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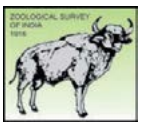

Occurrence of Soil-Inhabiting Nematoda (Dorylaimida and Tylenchida) in Some Protected Areas and Tea Estates of Assam with Four New Records of Dorylaimida from India

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Abstract

During a survey in 2018, soil samples were collected to explore the occurrence and diversity of soil-inhabiting nematode in some of the districts of Assam state including several protected areas and Tea Estates/gardens which have immense economic importance. The soil samples were processed by Cobb's Sieving and Decantation Method and the extraction of nematodes was done by modified Baerman Funnel Technique. 25 Nematodes have been reported from several conservation areas and Tea gardens. Among these, 21 species belong to the order Dorylaimida and 4 to the order Tylenchida. Out of these nematodes, 15 species are reported as new distributional records from Assam. Four species, *Mesodorylaimus bastiani* (Butschli, 1873) Andrassy, 1959, *Aporcelaimellus taylori* Yeates, 1967, *Makatinus punctatus* Heyns, 1965 and *Nygolaimus macrobrachyurus* (Heyns, 1968) Thorne, 1974 are recorded for the first time from India. The nematodes reported exhibited various feeding habits like omnivore, herbivore, predatory & predatory- omnivore.

Keywords: Soil-inhabiting Nematoda, Assam, Protected areas, Tea gardens, New records, Trophic groups.

Introduction

A survey was conducted in different districts of Assam in 2018. Soil samples were collected to explore the occurrence and diversity of soil-inhabiting nematode fauna from several protected areas and Tea Estates/gardens having immense economic importance. Soil samples were collected from Pobitora Wildlife Sanctuary, Morigaon district; Nameri forest range of Nameri National Park and Bhomoraguri Reserve Forest, Shonitpur district; Jeypore Forest Range of Dehing-Patkai Wildlife Sanctuary and Mariani Forest Range of Hollongapar Gibbon Wildlife Sanctuary, Jorhat district along with Panbari Tea Estate, Golaghat district; Experimental garden of Tocklai Tea Research Institute and Holangooree Tea Estate, Jorhat district; Burrapahar Tea Estate, Nawgaon district.

Nematodes are important for their significant role, both beneficial and harmful, in soil ecosystem as well as for their agricultural importance from economic point of view as they are responsible for crop loss. These micro-organisms are significantly important for decomposition in soil ecosystem (Yeates and Coleman, 1982) and are responsible for nitrogen mineralization and nutrient cycling in soil micro-habitat. They are bio-indicators of soil health because of their presence in all possible habitats and diverse feeding habits (Bongers and Bongers, 1998; Neher, 2001).

Literature review revealed significant works on soil and phytonematodes from Assam although the reports from protected areas are meagre. Das (1958) first reported the occurrence of *Meloidogyne hapla*, *Meloidogyne incognita* and *Pratylenchus* sp. from the soil of tea seedlings from Tocklai experimental station, Jorhat district, Assam. Jairajpuri (1964a, b, c) described *Basirotyleptus basiri*, *Dorylaimellus curvatus* and reported *Tyleptus striatus*, *Nygellus clavatus*, *Belondira ortha* from the soil around tea plantations and sugarcane of Jorhat district. *Paratylenchus pseuduncinatus*

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was described and *Hoplolaimus indicus* was reported by Phukan and Sanwal (1979, 1980) from the soil associated with tea plant in Jorhat district. Ahmad and Jairajpuri (1987) reported *Oriverutus sundarus* from TTRI in Jorhat district. Saha *et al.* (2000) described *Helicotylenchus assamensis* from Assam. Mushtaq *et al.* (2006) reported *Mylodiscus nanus* Thorne, 1939, Ahmad *et al.* (2010) described a new genus *Rhinodorylaimus* to accommodate a new species *Rhinodorylaimus kazirangus*, Baniyamuddin and Ahmad (2011) described two new species along with one known species from Kaziranga National Park. In recent times, significant contributions to the study of soil-inhabiting nematodes were done by Deuri *et al.* (2016), Das *et al.* (2016), Jena *et al,* (2017) and Khan *et al.* (2017).

Distribution of twenty-five species of soil-inhabiting Nematodes from the above mentioned conservation areas and Tea gardens along with their distribution in forest ecosystem and agro-ecosystem were observed (Table 1, Figure 1, 2 & 3). Among these twenty-one species belong to the order Dorylaimida and four to the order Tylenchida. Fifteen species are reported as new distributional record from Assam (Table 1). Four species have been recorded for the first time from India. In the present study, nematodes with various feeding habits like omnivore, herbivore, predatory & predatory-omnivore exhibiting different trophic levels were observed (Table 1, Figure 4 & 5).

Materials and Methods

For the present study, soil samples were collected from rhizosphere of various plants from forest ecosystem (conservation areas) and agro-ecosystem (agricultural fields in the buffer zone of protected areas and tea gardens) with the help of a hand-shovel. At the time of collection, the collection data were kept and the geographical position of a particular sampling site was recorded by a GPS. The collected soil samples were processed by 'Cobb's sieving and decantation technique' (Cobb, 1918) followed by 'modified Bearmann's funnel technique' (Christie and Perry, 1951) to extract the nematodes. The extracted nematodes were killed and fixed instantly in their characteristic body posture by Seinhorst's method in hot Formaldehyde-acetic acid solution (FA) solution. These were preserved in the same solution with appropriate labels. The specimens were transferred in cavity blocks containing glycerine-alcohol and were kept in a desiccator for 3 to 6 weeks. After complete dehydration of the specimens, permanent slides were prepared by using anhydrous glycerine as a mountant medium. Permanent slides were prepared by the wax ring method. The nematodes were observed and studied under a Nikon eclipse Ni DIC microscope (model YTV55) for taxonomic studies and identification. Photomicrographs were taken with the digital camera, attached with the same microscope.

Systematic Account of the New Records from India

Phylum NEMATODA Rudolphi, 1808 (Lankester, 1877)

Order DORYLAIMIDA Pearse, 1942

Suborder DORYLAIMINA Pearse, 1936

Superfamily DORYLAIMOIDEA De Man, 1976

Family DORYLAIMIDAE De Man, 1976

Subfamily LAIMYDORINAE Andrássy, 1969

Genus *MESODORYLAIMUS* Andrassy, 1959

1. ***Mesodorylaimus bastiani*** (Butschli, 1873) Andrassy, 1959

Family APORCELAIMIDAE Heyns, 1965

Subfamily APORCELAIMINAE Heyns, 1965

Genus *APORCELAIMELLUS* Heyns, 1965

2. ***Aporcelaimellus taylori*** Yeates, 1967

Genus *MAKATINUS* Heyns, 1965

3. ***Makatinus punctatus*** Heyns, 1965

Suborder NYGOLAIMINA Ahmad & Jairajpuri, 1979

Superfamily NYGOLAIMOIDEA Thorne, 1935

Family NYGOLAIMIDAE Thorne, 1935

Subfamily NYGOLAIMINAE Thorne, 1935

Genus *NYGOLAIMUS* Cobb, 1913

4. ***Nygolaimus macrobrachyurus*** (Heyns, 1968) Thorne, 1974

Genus *MESODORYLAIMUS* Andrassy, 1959

Mesodorylaimus bastiani (Butschli, 1873) Andrassy, 1959

(Plate 1: A- G; Table 2)

Material examined: 2 females, 2 males. India, Assam, Morigaon dist., Pobitora Wild Life Sanctuary, Lat 26°14.534N and long 092°02.926E, 31-i-2018, coll. D. Sen (Reg. No. ZSI/WN2239/2).

Diagnosis: Female: Body slender, slightly ventrally curved on fixation. Cuticle smooth, thicker on tail. Lip region almost continuous or slightly offset by weak depression, lips amalgamated. Odontostyle about 1.5 times the labial

diameter, its aperture occupying 33.3 – 35.7% or about one-third of odontostyle length. Guiding ring single, 0.9 – 1.1 lip region-width from anterior end. Odontophore straight, 1.4 times the odontostyle length. Nerve ring 11 – 11.1 labial diameters from anterior end or at 32.0 - 33.6% of the pharyngeal length. Reproductive system amphidelphic. Vulva transverse, pre- to slightly post-equatorial. Vagina extending inward more than half (54 – 61%) of the corresponding body width. Posterior gonad and ovary longer than the anterior. Prerectum 3.8 – 4.0, rectum 0.8 – 1.3 anal body-widths long. Tail straight, elongated, consisting of an anterior convex-conoid portion followed by a slender portion, narrowing on both sides, tapering continuously to an acute or finely rounded terminus. Posterior narrow portion of tail longer than anterior conical portion, 2.2 – 2.6 times of the anterior wide part.

