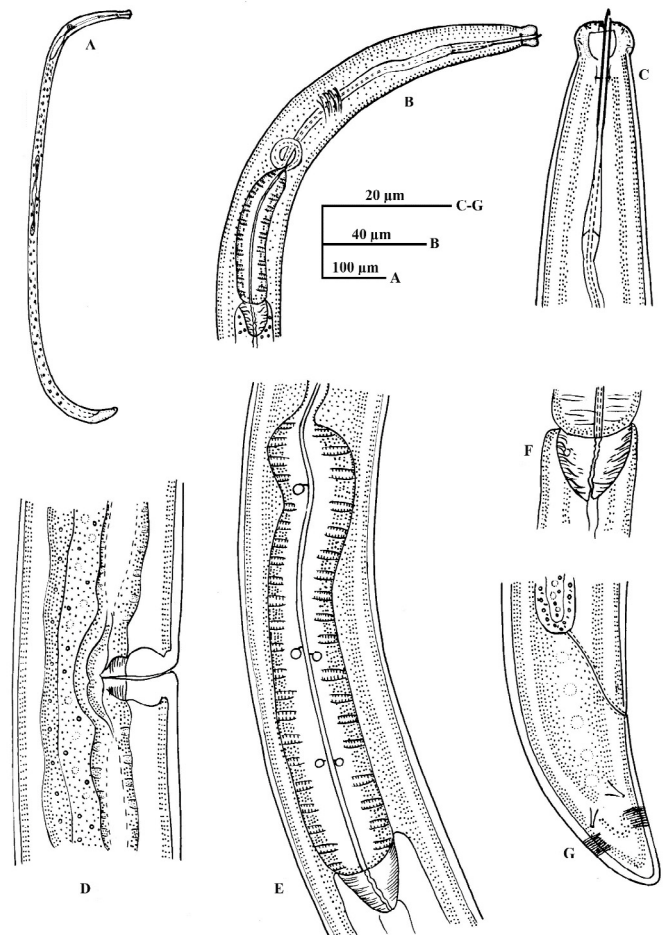


Figure 3: (A-G). *Kochinema kanganiensis* sp. nov. Female A: Entire body; B: Oesophageal region; C: Anterior region showing amphid; D: Vulval region; E: Basal bulb showing gland nuclei; F: Elongate conoid cardia; G: Tail region.

Vulva a transverse slit, vagina at right angles to body axis measuring a little less than 1/2 of body width

across. Female gonad paired, amphidelphic; ovaries reflexed at oviduct; oocytes mostly arranged in single row except the zone of multiplication. Rectum about 1 anal-body-width in length. Tail dorsally convex-conoid, measuring about one time the anal-body-width in length ending with a sub-acute rounded terminus bearing two pairs of caudal pores.

Male: Not found.

Type specimens: Holotype female on slide No. PN/KOC/6 in authors' collection and paratypes females on slide No. PN/KOC/4-5 deposited at the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Lycopersicon esculentum* Miller. From Kangan, Kashmir.

Diagnosis and relationship

Kochinema kanganiensis n. sp. is distinctive by having knob like set off head, funnel shaped amphid, well developed elongate conoid cardia and dorsally convex-conoid tail. However, it comes close to *K. tenue* Argo and Van den Berg, 1971 and *K. secutum* Siddiqi, 1965. From *K. tenue*, the new species differs by its smaller body, longer stylet and anteriorly located vulva (L=0.81-0.87 mm; stylet= 17 µm; V= 55% in *K. tenue*) while from *K. secutum* the present species differs by shorter body, longer spear and anteriorly located vulva (L= 1.03 mm; stylet= 15 µm; V= 53% in *K. secutum*). In view of the above differences the present form is considered here as a new species for which the name *K. kanganiensis* is proposed.

Etymology: The species name refers to the type locality Kangan.

***Parasicagutter* gen. nov.**

Diagnosis: Parasicagutterinae. Nematodes belonging to this genus are characterized by having the body almost straight, thick cuticle, interrupted by transverse striations. Lip region conoid smooth and continuous. Four cuticularized small platelets surround the oral opening. Amphid funnel like located at the base of the head, with fairly cuticularized aperture. Body cuticle in the anterior region of the head (near the head) exceptionally thickened. Stoma moderately cuticularized, inverted funnel like forming a single guiding ring. Stylet is robust measuring about 2 head widths in length, with its lumen about 1/7th

of stylet length in width; stylet extension less than two stylet length long, with a flanged base. Anterior part of oesophagus narrow, then expands generally to the main muscular part which is about 40% of total oesophageal length and lodges the five oesophageal gland nuclei and their openings. The dorsal oesophageal gland nucleus located almost at the level where the oesophagus starts expanding. Cardia large measuring about 30 µm in length, having distally a stem like projection which is jutting into the beginning of intestine. Pre-rectum differentiated, about two rectal length long. Vulva pre-equatorial in position; gonad single and posteriorly located, ovary reflexed. Tail long and filiform with a protoplasmic core running till the tip.

Type and only species *Parasicagutter chitwoodi* gen. n. sp. nov.