Males: Similar to female in general body shape and morphology except reproductive system and tail shape. Supplements consist of 14 – 16 regularly spaced ventromedians and an adanal pair. Spicules 1.6 anal body-widths long. Lateral guiding piece about one-third to one-fourth of spicule length. Prerectum 4.1 – 4.2 and rectum about 1.0 anal body-widths long. Tail short, rounded, slightly concave ventrally.

Habitat: Soil around the roots of unidentified wild plant.

Distribution in world: Holland, Germany, Sweden, Poland, Austria, United States, Mexico, Australia, Czechoslovakia, Hungary, Yugoslavia, Spain, France, Italy, Russia, Ukraine, Estonia, Latavia, Lithuania, Georgia, Armenia, Uzbekistan, Morocco, Cameroon, Tanzania, Zaire, South Africa, Mauritius, Java, Sumatra .

Remark: Mesodorylaimus bastiani can be distinguished in having elongated tail consisting of a conical part followed by a slender portion which tapers to an acute or finely rounded tip in female. The present specimens of *Mesodorylaimus bastiani* (Butschli, 1873) Andrassy, 1959, reported from India, agree well with the type and other reported specimens of the species except the number of ventromedian supplements in males (number of supplements in type species is 9 – 13 and 8 – 11 in the specimens reported from Spain by Pena-Santiago *et al.*, 2000 *vs.* 14 – 16 in the present specimens). Since the morphology and all other morphometric measurements show similarities with the previously reported specimens, the difference in the number of supplements may be considered as an intraspecific variation for the specimens reported from India. Yeates (1993) categorized *Mesodorylaimus* as an omnivore. The predatory behaviour of M. *bastiani* was observed on bacterial feeder, other predatory groups and on the phytonematodes of different feeding habits (Bilgrami, 1995; Bilgrami *et al.* 2001). This is the first record of the species from India.

Genus *APORCELAIMELLUS* Heyns, 1965

Aporcelaimellus taylori Yeates, 1967

(Plate 2: A – H; Table 3)

Material examined: 2 females, 1 juvenile. India, Assam, Nawgaon district: Burrapahar: Rangalu Paharguri village, Lat 26°34.541N and long 093°01.007E, 04-ii-2018, coll. D. Sen (Reg. No. ZSI/WN2467).

Diagnosis: Female: Body ventrally curved on fixation, the posterior portion in particular in one specimen, slightly tapering towards anterior end. Cuticle distinctly in two layers, thick near labial region at the level of odontostyle and on tail. Lip region clearly set off by constriction, almost same or slightly wider than adjoining body, 16.5 – 17.0mm wide or about 1/3.5 of body width at neck base. Amphids stirrup-shaped. Odontostyle 1.1 – 1.2 times the labial diameter, its aperture slightly more than half or occupying about 57.5 – 57.8% of odontostyle length. Guiding ring 0.5 – 0.6 lip region-width from anterior end. Odontophore rod-like, 1.7 – 1.8 times the odontostyle length. Nerve ring 9.1 – 11.1 labial diameters from anterior end or at 27.0 - 33.4% of the pharyngeal length. Expanded part of pharynx about half or 49.8 – 51.5% of the pharyngeal length. Thin cardiac disc present, cardia conoid, about one-third or 1/2.7 – 1/3.4 neck base width long. Vulva transverse, post-equatorial. Vagina extending inward about half or 46.7 – 49.2% of the corresponding body width (length of *pars proximalis* vagina 21.0 – 17.6mm, *pars refringens* 5.0 – 7.0mm and combined width (CW) 9.0 – 10.0mm and *pars distalis* 3.0mm), distally sclerotized. Female genital system amphidelphic, both ovaries reflexed, both the gonads equally developed. Prerectum 2.4 – 3.5 and rectum 1.2 – 1.4 anal body diameters long. Tail short, 0.9 – 1.0 anal body diameter long, convex and uniformly conoid ending in a rounded terminus.

Male: Not found.

Juvenile: Morphologically similar to female with a shorter body length and some relevant differences in morphometric measurements, shown in table 3.

Habitat: Soil around the roots of paddy (*Oryza sativa*).
Distribution in world: New Zealand, U.S.A, Pakistan.

Remark: Aporcelaimellus taylori can be recognized by the thick cuticle near the head and uniformly conoid tail. Yeates (1967) described the species from New Zealand. Thorne (1974) reported this species from USA. Álvarez-Ortega *et al.* (2012) proposed a new combination of the species as *Aporcella taylori* (Yeates, 1967) Álvarez-Ortega, Subbotin & Peña-Santiago, 2012. The present female specimens of *Aporcelaimellus taylori* Yeates, 1967, reported from India, agree well morphologically with the type and other reported specimens of the species except some minor morphometric variations (in the type specimen tail is longer evident from 'c' value. c = 46 in type *vs.* 60.9 – 73.5 in the present specimens. In the reported specimens prerectum slightly longer than body diameter *vs.* 2.4 – 3.5 anal body diameter in the present specimens). This is the first record of the species from India.

Genus *MAKATINUS* Heyns, 1965

Makatinus punctatus Heyns, 1965

(Plate 3: A-F; Table 3)

Material examined: 1 female. India, Assam, Golaghat dist., Bokakhat, Panbari Tea Estate, Lat 26°37.385N and long 093°31.559E, 04-ii-2018, coll. D. Sen (Reg. No. ZSI/WN2403).

Diagnosis: Female: Body ventrally curved on fixation, particularly the posterior portion, slightly tapering towards anterior end. Cuticle in two layers, thicker on tail. Lip region set off by weak constriction, its width about one-fifth of body width at neck base. Amphids funnel-shaped. Odontostyle strong and wide, ventral arm with thick wall, length equal to labial diameter, aperture more than half or occupying about 62% of odontostyle length. Guiding ring about half lip region-width from anterior end. Odontophore about twice the odontostyle length. Nerve ring 8.6 labial diameters from anterior end. Pharynx muscular, expanded part of pharynx slightly more than half or 52.5% of the pharyngeal length. Vulva transverse, heavily sclerotized distally, post-equatorial. Vagina extending inward little less than one-third or 36.5% of the corresponding body width (length of *pars proximalis* vagina 42mm, *pars refringens* 16mm and combined width (CW) 18mm and *pars distalis* 2.0mm). Female reproductive system amphidelphic. Prerectum 2.8 and rectum 0.8 anal body diameters long. Tail short, convex both dorsally and ventrally 0.4 anal body diameter long, conically ending in a small hyaline projection of digitate terminus.

Male: Not found.

Habitat: Soil around the roots of tea plant (*Camellia sinensis*).

Distribution in world: South Africa, U.K., USA, California, Hawaii, Netherland, Venezuela.

Remark: Makatinus punctatus can be characterized by its tail conically ending in a small hyaline projection of digitate terminus. Heyns (1965) described the species from South Africa. Pena-Santiago and Varela (2017) reviewed the genus *Makatinus* Heyns, 1965 and observed that *Makatinus punctatus* perfectly agrees with the characteristics of the genus and the species differs from all other species of genus by its typical conical tail shape with a small digitate terminal hyaline projection. The present single female specimen of *Makatinus punctatus,* reported from India, shows clear affinity and similarity to the type specimens in general morphology having some variation in morphometric measurements (in female type specimens L = 2.40 - 3.17mm, a – 36 – 42, b = 4.2 – 4.4, c = 84 – 99, $c^{/=}$ 0.7, odontostyle = 25 - 27mm). This is the first report of the species from India.

Genus *NYGOLAIMUS* Cobb, 1913

Nygolaimus macrobrachyurus (Heyns, 1968) Thorne, 1974

(Plate 4: A-H; Table 2)

Material examined: 1 female, 1 male. India, Assam, Jorhat dist., Meleng: Holongapar Gibbon WLS: Mariani Forest Range, Lat 26°40.989N and long 094°21.063E, 26-x-2018, coll. D. Sen (Reg. No. ZSI/WN2624/1); India, Assam, Majuli dist., Majuli island: Chitadarsuk village, and Lat 26°59.507N and long 094°09.070E, 27-x-2018, coll. D. Sen (Reg. No. ZSIWN2625/1).

Diagnosis: Large nematode, Body ventrally curved upon fixation, cylindrical. Cuticle thick on tail. Lip region elevated, minutely angular, distinctly set off from body by deep constriction, slightly wider than adjoining body, lips amalgamated. Amphids not clearly visible. Mural tooth deltoid, linear, little more than half or 0.55 labial diameter long. Expanded portion of pharynx occupies more than half (67.2%) of total pharyngeal length. Nerve ring 8.8 labial diameters from anterior end. Cardia tongue-shaped, 10.0mm long, surrounded by three vertically oval glands present at the pharyngo-intestinal junction. Vulva transverse, post-equatorial. Vagina extending inward little more than half or 54.2% of the corresponding body width. Reproductive system amphidelphic. Distinct sphincter present at uterus-oviduct junction. Prerectum short, 1.1 anal body diameter and rectum about one anal body diameter long. Tail short, convex-conoid with rounded terminus, 0.8 anal body diameter long.

Male: Similar to female in general body shape and morphology except reproductive system and tail shape. Supplement consists of a single rudimentary ventromedian and an adanal pair. Spicules 1.2 anal body diameter long. Prerectum 0.8 and rectum about 1.0 anal body-widths long. Tail short, rounded.

Habitat: Soil around the roots of unidentified grass (from Jorhat dist.) and fern (from Majuli dist.)

Distribution in world: The Netherlands, U. S. A.
Remark: Nygolaimus macrobrachyurus can be distinguished by its longer body length and a single rudimentary ventromedian supplement in addition to the adanal pair in male. Heyns (1968) described the species under the subgenus *Nygolaimus* as *Nygolaimus (Nygolaimus) macrobrachyuris*. Thorne (1974) reported the species from South Dakota, U.S.A. and renamed the species as *Nygolaimus macrobrachyurus* with a new rank. The present female and male specimens of *Nygolaimus macrobrachyurus*, reported from India, are longer and body to pharyngeal length ratio (b) is more than in the type specimens, yet they show very close morphological similarities with those of the type specimens except some morphometric variations (in the female holotype, L = 3.49mm, b = 3.2 – 3.6; in male paratypes L = 2.73 – 2.84mm, b = 3.7, spicule length in male = 45 - 46mm; In the specimen reported from USA, L = 3.5mm). This is the first record of the species from India.

Discussion

Total twenty-five species of soil-inhabiting Nematodes belonging to 9 families and 14 genera under the orders Dorylaimida and Tylenchida have been reported from the conservation areas and tea gardens and their distributions in forest ecosystem and agro-ecosystem were observed (Figure 2). Seventeen species were reported from conservation areas and 10 species from the agricultural system and among these, 4 species, *Laimydorus multialaeus*, *Aporcelaimellus chauhani*, *Aporcelaimellus baqrii* and *Xiphinema gracilicaudatum* were found to occur either in more than one conservation areas and tea gardens or in both (Table 1). Among these 25 species, 63% species was found to occur from conservation areas and 37% from the soils of tea gardens with the repetition of some species either in protected areas or in tea gardens or in both (Figure 1). Again, 56% species was found in forest ecosystem and 44% species in agro-ecosystem (Figure 2). Maximum and minimum number of occurrence of different species and their distribution in different protected areas and tea gardens has been observed (Table 1, Figure 3). Yeats (1971) studied the Feeding types and feeding groups in plant and soil nematodes and their trophic groups can be categorized as omnivorous, plant feeders or herbivorous, fungal feeders, bacterial feeders, predators, predatory-omnivore etc. (Yeates *et al.*, 1993). In the present study, nematodes of different trophic groups depending on their feeding habits were observed. The reported nematode species were found to belong to four trophic groups, 10 species (40%) are herbivores, 09 species (36%) are predatory omnivorous, 5 species (20%) are omnivorous and 1 species (4%) is predatory (Figure 4 & 5).

Table-1. Distribution of dorylaimid and tylenchid nematodes in some protected areas and tea estates of Assam

Protected Area / Tea Estate	Species	Locality with Geographic coordinate	Habitat	Trophic group (Feeding habit)	New record Status
Pobitora Wild Life Sanctuary	1. ***Laimydorus multialaeus*** (Khera, 1970) Baqri, 1985	Lat 26°14.534N & long 092°02.926E, Pobitora Wild Life Sanctuary, Morigaon dist.	Forest Ecosystem	Omnivorous	First report from Pobitora WLS
	2. ***Mesodorylaimus bastiani*** (Butschli, 1873) Andrassy, 1959	Lat 26°14.534N & long 092°02.926E, Pobitora Wild Life Sanctuary, Morigaon dist.	Forest Ecosystem	Predatory omnivore	New Record from India
	3. ***Aporcelaimellus chauhani*** Baqri & Khera, 1975	Lat 26°14.534N & long 092°02.926E, Pobitora Wild Life Sanctuary, Morigaon dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	4. ***Aporcelaimellus heynsi*** Baqri & Jairajpuri, 1968	Lat 26°14.534N & long 092°02.926E, Pobitora Wild Life Sanctuary, Morigaon dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	5. ***Lindseyus indicus*** Dhanachand & Jairajpuri, 1980	Lat 26°14.534N & long 092°02.926E, Pobitora Wild Life Sanctuary, Morigaon dist.	Forest Ecosystem	Omnivorous	New distributional record from Assam
Nameri forest range, Nameri National Park	1. ***Laimydorus multialaeus*** (Khera, 1970) Baqri, 1985	26°56.565N & long 092°50.770E and 26°56.324N & long 092°50.577E, Nameri forest range, Nameri N. P., Shonitpur dist.	Forest Ecosystem	Omnivorous	First report from Nameri N. P.
	2. ***Aporcelaimellus amylovorus*** (Thorne & Swanger, 1936) Heyns, 1965	Lat 26°56.565N & long 092°50.770E, Nameri Forest Range, Nameri N. P., Shonitpur dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	3. ***Aporcelaimellus baqrii*** Ahmad & Jairajpuri, 1982	Lat 26°56.565N & long 092°50.770E, Nameri forest range, Nameri N. P., Shonitpur dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	4. ***Xiphinema insigne*** Loos, 1949	Lat 28°41.522N & long 080°01.686E, Nameri forest range, Nameri N. P., Shonitpurdist,	Forest Ecosystem	Herbivorous	First report from Nameri N. P.
	5. ***Hoplolaimus imphalensis*** M. L Khan & S. H. Khan, 1985	Lat 26°55.418N & long 092°49.642E, Potashali village, buffer zone of Nameri N. P. Shonitpur dist.	Forest Ecosystem	Herbivorous	New distributional record from Assam

Protected Area / Tea Estate	Species	Locality with Geographic coordinate	Habitat	Trophic group (Feeding habit)	New record Status
Jeypore Forest Range, Dehing-Patkai Wildlife Sanctuary	1. ***Laimydorus siddiqii*** Baqri & Jana, 1983	Lat 26°15.235N & long 092°02.482E,Jeypore village, Jeypore Forest Range, Buffer zone of Dehing-Patkai WLS, Dibrugarh dist.	Agro-ecosystem	Omnivorous	New distributional record from Assam
	2. ***Sectonema procta*** Jairajpuri and Baqri, 1966	Lat 27°14.932N & long 095°25.694E, beside Namchang road, Jeypore forest range, DehingPatkai WLS, Dibrugarh dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	3. ***Xiphinema elongatum*** Schuurmans-Stekhoven & Teunissen, 1938	Lat 27°14.932N & long 095°25.694E, beside Namchang road, Jeypore forest range, Dehing Patkai WLS, Dibrugarh dist.	Forest Ecosystem	Herbivorous	New distributional record from Assam
	4. ***Xiphinema gracilicaudatum*** (Singh & Khan, 1997) Ganguly *et al.*, 2000	Lat 27°14.932N & long 095°25.694E, Jeypore Forest Range, Namchang road, Dehing-Patkai WLS, Dibrugarh dist., Assam	Forest Ecosystem	Herbivorous	New distributional record from Assam
	5. ***Xiphinema manasiae*** Sen, Chatterjee & Manna, 2010	Lat 27°15.836N & long 095°23.900E, buffer zone of Jeypore forest range, Dehing Patkai WLS, Jeypore, Dibrugarh dist.	Agro-ecosystem at the buffer zone of Dehing-Patkai WLS	Herbivorous	New distributional record from Assam
Bhomoraguri Reserve Forest	1. ***Aporcelaimellus baqrii*** Ahmad & Jairajpuri, 1982	Lat 26°37.072N & long 092°51.208E, Bhomoraguri Reserve Forest, Tezpur,Shonitpur dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	2. ***Dorylaimoides (Digidorylaimoides) micoletzkyi*** (De Man, 1921) Thorne & Swanger, 1936	Lat 26°37.072N & long 092°51.208E, Bhomoraguri Reserve Forest, Tezpur, Shonitpur dist.	Forest Ecosystem	Omnivorous	New distributional record from Assam
Mariani Forest Range, Hollongapar Gibbon Wildlife Sanctuary	1. ***Aporcelaimellus chauhani*** Baqri & Khera, 1975	26°40.732N & long 094°21.226E, Mariani Forest Range, Hollongapar Gibbon WLS, Jorhat dist.	Forest Ecosystem	Predatory omnivore	New distributional record from Assam
	2. ***Paralongidorus sali*** Siddiqi, Hooper & Khan, 1963	Lat 26°40.989N & long 094°21.063E, Holongapar Gibbon WLS, Mariani Forest Range, Jorhat dist.	Forest Ecosystem	Herbivorous	First report from Hollongapar Gibbon WLS
	3. ***Nygolaimus macrobrachyurus*** (Heyns, 1968) Thorne, 1974	Lat 26°40.989N & long 094°21.063E, Holongapar Gibbon WLS, Mariani Forest Range, Jorhat dist.	Forest Ecosystem	Predator	New Record from India