***Parasicagutter chitwoodi* gen. n. sp. nov.**
(Figure 4A-G)

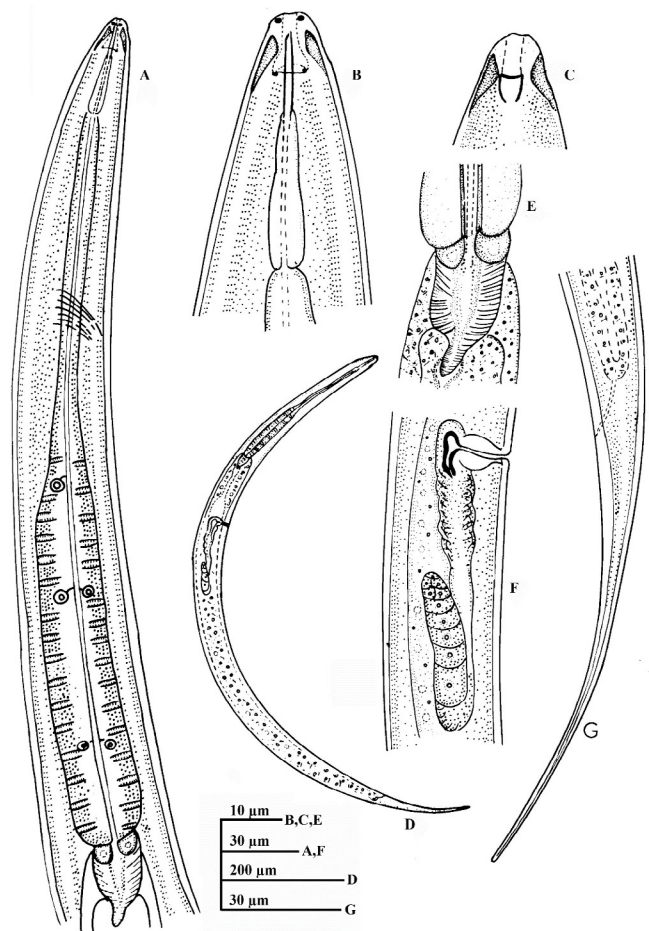


Figure 4: (A-G). *Parasicagutter chitwoodi* gen. n. sp. nov. Female. A: Oesophagel region; B: Anterior region; C: Amphid showing sclerotization; D: Entire body; E: Cardia showing stem like projection jutting into intestine; F: Vulval region showing posterior gonad reflexed at oviduct; G: Tail region.

Measurements

Female (Holotype): L= 1.2 mm; a= 26; b= 4.3; c= 9.7; V= 34%; stylet= 13 μ m.; stylet extension= 24 μ m.

Female (8 paratypes): L= 1.1-1.5 mm; a= 25.3-27.7; b= 4.3-5.1; c= 9.6-9.9; V= 32-34%; stylet= 13-14 μ m; stylet extension 24-25 μ m.

Description

Female: When killed the nematodes assume a slightly ventrally curved posture (body straight in some paratypes). Body robust, cylindrical, distinctly transversally striated throughout its length. Body cuticle thick, special thickenings present below the head. Head continuous, low and round measuring 6 μ m across, with four cuticularized platelets surrounding the oral aperture. Labial papillae indistinct. Stoma weakly developed, inverted funnel like, extending up to 9 μ m from anterior end and forming a single guiding ring. Stylet asymmetrical, 13 μ m in length and with its lumen 2 μ m broad. Stylet extension flanged, measuring 24 μ m in length. Anterior tubular part of oesophagus measures about 211 μ m in length and expands gently at its distal end to form the cylindrical basal oesophageal bulb which measures 142 μ m in length having a maximum width of 25 μ m. Dorsal oesophageal gland nucleus almost at the level where the basal bulb starts expanding, whereas the first pair of sub-ventral gland nuclei located anterior to the middle of bulb and posterior pair of sub-ventral gland nuclei is situated in the posterior 3rd of bulb. The gland opening lies close to the gland nuclei. Oesophago-intestinal junction well marked. Cardia large, measures about 30 μ m in length having distally a stem like projection which is protruding in the beginning of intestine.

Vulva a transverse slit located at 33% of body length. Gonad single, posterior ovary reflexed at oviduct arranged in double row in zone of reproduction while a single row in zone of maturation. Uterine-sac anterior, small and rudimentary. Vagina extending little less than half of vulval body width into the body. Tail filiform gradually narrowing and measuring 9 anal-body widths in length. Tail terminus finely rounded.

Male: Not found.

Type specimens: Holotype female on slide No. PN/ PAR/3 in authors collection and paratype females on

slide No. PN/PAR/1-2 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Pyrus malus* L. Pattan, Kashmir.

Diagnosis and relationship

The new genus *Parasicagutter* resembles *Pungentus* Thorne and Swanger, 1936, *Thornenema* Andr ssy, 1959 and *Sicagutter* Siddiqi, 1971. From *Pungentus*, n. genus differs in the shape of lip region, shape of amphid, number of guiding ring and by the presence of lateral cuticularization below the head. Head offset by sharp constriction, guiding ring double, amphid stirrup shaped, cuticularization absent below the head in *Pungentus*. From *Thornenema* the present genus differs by the thick cuticularization below the head. The new genus however, comes close to *Sicagutter* from which it differs by having asymmetrical stylet, flanged extension, large and complexed cardia and by the single gonad. It also comes close to *Indodorylaimus* Prabha and Ali, 1973 but can be distinguished by the striated nature of body cuticle, presence of four cuticularized platelets around the oral aperture, asymmetrical stylet, flanged extension and by the long and complex nature of cardia. In view of the above differences, the present form *Parasicagutter chitwoodi* sp. nov. is distinct and a new genus *Parasicagutter* is proposed to accommodate the new species.

Etymology: The species name is given in honor of Dr. D.J. Chitwood, former Research Leader of Nematology and then Mycology and Nematology Genetic Diversity and Biology Laboratory, USDA, ARS, Northeast Area, Beltsville, Maryland, USA for his outstanding contribution to Nematology.

Tylencholaimellus brassicus sp. nov. (Figure 5A-F)*Measurements*

Female (Holotype): L= 0.53 mm; a= 21.2; b= 4.1; c= 21.0; stylet= 10 μ m; stylet extension= 9 μ m V= 41%.

Female (8 paratypes): L= 0.50-0.59 mm; a= 20.2-22.3; b= 3.9-4.7; c= 20.3-22.7; V= 38-40%; stylet= 9 μ m; stylet extension= 10 μ m.