Protected Area / Tea Estate	Species	Locality with Geographic coordinate	Habitat	Trophic group (Feeding habit)	New record Status
Panbari Tea Estate	1. ***Aporcelaimellus chauhani*** Baqri & Khera, 1975	Lat 26°37.385N & long 093°31.559E, Panbari Tea Estate, Bokahat, Golaghat dist.	Agro-ecosystem	Predatory omnivore	New distributional record from Assam
	2. ***Makatinus punctatus*** Heyns, 1965	Lat 26°37.385N & long 093°31.559E, Panbari Tea Estate, Bokakhat, Golaghat dist.	Agro-ecosystem	Predatory omnivore	New Record from India
	3. ***Xiphinema gracilicaudatum*** (Singh & Khan, 1997) Ganguly *et al.*, 2000	Lat 26°37.385N & long 093°31.559E, Panbari Tea Estate, Bokakhat, Golaghat dist.	Agro-ecosystem	Herbivorous	New distributional record from Assam
	4. ***Helicotylenchus assamensis*** Saha, Lal, Singh, Kaushal & Sharma, 2000	Lat 26°37.385N &long 093°31.559E, Panbari Tea Estate, Bokahat, Golaghat dist.	Agro-ecosystem	Herbivorous	First report from Panbari Tea Estate
Experimental garden of TTRI	1. ***Aporcelaimellus coomansi*** Baqri & Khera, 1975	Lat 26°43.807N & long 094°13.779E, Experimental garden, TTRI, Jorhat dist.	Agro-ecosystem	Predatory omnivore	New distributional record from Assam
Burrapahar Tea Estate	1. ***Oriverutus sundarus*** (Williams, 1964) Siddiqi, 1971	Lat 26°34.534N & long 093°09.789E, Burrapahar Tea Estate, Nawgaon dist.	Agro-ecosystem	Not determined	Ahmed & Jairajpuri,1987 reported from TTRI
	2. ***Hoplolaimus indicus*** Sher, 1963	26°34.534N & long 093°09.789E, Burrapahar Tea Estate, Nawgaon dist.	Agro-ecosystem	Herbivorous	First report from Burrapahar Tea Estate
Holangooree Tea Estate	1. ***Xiphinema brasiliense*** Lordello, 1951	Lat 26°39.442N & long 094°23.095E, Holangooree Tea Estate, Jorhat dist.	Agro-ecosystem	Herbivorous	New distributional record from Assam
	2. ***Xiphinema gracilicaudatum*** (Singh & Khan, 1997) Ganguly *et al.*, 2000	Lat 26°39.442N & long 094°23.095E, Hoolangooree Tea Estate., Jorhat dist.	Agro-ecosystem	Herbivorous	New distributional record from Assam
	3. ***Axonchium* (*Axonchium*) *nitidum*** Jairajpuri, 1964	Lat 26°39.442N & long 094°23.095E, Holangooree Tea Estate, Jorhat dist.	Agro-ecosystem	Predatory omnivore	Jairajpuri, 1964 reported from Jorhat and Sibsagar dist.
	4. ***Hoplolaimus pararobustus*** (Schuurmans-Stekhoven & Teunissen, 1938) Sher, 1963	Lat 26°39.442N & long 094°23.095E, Holangooree Tea Estate, Jorhat dist.	Agro-ecosystem	Herbivorous	New distributional record from Assam

Table – 2: Morphometric measurements of *Mesodorylaimus bastiani* & *Nygolaimus macrobrachyurus* (All measurements are in µm except the total length, L in mm.)

Characters	Mesodorylaimus bastiani				Nygolaimus macrobrachyurus	
	Female (n=2)		Male (n=2)		Female (n=1)	Male (n=1)
	Min	Max	Min	Max		
L	1.73	1.77	1.56	1.74	3.97	3.28
a	46.8	49.1	48.8	51.4	56.8	42.1
b	5.0	5.2	4.8	4.8	5.0	4.0
c	15.6	18.4	60.1	67.2	99.4	93.9
c'	3.9	5.3	1.0	1.0	0.8	0.6
V/T %	46.8	51.4	67.6	71.2	54.3	61.6
G_1 %	11.0	13.0	-	-	12.0	-
G_2 %	13.8	15.3	-	-	11.8	-
Length of odontostyle	14.0	15.0	15.0	16.0	-	-
Width of odontostyle	2.0	2.5	2.0	2.5	-	-
Length of odontostyle aperture	5.0	5.0	5.0	5.0	-	-
Length of odontophore	20	22	20	21	-	-
Guiding ring from anterior end	9.0	11.0	-	-	-	-
Length of mural tooth	-	-	-	-	13.0	15.0
Maximum body width	36.0	37.0	32.0	34.0	70.0	78.0
Length of Pharynx	330.0	353.0	322.0	360.0	781.0	815.0
Length of expanded pharynx	165.0	201.0	166.0	254.0	525.0	508.0
Cardiac Glands	-	-	-	-	5.5-7.5 x 6.5-8	7.5-10.0 x 5.5-6.5
Nerve ring from anterior end	111.0	113.0	83.0	111.0	207.0	238.0
Lip height	4.0	4.5	4.0	4.5	6.5	6.5
Lip width	10.0	10.5	10.5	11.0	23.5	24.0
Neck base width	34.0	35.0	30.0	32.0	67.0	74.0
Body width at vulva	36.0	37.0	-	-	70.0	-
Lip adjoining body width	11.0	11.5	12.5	13.0	22.0	25.0
Cuticle anterior end	1.0	1.0	1.0	1.0	4.5	5.0
Cuticle at mid body	1.0	1.5	2.0	2.0	5.0	5.0
Cuticle on tail	2.0	2.5	2.0	2.0	11.0	11.0

Characters	Mesodorylaimus bastiani				Nygolaimus macrobrachyurus	
	Female (n=2)		Male (n=2)		Female (n=1)	Male (n=1)
Vulva from anterior end	814.0	901.0	-	-	2165.0	-
Length of vagina	20.0	22.0	-	-	38.0	-
Length of anterior gonad	191.0	246.0	-	-	480.0	-
Length of uterus	44.0	58.0	-	-	156.0	-
Length of oviduct	90.0	104.0	-	-	125.0	-
Length of ovary	57.0	84.0	-	-	199.0	-
Length of posterior gonad	240.0	272.0	-	-	472.0	-
Length of uterus	45.0	63.0	-	-	132.0	-
Length of oviduct	119.0	123.0	-	-	162.0	-
Length of ovary	76.0	86.0	-	-	178.0	-
Tail length	94.0	113.0	26.0	26.0	40.0	35.0
Length of anterior convex part of tail	29	31	-	-	-	-
Length of posterior narrow part of tail	65.0	82.0	-	-	-	-
Anal body diameter	21.0	24.0	25.0	26.0	46.0	55.0
Length of prerectum	86.0	93.0	105.0	108.0	51.0	48.0
Length of rectum	20.0	29.0	27.0	28.0	46.0	57.0
Length of testes	-	-	1115.0	1182.0	-	2027.0
Number of ventromedian supplements	-	-	12	15	-	1 + (1 adanal)
Length of spicule	-	-	41.0	43.0	-	69.0

Table – 3: Morphometric measurements of *Aporcelaimellus taylori* and *Makatinus punctatus* (All measurements are in µm except the total length, L in mm.)

Characters	Aporcelaimellus taylori			Makatinus punctatus
	Female (n=2)		Juvenile (n=1)	Female (n=1)
	Min	Max		
L	2.35	2.37	1.65	3.54
a	37.7	37.9	33	21.5
b	4.1	4.3	3.4	3.9
c	60.9	73.5	57.0	122.0
c'	0.9	1.0	0.9	0.4
V %	53.5	53.8	-	56.4
G_1 %	14.0	16.7	-	16.1
G_2 %	13.5	13.7	-	12.9
Length of odontostyle	19.0	21.0	17.0	29.0
Length of odontostyle aperture	11.0	11.5	10.0	18.0
Length of odontophore	36.0	36.0	31.0	63.0
Width of odontostyle	3.5	3.5	2.5	6.0
Guiding ring from anterior end	10.0	11.0	-	14.0
Maximum body width	62.0	63.0	50.0	164.0
Length of Pharynx	550.0	572.0	480.0	893.0
Length of Expanded Pharynx	274.0	295.0	253.0	469.0
Length of cardia	17.0	22.0	10.0	-
Nerve ring from anterior end	155.0	184.0	103.0	250.0
Lip height	5.0	6.0	5.0	9.5
Lip width	16.5	17.0	14.0	29.5
Neck base width	59.0	60.0	48.0	160.0
Body width at vulva	62.0	63.0	-	164.0
Lip adjoining body width	17.0	18.0	15.0	31.0
Cuticle anterior end	3.0	3.5	2.0	5.0
Cuticle at mid body	2.5	3.0	2.0	6.0
Cuticle on tail	6.5	7.0	4.0	10.0
Vulva from anterior end	1260.0	1280.0	-	2000.0

Characters	Aporcelaimellus taylori			Makatinus punctatus
	Female (n=2)		Juvenile (n=1)	Female (n=1)
Length of vagina	29.0	31.0	-	60.0
Length of *Pars distalis* vagina	3.0	3.0	-	2.0
Length of *Pars refringens* (CW)	5.0x9.0	7.0x10.0	-	16.0x18.0
Length of *Pars proximalis* vagina	21.0	21.0	-	42.0
Length of anterior gonad	330.0	399.0	-	571.0
Length of uterus	51.0	83.0	-	130.0
Length of oviduct	138.0	151.0	-	259.0
Length of ovary	141.0	165.0	-	182.0
Length of posterior gonad	320.0	327.0	-	457.0
Length of uterus	51.0	52.0	-	94.0
Length of oviduct	116.0	128.0	-	202.0
Length of ovary	148.0	152.0	-	161.0
Tail length	32.0	39.0	29.0	29.0
Anal body diameter	35.0	39.0	30.0	65.0
Length of prerectum	97.0	124.0	97.0	187.0
Length of rectum	47.0	51.0	40.0	53.0

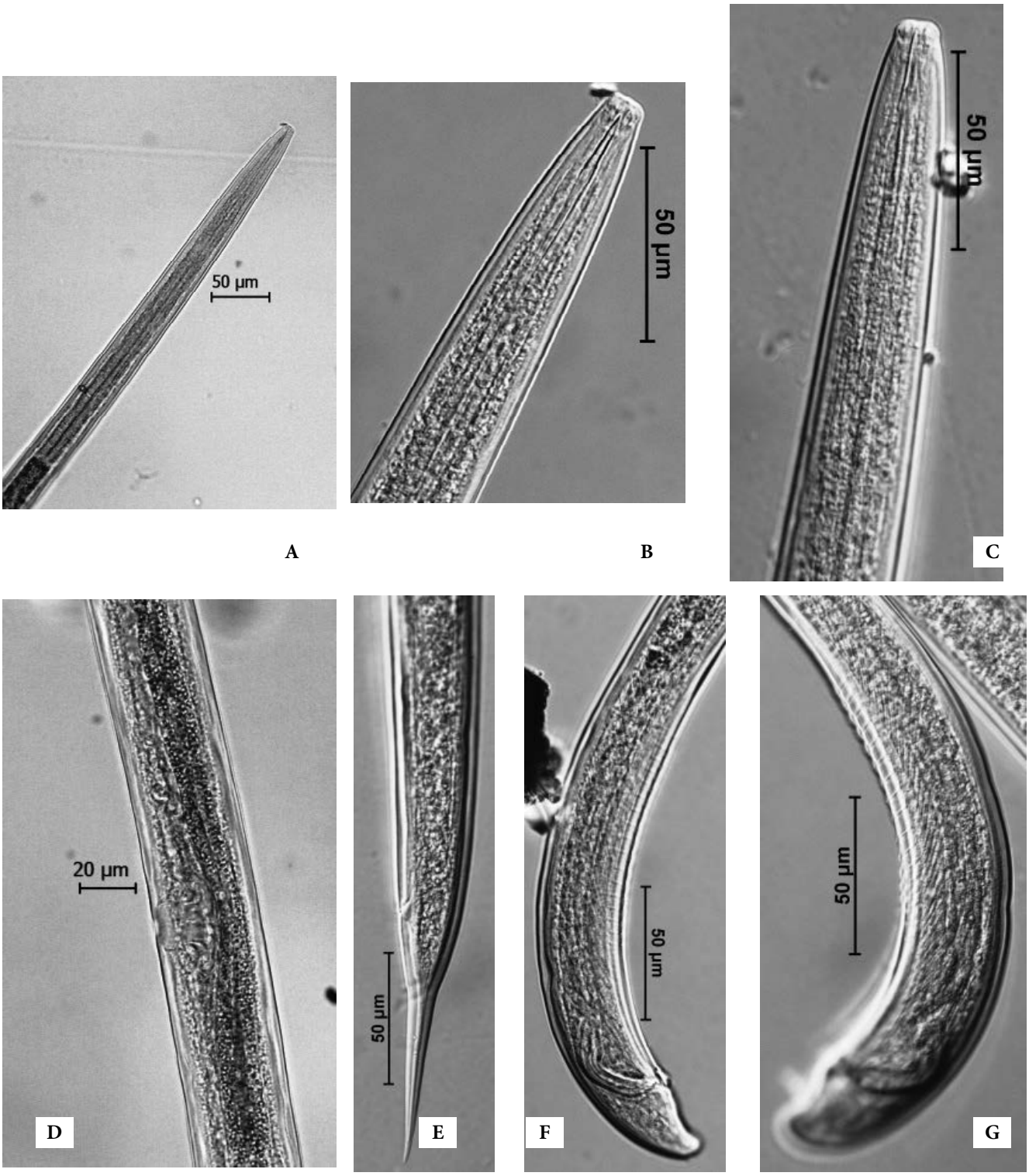

Plate 1 (A - G): Photomicrographs of *Mesodorylaimus bastiani* (Butschli, 1873) Andrassy, 1959. **A. Pharynx of Female, , B. Odontostyle of Female, C. Odontostyle of Male, D. Vulva, E. Posterior end of female showing tail, F & G. Posterior end of male showing ventromedian supplements, spicule & tail**