Description

Female: Body almost straight in the anterior half of its length with a slight ventral curvature in the posterior

3rd region. Body cuticle, distinctly transversally striated and having a radial element in the tail region. Cuticle thick made up of 3 layers getting very much thickened at the tail terminus, the inner most layer being two and a half microns thick. Body tapering at either ends, anteriorly from neck base to a slightly set off head measuring a little less than one fourth of the body at neck base. Lateral hypodermal chord arising as a thin stria below the stylet extension assuming a maximum width of one fifth of body at mid body. Lateral pores arranged generally in lip region thereafter arrangement becomes irregular. Head angular, in outline with distinctly projecting outer circlet of papillae giving a faint suggestion of labial disc. Head measuring 6 μ m x 2 μ m in dimension, stoma weakly cuticularized tubular, guiding ring single located at 4 μ m from head end. Stylet measuring 10 μ m in length with its aperture measure 2.5 μ m i.e. one fourth of stylet length. A distinct dorsal siphon present. Stylet extension measuring 10 μ m having a small flange like knobs at its base. Oesophagus consists of 2 parts. The anterior part tubular, non-muscular, measuring 90 μ m in length, encircled by nerve ring located 60 μ m from anterior end. Hemizonid present. Basal oesophageal bulb measures 20 x 10 μ m in dimension, set off by constriction from anterior tubular part. Cardia rounded. Intestine oligocytus having a broad lumen, running throughout its entire length. Pre-rectum distinct and well-marked measuring 73 μ m in length i.e., 5.6 times the anal-body width in length.

Vulva a depressed transverse slit. Vagina wall distinctly cuticularized, with vagina extending up to about half of vulva body-width across. Gonad single, posterior ovary reflexed at oviduct, with anterior end extending up to the vagina. Anterior uterine branch small and rudimentary. Rectum measures 13 μ m in length, being slightly less than one anal body width in length. Tail cylindrical mostly clavate, measuring 23 μ m in length i.e., 1.4 times the anal body width in length, with two pairs of caudal pores.

Male: Not found.

Type specimens: Holotype female on slide no. PN/IYL/C in authors collection and paratype females on slide No. PN/TYL/A deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Brassica oleracea* var. *capitata* L. from Pulwama,

Kashmir.

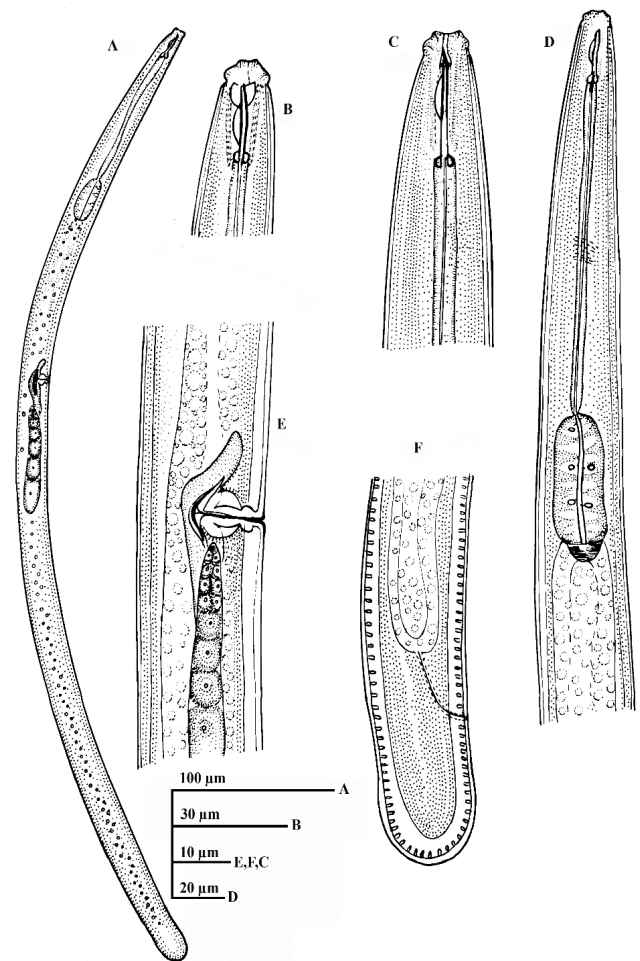


Figure 5: (A-F). *Tylencholaimellus brassicus* sp. nov. Female. A: Entire body; B: Anterior region showing amphid; C: Neck region; D: Oesophageal region showing posterior gonad reflexed at oviduct; E: Vulval region showing posterior gonad reflexed at oviduct; F: Tail region.

Diagnosis and relationship

Tylencholaimellus brassicus n. sp. is distinctive from all the nominal species of genus *Tylencholaimellus* by having a head angular in outline with distinctly projecting outer circlet of papillae giving a faint indication of labial disc, presence of a dorsal stiphin, conoid rounded cardia and clavate rounded tail. However, it comes close to *T. rotundoconicus* Kmuzova, 1966 and *T. eskei* Siddiqi and Khan, 1964. From the former, the new species differs by having a smaller stylet, stylet extension ratio (stylet extension equal in length) and shape of tail (clavate rounded in present species). Stylet measures 9.14 μ m and stylet extension 6.8 μ m with a conoid rounded tail in *T. rotundoconicus*. From *T. eskei*, the new species differs by smaller spear extension, position of vulva and longer and differently shaped tail (stylet= 17-19 μ m, V= 33-37%; c= 24-28; tail conoid rounded in *T. eskei*).

In view of the above differences the present form is considered here a new species for which the name *T. brassicus* is proposed.

***Tylencholaimus orientalis* sp. nov.**
(Figure 6A-E)

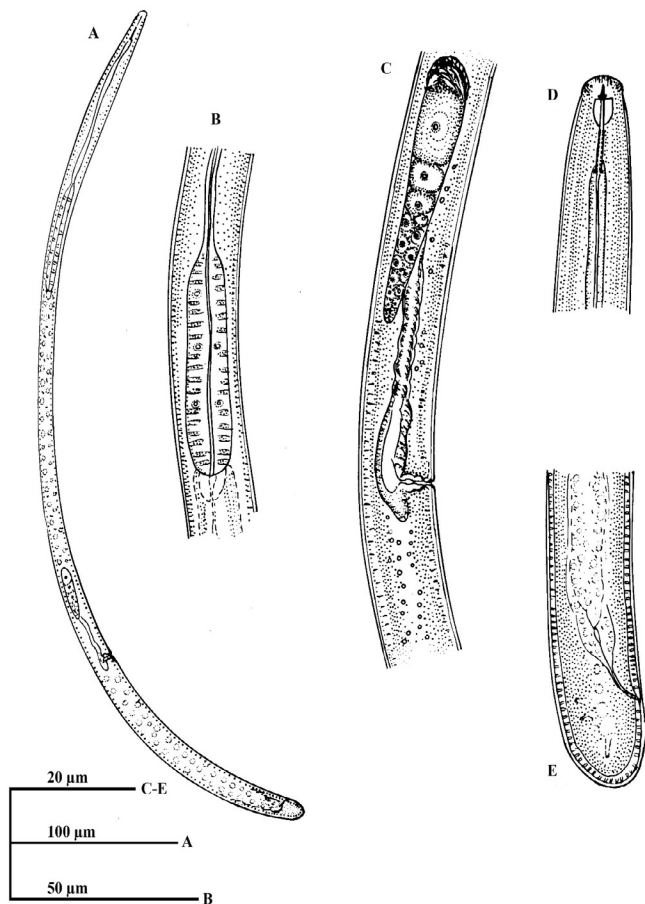


Figure 6: (A-E). *Tylencholaimus orientalis* sp. nov. Female A: Entire body; B: Posterior end of oesophagus; C: Vulval region showing anterior ovary, reflexed; D: Anterior end showing amphid; E: Tail region.

Measurements

Female (Holotype): L= 0.48 mm; a= 26.6; b= 3; c= 40; V= 75%; stylet= 7µm; stylet extension= 7µm.

Female (13 paratypes): L= 0.45-0.49 mm; a= 24.7-6.9; b= 3-4.1; c= 36-41; V= 72-76%; stylet= 7-9µm; stylet extension= 7-8µm.

Description

When killed in 3% formaldehyde, nematodes assume a ventrally arcuate shape. Body short and slender. Body cuticle coarsely striated with distinct radial elements. Lateral hypodermal chord originating in region of stylet base and assumes a maximum width of about half of body width at mid body. Lip region is almost continuous, with slight depression at the adjoining

neck measuring 6 x 3µm in dimension. Stoma weakly sclerotized forming a single stylet guiding ring located at 4µm from anterior end. Amphid stirrup shaped, its apertures measuring 3µm across i.e., 50% of lip width. Sensillar sac is located at 14µm from anterior end. Stylet slender, measuring 7µm in length, stylet extension is simple rod like, its length being equal to stylet and distally provided with slight thickening at base. Oesophagus with an anterior slight tubular part measuring 90 µm in length with the reduced musculature expanding gradually at its base into a cylindrical basal oesophageal bulb, the latter measuring 63 µm in length i.e., 39% of the bulb. Cardia conoid rounded. Intestine has a distinct lumen. Pre-rectum not found. Gonad single, anteriorly located and ovary reflexed in the oviduct. Ovocytes mostly arranged in single rows. Vagina sigmoid, distinctly cuticularized pushing up to half of body width into the body. Post uterine sac absent. Rectum slightly longer than half of anal body width in length. Tail cylindrical with hemispherical terminus measuring 12µm in length, being slightly longer than anal body width, 2 pairs of caudal pores present.

Male: Not found.

Type specimens: Holotype female on slide No. PN/Tyl/14 in authors collection and paratype females on slide No. PN/Tyl/11-13 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Glycine max* L. from Handwara, Kashmir.

Diagnosis and relationship

Tylencholaimus orientalis n. sp. is distinctive by having body length from 0.45-0.49 mm, stylet= 7-9µm, stylet extension 7-8µm, V= 72-76%; stirrup shaped amphid; cardia conoid rounded, tail cylindrical with hemispherical terminus. However, it comes close to *T. minimus* De Man, 1876 and *T. pusillus* Loof and Jairajpuri, 1968, from the former the new species differs by having slightly set off lip region and smaller body, while from *T. pusillus* by longer body and stylet, shape of lip region, shorter tail and presence of distinct radial striae (L= 0.34-0.40 mm; c= 24-28; lip region deeply set off; stylet and extension 5-6 µm and 4-5 µm, respectively and radial striae absent in *T. pusillus*). In view of the above differences the present form is considered a new species for which the name *Tylencholaimus orientalis* sp. nov. is proposed.