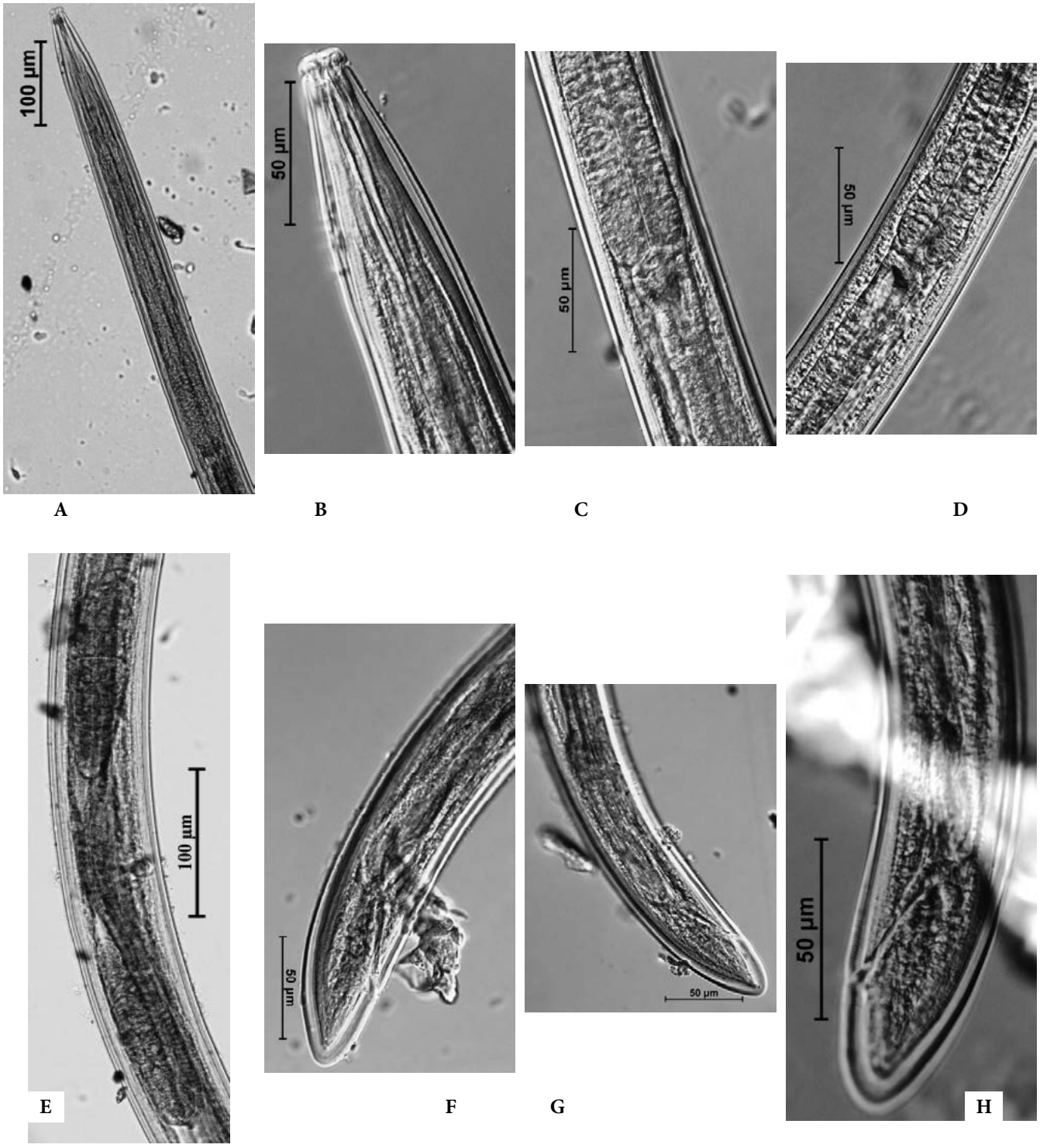

Plate 2 (A - H): Photomicrographs of *Aporcelaimellus taylori* Yeates, 1967. **A. Pharynx of Female, B. Odontostyle of Female, C. Pharyngo-intestinal junction of Female, D. Pharyngo-intestinal junction Juvenile, E. Gonads, F & G. Posterior end of female showing variation in tail terminus, H. Posterior end of Juvenile**

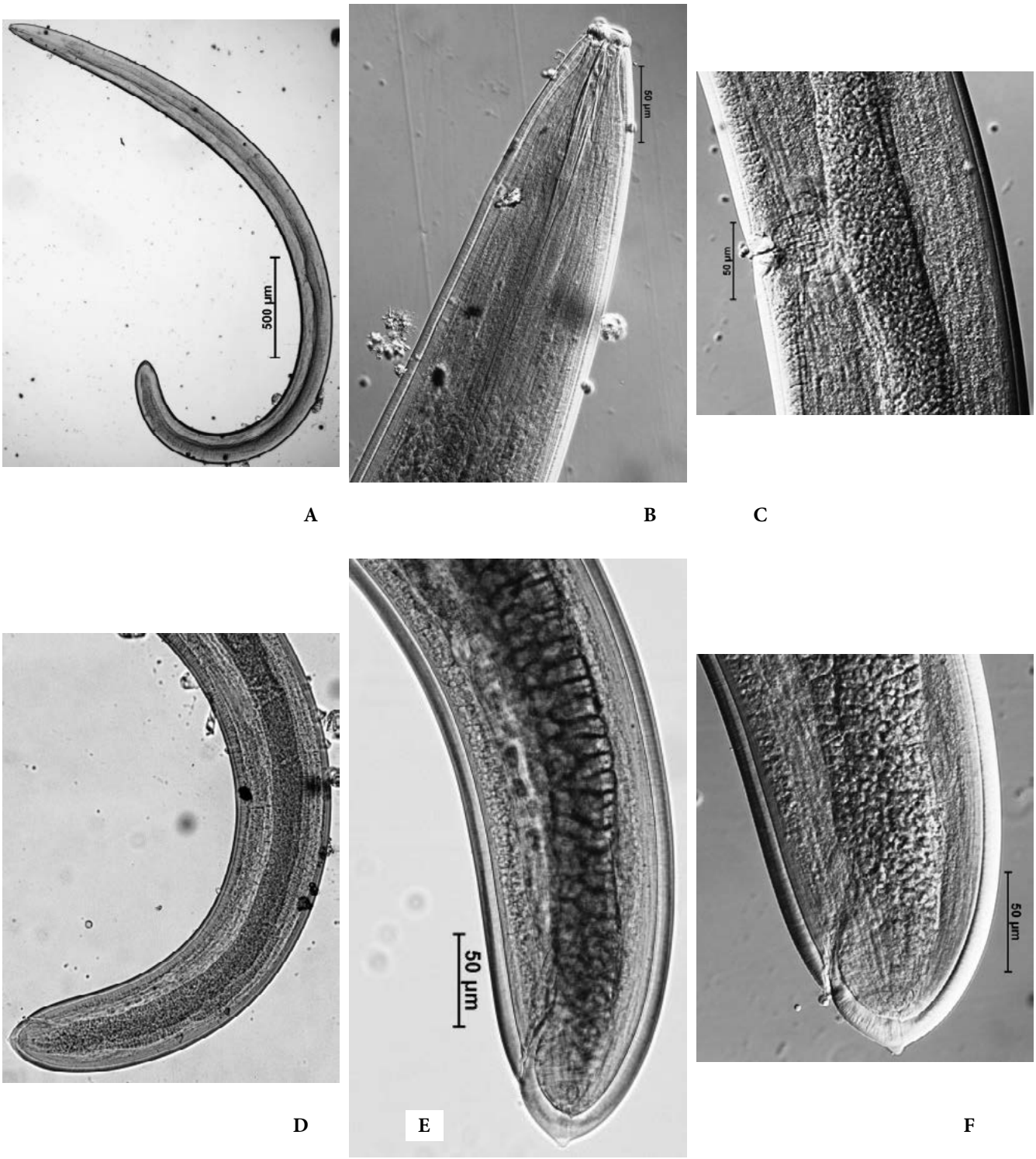

Plate 3 (A - F): Photomicrographs of *Makatinus punctatus* Heyns, 1965 **A. Entire Female, B. Odontostyle, C. Vulva, D. Posterior end, E & F. Tail End**