***Longidorus goldeni* sp. nov.**
(Figure 7A-E)

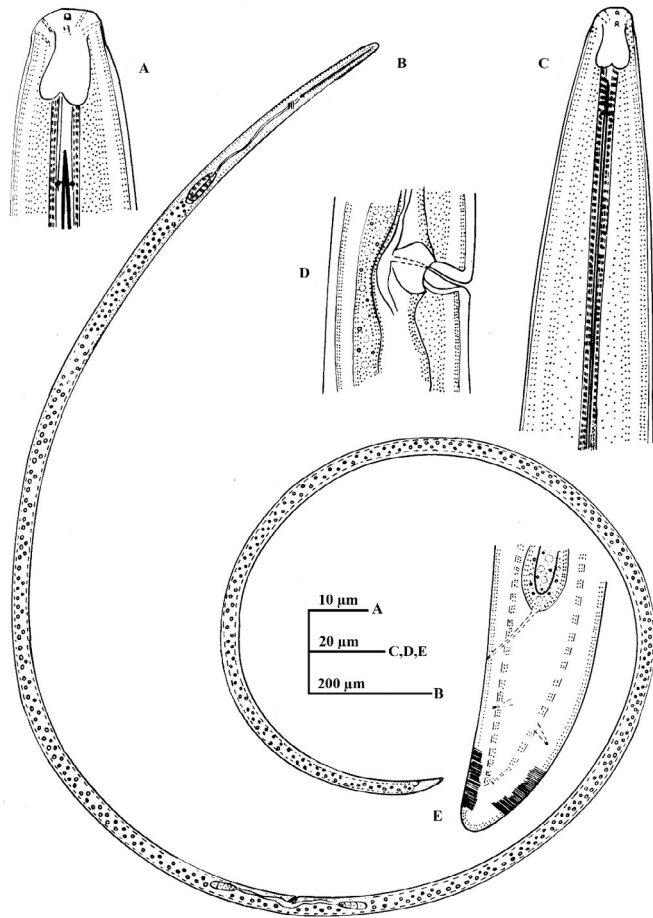


Figure 7: (A-E). *Longidorus goldeni* sp. nov. Female. A: Anterior region showing amphid; B: Entire body; C: Anterior region showing amphid; D: Vulval region; E: Tail region.

Measurements

Female (Holotype): L= 4.1 mm; a= 120; b= 10.5, c = 92; V= 45%; stylet= 95 µm, stylet extension= 50 µm.

Female (6 paratypes): L= 4.1-4.5 mm; a= 120-125; b= 9-10.5; c= 92-95; V= 44-46%, stylet= 95-100 µm, stylet extension 50-55 µm.

Description

Female: When relaxed in hot water nematodes assume a strong ventral arcuature especially in the posterior 3rd of body, the body shape often assuming the form of single or double spiral. Body long and slender, tapering anteriorly from base of neck to a continuous rounded head, which is about 1/3rd of body width at base of oesophagus whereas posteriorly to a cylindrical and elongated tail. Lateral body pores present throughout the length of body, leading into hypodermal pouches, which are arranged serially in the neck region while becoming irregular in the rest

of body. Dorsal and ventral pores not seen. Lateral hypodermal chord arising as a thin streak in region of stylet extension and continues to entire body length assuming a maximum width of 1/3rd of body. Stylet 95 µm. Body cuticle thick made up of 3 layers, becoming quite distinct in region of head and tail. Faint transverse striations are interrupting the body cuticle throughout. Lip region continuous rounded, measuring 12µm x 5µm in dimension. Amphid bilobed and slightly asymmetrical. Amphidial aperture minute. Sclerotization of stoma weak, guiding ring located at about 30 microns from anterior end i.e., 2.5 times lip width from anterior end. Oesophagus with a long cylindrical slender, non-muscular tubular part expanding posteriorly to a setoff basal oesophageal bulb, the latter lodging the dorsal and the first pair of sub ventral gland nuclei and the openings of dorsal and sub ventral glands (the posterior sub-ventral gland nuclei absent). Nerve ring located at 175 µm from anterior end. Cardia conoid rounded. Oesophago-intestinal junction well marked. Vulva, a transverse slit. Vagina inclined extending to half the body width across. Uterus with a thick muscular distal part. Gonads didelphic, opposed, reflexed. Oocytes mostly arranged in single row except in the zone of multiplication. Rectum shorter than one anal-body width in length. Tail elongate cylindrical, slightly, dorsally curved measuring about 45 µm in length i.e., 1.7 anal-body widths long ending with a rounded terminus. Two pairs of caudal pores present.

Male: Not found.

Type specimens: Holotype female on slide No. PN/LON/3 in authors collection and paratype females on slide No. PN/LON/1-2 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Prunus persica* L. from Sopore, Kashmir.

Diagnosis and relationship

Longidorus goldeni sp. nov. is distinctive by having a long and slender body, stylet measuring 95-100 µm with its extension equal to about half of the stylet length, presence of conoid rounded cardia and by having an elongate cylindrical tail with two pairs of caudal pores. However, the new species comes close to *Longidorus mirus* Khan *et al.*, 1971 and *Longidorus nirulai* Siddiqi, 1965. From *L. mirus* it differs by having longer and slender body, long stylet and extension, shape of the

vagina and longer rectum ($L= 3-3.6$ mm; $a= 70-90$; stylet= $75-85$ μm ; stylet extension= $40-50$ μm , vagina at right angles to body axis and rectum $1/2$ of anal-body width in length in *L. mirus*). From *L. nirulai* the present species can easily be differentiated by shorter stylet, extension length and shape of female tail and the absence of males (stylet= $100-160\mu\text{m}$, stylet extension $62-68$ μm ; $c= 54-66$; tail subconoid, subdigitate and males present in *L. nirulai*). In view of the above differences the present form is considered here to constitute a new species for which the name *Longidorus goldeni* is proposed.

Etymology: The species name is given in honor of Dr. A.M. Golden for his outstanding contribution to Nematology and for the guidance he provided to senior author while working with him in his Laboratory as well as he also established Nematode Taxonomy Program and USDA Nematode Collection at Beltsville, Maryland, USA.

***Mylonchulus shamimi* sp. nov.**
(Figure 8A-E)

Measurements

Female (Holotype): $L = 0.95$ mm; $a = 23.7$; $b = 2.9$; $c = 39.5$; $V = 67\%$.

Female (10 paratypes): $L = 0.93-0.96$ mm, $a = 23.1-25.3$; $b = 2.7-2.9$; $c = 37-39.5$; $V = 67-69\%$.

Description

Female: Nematodes when killed in hot water, assume an almost straight shape in the anterior two third of the body whereas in the posterior 3rd body region getting strongly ventrally arcuate. Body tapering only slightly anteriorly from the head which is about $2/3^{\text{rd}}$ as wide as body at base of neck. Body cuticle thick, smooth, getting more thicker in the region of head and tail. Lip region only slightly set off rounded in outline measuring 22×6 μm in dimension with labial papillae projecting well beyond the contour. Stoma almost oval with pointed base and measuring 26×13 μm in dimension. Dorsal tooth large, anterior edge concave and the posterior edge convex merging into the stoma at about middle of stomal length. Apex of tooth extending to almost anterior half of stoma. Sub ventral denticles fairly distinct, equal in size, and arranged in six rows. Posterior 3rd of stoma embedded in anterior portion of oesophagus. Oesophagus narrowing slightly to nerve ring, the

latter located at about $118\mu\text{m}$ from anterior end. The oesophagus gradually widens towards base behind the nerve ring. Oesophago-intestinal junction non-tuberculate. Intestine with wide lumen and provided with numerous refractive granules.

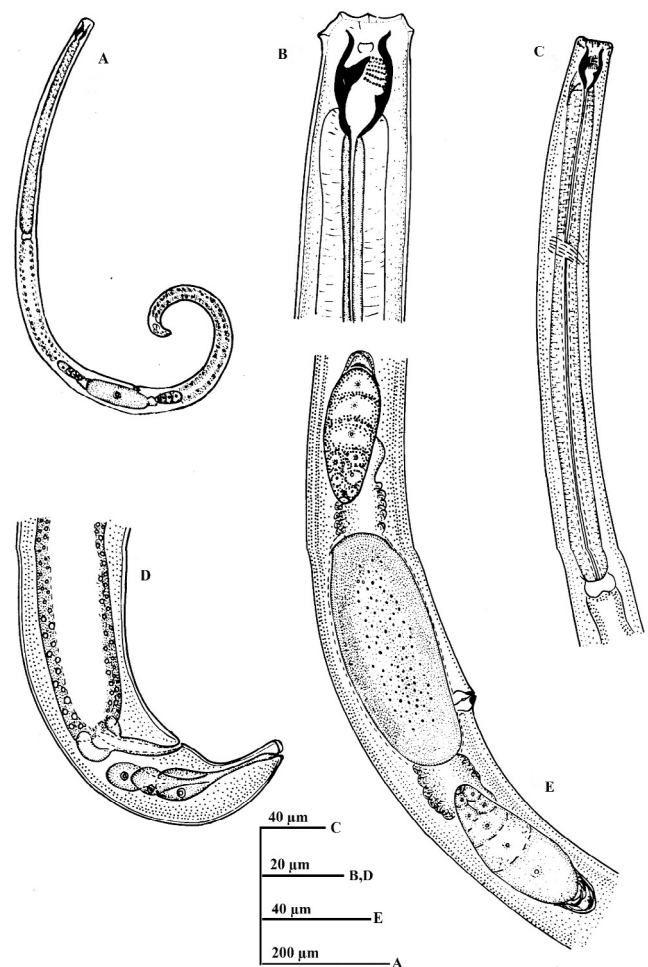


Figure 8: (A-E). *Mylonchulus shamimi* sp. nov. Female. A: Entire body; B: Anterior region; C: Oesophageal region; D: Tail region; E: Vulval region showing reflexed ovary.

Vulva, a transverse slit, post equatorial with slightly thickened lips. Vagina with sclerotization stretching across about one fifth of vulval body width. Uteri paired, opposed outstretched, ovaries reflexed up to the vulval region. Eggs measuring 90×38 μm in dimension. Sperms not observed in the gonad. Rectum sigmoid measuring about $14\mu\text{m}$ in length. Gonads amphidelphic. Caudal glands in tandem. Spinneret sub terminal, opening on the dorsal side of tail. Tail strongly dorsally curved tapering to a sub-acute rounded terminus.

Male: Not found.

Type specimens: Holotype female on slide no. PN/MYL/3 in authors collection and paratype females on

slide no. PN/MYL/1-2 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around roots of *Pyrus communis* L. from Sonamarg, Kashmir.

Diagnosis and relationship

Mylonchulus shamimi sp. nov. is distinctive by having lip region continuous with very faint depressions, large dorsal tooth with anterior edge concave while posterior edge convex, vulva with slightly raised lips and by the presence of caudal gland and spinnert on tail. However, it comes close to *M. nainitalensis* [Jairajpuri, 1970](#) and *M. agriculturae* [Coetzee, 1967](#). From *M. nainitalensis* the present species differs by longer body and oesophagus and posteriorly located vulva (L= 0.80-0.88 mm; a= 27-30; b= 3.2; V= 63% in *M. nainitalensis*). From *M. agriculturae* it can easily be differentiated by the value of a, b, c, position of vulva and by having comparatively smaller body (L= 1 mm; a= 28.3; b= 3.5; c= 23.6 and V= 57.4 % in *M. agriculturae*). In view of the above differences the present species is considered here to constitute a new species for which the name *M. shamimi* is proposed.

Etymology: The species name is given in honor of Dr. Shamim Jairajpuri, former Head, Section of Nematology, Department of Zoology, Aligarh Muslim University, Aligarh, and Vice Chancellor of Maulana Azad National Urdu University, Hyderabad, India for his outstanding contribution to Nematology and for the Lab facilities and help provided to the senior author at Aligarh Muslim University, Aligarh, India during the beginning of his Ph. D work.

***Chronogaster anantnagiensis* sp. nov. (Figure 9A-F)**

Measurements

Female (Holotype): L= 1.2 mm; a= 41; b= 4; c= 7.6; V= 52%.

Female (7 paratypes): L= 1.1-1.3 mm; a= 41-46; b= 4-4.4; c= 7.5-9; V = 50-52%.

Description

Female: When killed by hot water body assumes an open “C” shape. Body cylindrical, tapering at both the ends from the base of neck to a conoid un-striated lip region, which measures 1/3rd of body width at base of oesophageal bulb. Lateral fields not marked.