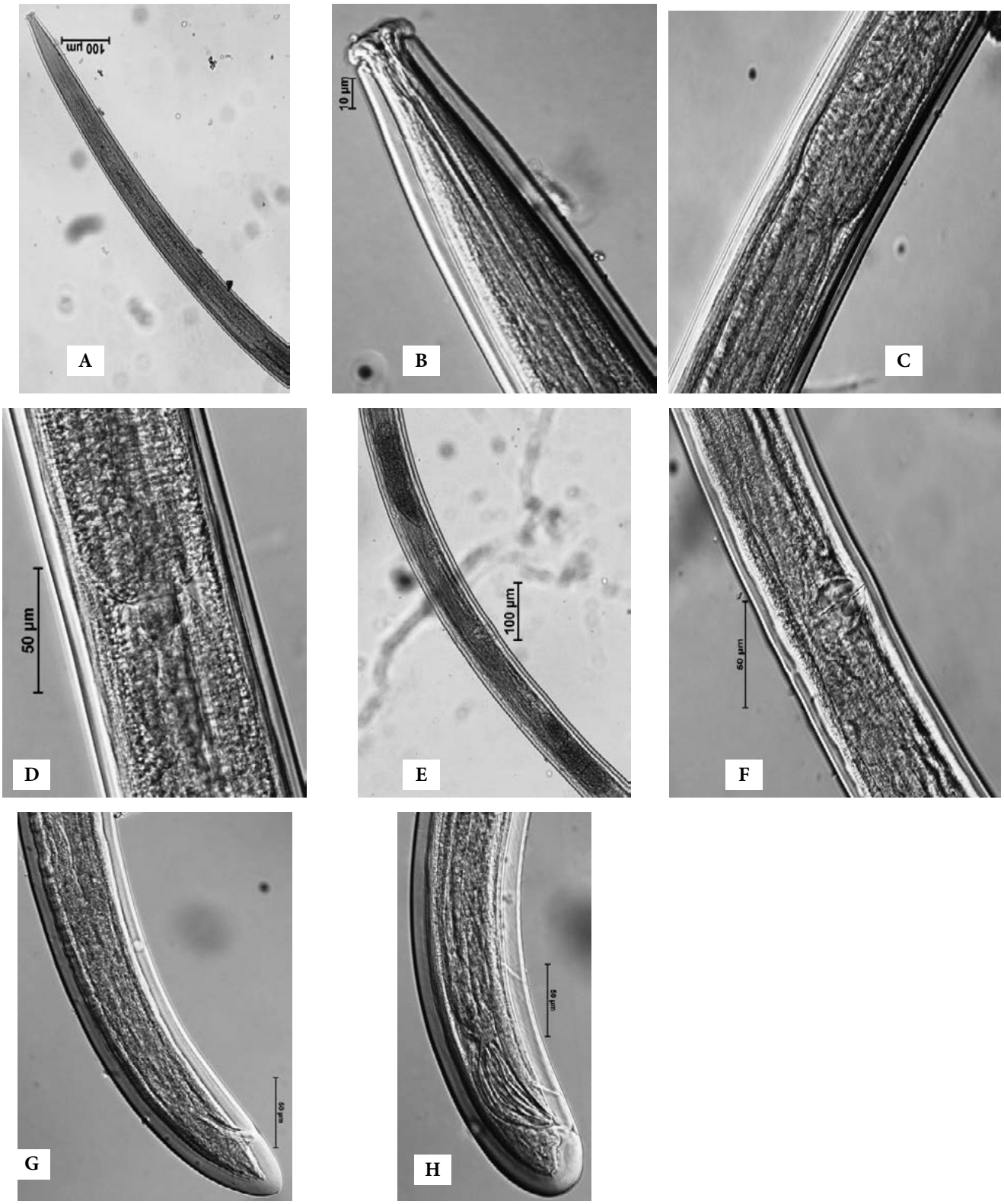

Plate 4 (A - H): Photomicrographs of *Nygolaimus macrobrachyurus* (Heyns, 1968) Thorne, 1974 **Pharynx of female, B. Mural tooth of female, C. Cardiac glands of female, D. Cardiac glands of male, E. Gonads of female, F. Vulva, G. Posterior end of female, H. Posterior end of male showing spicule, single ventromedian supplemnent and tail**

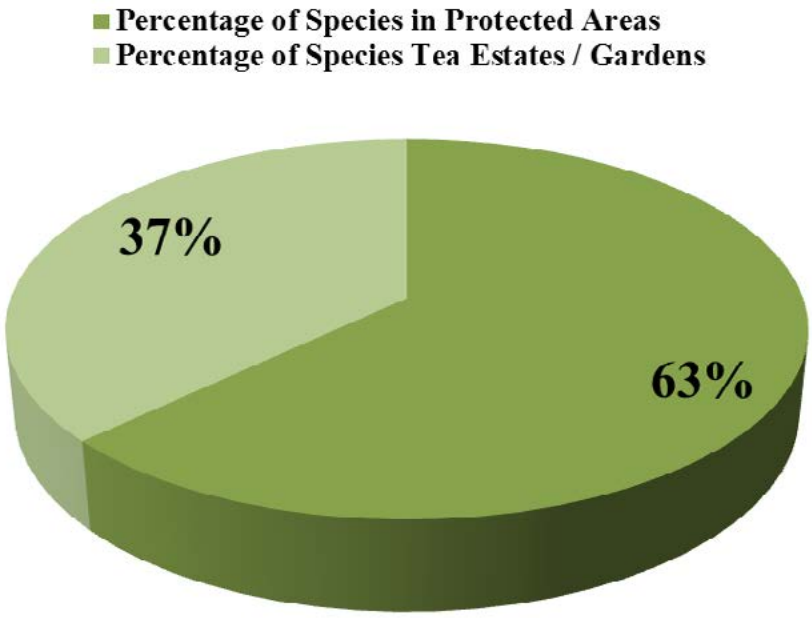

Figure 1. Percentage of nematode Species in Protected Areas and Tea Estates/ Gardens