Transverse annulation of the cuticle measures 2.2 µm at the base of the neck and 2.3 µm apart at mid body. First annule below lip region, narrower than the succeeding annules. Crystalloids in the body cavity present especially prominent in the neck region. Lip region conoid, anteriorly flattened measuring 9 x 5 µm in dimension; no striations in lip region. Amphidial aperture an oval slit located at 6 µm below anterior end of body and measures 5 µm across. Four slender and curved forwards cephalic setae measuring 5 µm long i.e., have shorter than the head width and located in the first annule. Mouth cavity in two parts, anterior one measuring 7 x 3 µm in dimension, the posterior part narrow, measuring about 26 µm long separated from oesophageal lumen by an extension. Oesophagus a cylindrical tube measuring about 220 µm in length thereafter it expands to an oval bulbous part measuring 20 x 13 µm in dimension. Oesophagus lumen has two sections, the anterior one serrated bearing about 7 denticles, the posterior bulbal prolongation of oesophagus is about 34 µm in length i.e., 1.4 times as long as the bulb. Nerve ring located at about 130 µm from anterior end. Excretory pore located at 145 µm from anterior end. Hemizonid not present.

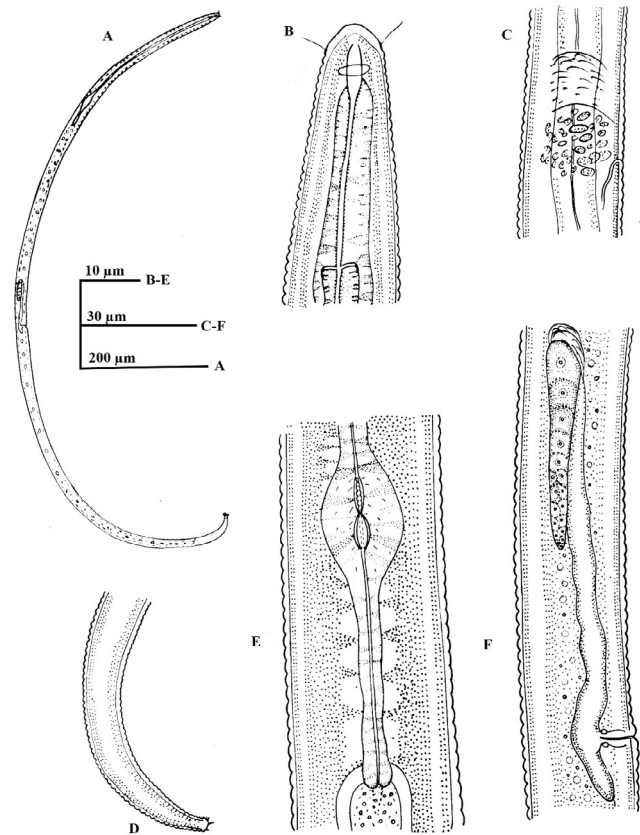


Figure 9: (A-F). *Chronogaster anantnagiensis* sp. nov. Female. A: Entire body; B: Anterior end showing amphid; C: Neck region showing crystalloids; D: Posterior region; E: Posterior part of oesophagus; F: Vulval region showing anterior reflexed ovary.

Vulva, a depressed inconspicuous transverse slit, vagina extending to more than one third of body width into the body. Gonad single anterior, ovary reflexed at the oviduct. Posterior uterine sac present, measuring more than half vulval body widths in length. Tail dorsally curved, uniformly striated till the tip measures 9 times anal body width in length with obtusely rounded terminus bearing four mucro of which the lateral mucro is slightly larger than the others. Caudal gland and spinneret absent.

Male: Not found.

Type specimens: Holotype female on slide no. PN/CHR/3 in authors collection and paratype females on slide no. PN/CHR/1-2 deposited in the Department of Zoology, University of Kashmir.

Type of host and locality Collected from around roots of *Pyrus malus* L. from Anantnag, Kasmir.

Diagnosis and relationship

Chronoaster anantnagiensis n. sp. is distinctive by having the above-mentioned characters. However, it comes close to *C. andrassyi* Loof and Jairajpuri, 1965; *C. serrulata* Loof, 1973 and *C. typica* De Man, 1921. From *C. andrassyi* the present species differs by the absence of longitudinal striations on lip region and presence of crystalloids and by the presence of posterior uterine branch (longitudinal striation on lip present, crystalloid and post uterine branch absent in *C. andrassyi*). From *C. serrulata* the new species differs by anteriorly located vulva, longer tail which is not notched terminally bearing three mucro (one large and two small). Vulva percentage between 52-57%, $c = 9.1-10.6$ and tail emarginated terminally with one large mucro bent ventrally and showing small thorns on its dorsal side in *C. serrulata*. The new species can easily be differentiated from *C. typica* by the shape of head, broader amphidial aperture, longer post bulbar along prolongation and the number of mucro on tail tip. Truncate flat head, amphidial aperture small, post bulbar elongation equal or shorter than bulb and tail tip with single mucro in *C. typica*. In view of the above differences the present species is considered to constitute a new species for which the name *C. anantnagiensis* is proposed.

Etymology: The species name refers to the type locality Anantnag.

Chronogaster mustafaensis sp. nov.