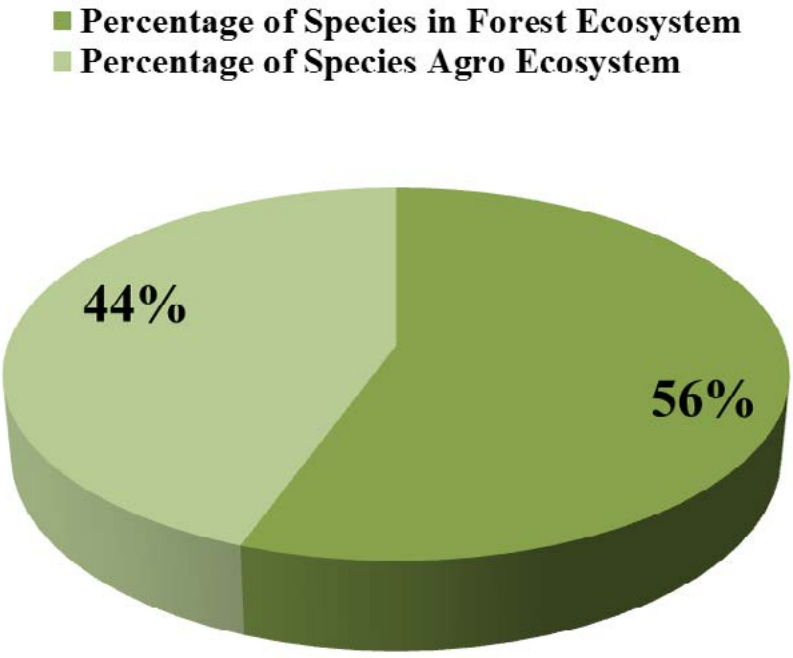

Figure 2. Percentage of Nematode species in Forest Ecosystem and Agro-Ecosystems

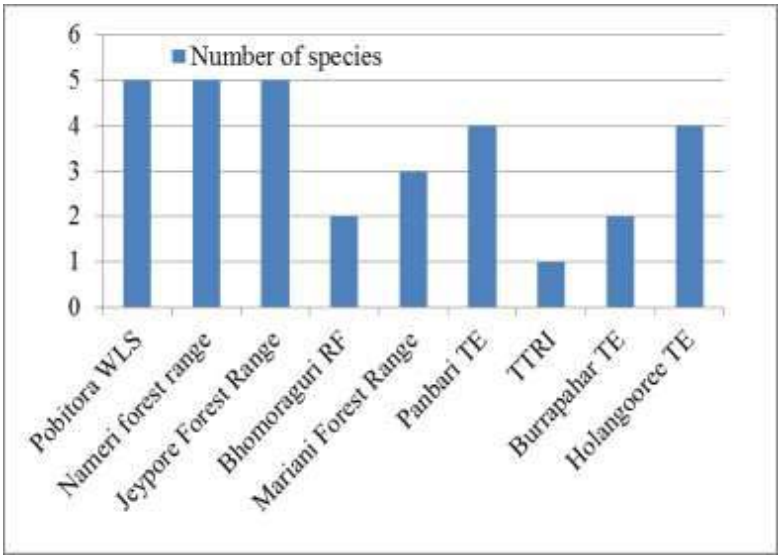

Figure 3. Number of species present in different protected areas and tea estates

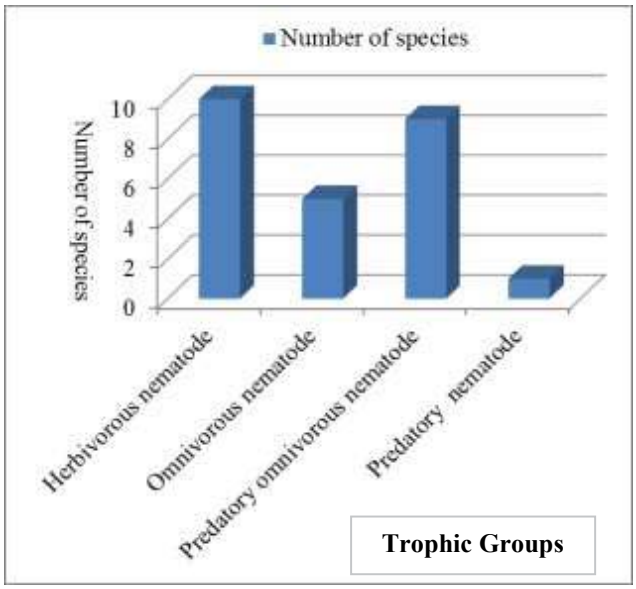

Figure 4. Number of species under different trophic groups of nematodes

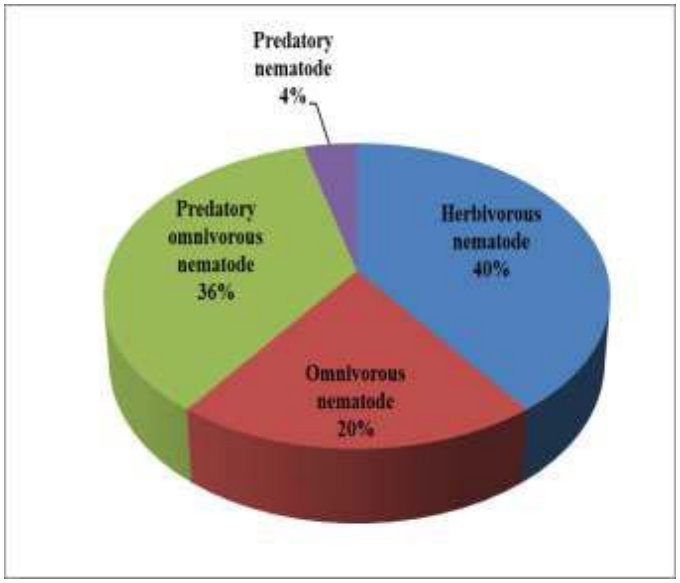

Figure 5. Percentage of nematode species under different trophic groups

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References

Ahmad, W., Baniyamuddin, M. and Tauheed, U. 2010. *Rhinodoryllaimus kazirangus gen*. n., ***sp. n. (Dorylaimida: Dorylaimidae) from kaziranga National Park, Assam, India.*** *Nematology*, **12***: 149 - 155.*.

Álvarez-Ortega, S., Subbotin, S. A. & Peña-Santiago, R. 2012. Morphological and molecular characterisation of *Aporcelaimellus simplex* (Thorne & Swanger, 1936) Loof & Coomans, 1970 and a new concept for *Aporcella* Andrássy, 2002 (Dorylaimida: Aporcelaimidae). *Nematology,* **15**:165-178.

Baniyamuddin, M. and Wasim, W. 2011. Two new and a known species of dorylaim nematodes (Dorylaimida: Nematoda) from Kaziranga National Park, Assam, India. *Journal of Natural History,* **45**: 2965-2980. 10.1080/00222933.2011.626125.

Bilgrami, A. L. 1995. Numerical analysis of the predatory relations between *Mesodorylaimus bastiani* (Nematoda: Dorylaimida) and different prey trophic categories. *Nematologia Mediterranea*, **23**: 81 – 88.

Bilgrami, A. L., Pervez, R., Yoshiga, T. and Kondo, E. 2001. Attraction and aggregation behavior of predatory nematodes, *Mesodorylaimus bastiani* and *Aquatides thornei* (Nematoda: Dorylaimida). *Applied Entomology and Zoology*, **36**: 243 – 249.

Bongers, T. and Bongers,M. 1998. Functional diversity of nematodes. *Applied Soil Ecology* **10**: 239-251

Christie, J. R. and Perry, V. G. 1951. Removing nematodes from soil. *Proceedings of Helminthological Society of Washington*, **17**: 106 – 108.

Cobb, N. A. 1918. Estimating the nema population of soil. *Agric. Tech. Cir.* Us Dept. Agric., **1**: 48pp.

Das, D., Deuri, R. and Das, P. 2016. Diversity of nematodes in North East India. *International Journal of Current Research,* **8**(1): 25023-25027.

Das, G. M. 1958. *Eel worms. Ann. Rept. Tocklai Expt. Stn. 1957-58*, p. 229.

Deuri, R., Choudhury, B. N. and Das. D. 2016. Diversity of plant parasitic nematodes associated with ornamental plants in Jorhat subdivision, Assam. *Current Nematology*, **27**(1): 63–67.

Heyns J. 1965. On the morphology and taxonomy of the Aporcelaimidae, a new family of dorylaimid nematodes. *Entomology Memoirs, Department of Agriculture Technical Services, Republic of South Africa*, **10**:1–51.

Heyns, J. 1968. A monographic study of the nematode families Nygolaimidae and Nygolaimellidae. *Entomology Memoirs, Department of Agriculture Technical Services, Republic of South Africa*, **19**: 1 – 144.

Jairajpuri, M. S. 1964a. Studies on Campydoridae and Leptonchidae (Nematoda: Dorylaimida) with description of *Basirotyleptus basiri* n. gen. n. sp. from India. *Proc. Helminth. Soc. Wash.*, **31**:59-64.

Jairajpuri, M. S. 1964b. Studies on genus *Proleptonchus* Lordello, 1955 (Dorylaimoidea: Leptonchidae) with description of two new species from India. *Nematologica*, **10**: 116-120.

Jairajpuri, M. S. 1964c. Studies on Nygellidae n. fam. And Belondiridae Thorne, 1939 (Nematoda: Dorylaimoidea) with description of ten new species from India. *Proc. Helmonth. Soc. Wash.*, **31**: 173 – 187.

Jena, R., B., Basumatary, B., Mohanta, & Pradhan, S. R. 2017. Comparative efficacy of bio control agents against root knot nematode (*Meloidogyne incognita*) infecting brinjal. *Journal of Entomology and Zoology Studies*, **5**(6): 254-257.

Khan, M. R., Somvanshi, V. S. and U. Rao, U. 2017. Emerging Nematode Pest of Rice, Wheat and Onion: Rice Root-Knot Nematode. *Popular Kheti,* **5**(3): 53-55

Neher, D. 2001. Role of nematodes in soil health and their use as indicators. *J.Nematol*.**33**: 161-168.

Pena-Santiago, R., Abolafia, J., Loof, P. A. A. 2000. Nematodes of the order Dorylaimida from Andalucia Oriental, Spain. The genus *Mesodorylaimus* Andrassy, 1959. III. On the identity of *M. bastiani* (Butschli, 1873) Andrassy, 1959. *Nematology*, **2**: 365 – 379.

Pena-Santiago, R. and Varela, I. 2017. Taxonomy and systematics of the genus *Makatinus* Heyns, 1965 (Nematoda: Dorylaimida: Aporcelaimidae). *Journal of Nematology*, **49**(3): 245 – 253.

Phukan, P. N. and Sanwal, K. C. 1980. Survey of plant parasitic and soil inhabiting nematodes of Assam. *J. Res. Assam Agri. Univ.,* **1**: 68-71.

Phukan, P. N. and Sanwal, K.C. 1979. Taxonomic studies on nematodes from Assam, India (Paratylenchidae: Tylenchida). *Indian J. Nematol.,* **9**: 20-26.

Saha, M., Lal, M., Singh, M. Kaushal, K. K. and Sharma, S. B. 2000. Four new species of Hoplolaimoidea (Nematoda: Tylenchida) from India. *International Journal of Nematology*, **10**(2): 192 – 198.

Thorne, G. 1974. Nematodes of Northern Great Plains. Part II. Dorylaimoidea in part, (Nematoda : Adenophorea). *Tech. Bull. Agric. Exp. Sta. South Dakota State Univ.,* **41**: 1 - 120.

Yeates, G. W. 1967. Studies on nernatodes frorn dune sands, 6, Dorylaimoidea. New *Zealand Jour . Sci*., **10**(3):752-784.

Yeates, G. W. 1971. Feeding types and feeding groups in plant and soil nematodes. *Pedobiologia*, **11**: 173 – 179.

Yeates, G. W. and Coleman, D. C. 1982. Nematodes in decomposition. In: *Nematodes in soil ecosystem* (Ed. D. W. Freckman) Austin, TX: University of Texas. pp. 55 – 80.

Yeates, G. W., Bongers, T., Goede de, R. G. M., Freckman, D. W. and Georgieva, S. S. 1993. Feeding habits in soil nematode families and genera – an outline for soil ecologists. *Journal of Nematology*, **25**(3): 315 – 331.