(Figure 10A-H)

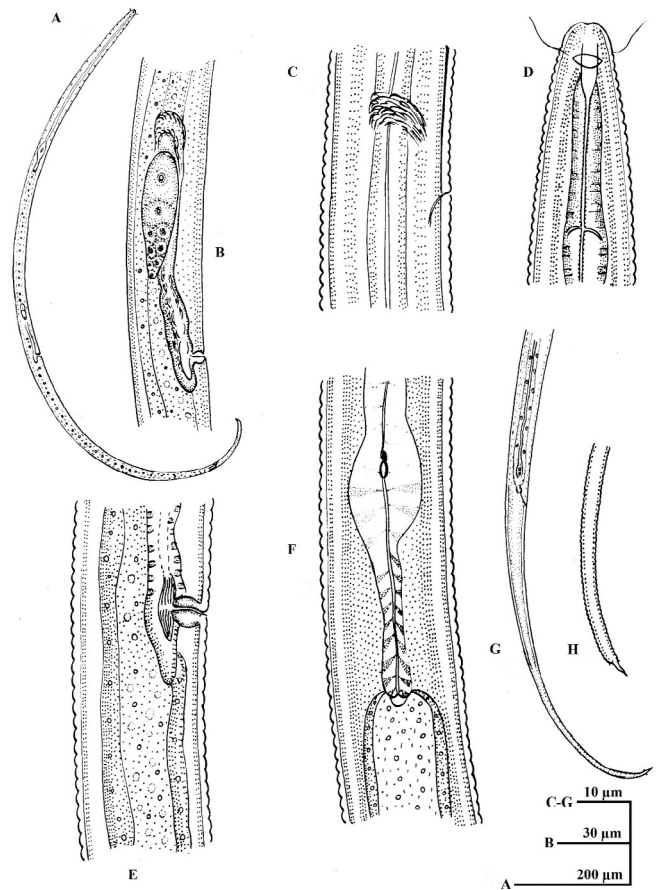


Figure 10: (A-H). *Chronogaster mustafaensis* sp. nov. Female. A: Entire body; B: Vulval region showing anterior reflexed ovary; C: Neck region showing nerve ring and excretory pore; D: Anterior region showing amphid; E: Vulval region; F: Posterior part of oesophagus; G: Tail region; H: Tail terminus- with one large mucro and two small spines.

Measurements

Female (Holotype): L= 1.1mm; a= 33; b= 3; c= 4.8; V= 54%.

Female (8 paratypes): L= 1-1.1mm; a= 34-36; b= 3-4; c= 4.8-5.1; V= 54-55%.

Description

Female: When killed, nematodes assume a strongly ventrally arcuate shape especially in the posterior 3rd region of the body. Body tapers at either ends, anteriorly from neck base to a hemispherical continuous head having slightly depressed sides, head being less than 1/3rd of body at base of oesophagus. Lateral field absent. Body cuticle coarsely annulated, the first body annule just below the head measures one micron apart and is considerably narrower than the succeeding body annules. The width in anterior

region of neck is about 1.9 μm apart. At base of neck it is 2 μm apart and reduced to about 1.8 μm wide in the ventral region. Head dome shaped, measuring 9 x 4 μm in dimension, its width being 39% of body width at neck base. There are no transverse and longitudinal striations on the lip. Four cephalic setae measuring 9 μm in length are slightly larger than the lip width. Amphid with oval curved transverse slits, measuring 5 μm across and located at about 4 μm from anterior end i.e., at the level of the 1st and 2nd body annule. Mouth cavity has two parts, the anterior one sub-cylindrical measuring 9 x 3 μm in dimension, the posterior part narrow measuring about 20 μm long, separated from oesophageal lumen by an expansion. Oesophagus cylindrical tube anteriorly widening in a spindle shape in the region of the narrower part where oesophageal lumen gets expanded. The anterior tubular part of oesophagus measures about 220 μm in length distally getting expanded into an oval bulbous part, the latter measuring 22 x 12 μm in dimension. The post bulbal prolongation of oesophagus about 24 μm in length i.e., about 1.1 times as long as the bulbous part. Nerve ring located at 5 to 8 annules anterior to excretory pore. Excretory pore situated about 8 annules posterior to nerve ring. Hemizonid absent. Excretory duct not cuticularized. Vulva an inconspicuous transverse slit. Vagina extending to one fourth of vulva body width across. Gonad single anterior, ovary reflexed at the oviduct. Posterior vulval sac is short. Rectum less than one anal body width in length. Tail strongly ventrally curved, narrowing to a sub-acute striated terminus with a one large mucro surrounded by two small spines. Tail measures almost fifteen anal body width in length.

Male: Not found.

Type specimens: Holotype female on slide No. PN/CHO/ 7 in authors collection and paratype females on Slide No. PN/CHO/5-6 deposited in the Department of Zoology, University of Kashmir.

Type host and locality: Collected from soil around the roots of *Juglans regia* L. from Tral, Kashmir.

Diagnosis and relationship

Chronogaster mustafaensis sp. nov. is distinct by having hemispherical continuous head, dome shaped, amphid with oval curved transverse slits and tail strongly ventrally curved regularly narrowing to a subacute striated terminus with one large mucro surrounded

by two small spines. However, it comes close to *C. andrassyi* Loof and Jairajpuri, 1968 and *C. citri* Khan and Nanjappa, 1972. From *C. andrassyi* it differs by the absence of longitudinal striae in the lip region, absence of hemizonid, posterior uterine branch present and length of tail (anal-body-width ratio). From *C. citri* to which it comes very close, can be differentiated by the shape of stoma, position of excretory pore in relation with nerve ring, more robust body and longer oesophagus which is posteriorly located ($a= 40-47$, $b= 4.5$, $V= 49-53$ % in *C. citri*).

In view of the above differences the present form is considered here in to constitute a new species for which the name *C. mustafaensis* is proposed.

Etymology: The species name is given in honor of my loving father for his support, constant encouragement, love, care, guidance, prayers and above all his service to the entire family, friends and community of Narwara, Srinagar, Kashmir.

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Novelty Statement

Current manuscript describes ten including two new genera of plant parasitic nematodes of agricultural importance from Kashmir Valley. This discovery is

significant because new morphological information obtained from these new species will facilitate future identifications of these plant-parasitic nematodes. This report will serve as a useful guide to researchers and diagnosticians identifying important nematodes from the various nematode genera.

Author's Contribution

Zafar Ahmad Handoo: Collection and description of the species.

Mihail Radu Kantor and Ekramullah Khan: Figures and text editing.

Conflict of interest

The authors have declared no conflict of interest.

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