

Status of helminthiasis in livestock of Northeast India

V. TANDON and B. ROY*

Department of Zoology; *Sophisticated Analytical Instrument Facility, North-Eastern Hill University,
Shillong 793022
E-mail: tandonveena@gmail.com

Abstract

A review of literature revealed the occurrence of as many as 4 species of larval/adult cestodes, 31 species of trematodes and 22 species of nematodes among cattle, buffaloes, goats, sheep and pigs in Northeast India. Many of these parasites are found to be zoonotically important in the region. The present communication highlights the description, systematic position, epidemiology and molecular diagnosis of these parasites.

Key words: Helminths/ Parasites/ Livestock/ Northeast India

Northeast India is known for its vast resource of animal husbandry and most of the tribal people of the region consume beef, pork and mutton as main source of protein. However, poor status of animal health in the region¹⁻⁴ reflects the quality of meat available and possible danger of health hazards, particularly to the consumers of these infected animals. A total of 4 species of adult/larval cestodes, 31 species of trematodes and 22 species of nematodes are reported from cattle (*Bos indicus*), buffaloes (*Bubalus bubalis*), sheep (*Ovis aries*), goats (*Capra hircus*) and pigs (*Sus scrofa domestica*) in N.E India, of which several species are zoonotically important⁵⁻⁹.

Characters

Helminth parasites are multicellular, bilaterally symmetrical, triploblastic animals belonging to Phyla Platyhelminthes (Classes: Cestoidea and Trematoda), Nematoda and Acanthocephala. Identification of different species of worms is generally based on morphology, histomorphology of different organs, and scanning electron microscopy¹⁰⁻³⁵. The cestode, trematode and nematode worms parasitizing the livestock in Northeast India are listed below, with diagnostic features of each.

Cestodes (Phylum Platyhelminthes: Class Cestoidea: Order Cyclophyllidea)

***Moniezia expansa* (Rudolphi, 1810)** (Anoplocephalidae): Adult may reach up to 600 cm long; scolex having suckers but no rostellum or hooks; proglottids broader than long with two sets of genital organs; eggs somewhat triangular in shape, 0.056-0.067 mm in diameter. Parasitic in goat¹³. Locality: Assam, Meghalaya.

***Echinococcus granulosus* (Batsch, 1786)** (Taeniidae): Adult 2-7 mm long, having three or four proglottids; rostellum with two rows of hooks; genital pore opening in posterior half of proglottid; eggs 0.032-0.036 by 0.025-0.030 mm. Hydatid cyst (=larval stage, occurring in herbivorous /omnivorous mammals including man) generally 5-10 cm in diameter, usually unilocular, composed of a thick outer concentrically laminated membrane having a granular germinal membrane within it, brood capsules containing protoscolices developed within germinal layer; parasitic in various organs of cattle, buffalo, goat, sheep and pig¹³. Adult parasitic in intestine of dog and other canid hosts. Locality: Assam, Meghalaya.

***T. hydatigena* Pallas, 1766:** Adult 75-500 cm long; scolex bearing two rows of (26 and 46) rostellar hook; uterus having 6-10 lateral branches; oval eggs 36-39 by 0.31-0.35 mm. Cysticerci (= bladder worms, larval stage *Cysticercus tenuicollis*) white in colour having an everted head with long neck; parasitic in cattle, goat and pig^{1,8,13}. Adult parasitic in intestine of dog and wild carnivores. Locality: Assam, Meghalaya, Mizoram, Nagaland.

***T. saginata* Goeze, 1782:** Adult 4-8 m long; scolex with four suckers; ovary bilobed; uterus having 14-32 lateral branches; oval eggs 0.046-0.05 by 0.039-0.041 mm; cysticerci (*Cysticercus bovis*) milky white in colour, parasitic in cattle, goat^{1,8,13}. Adult tapeworm in intestine of man. Locality: Assam, Meghalaya, Mizoram, Nagaland.

***Taenia solium* Linnaeus, 1758:** Adult 4-8 mm long; scolex bearing rostellum having two rows of hooks; ovary trilobed; uterus having 7-16 lateral branches; spherical eggs 0.026-0.034 mm in diameter. Cysticerci (*Cysticercus cellulosae*) small, oval, 10-12 by 18-20 mm, parasitic in pig, man^{1,8,13}. Adult tapeworm parasitic in intestine of man. Locality: Assam, Meghalaya, Mizoram, Nagaland.

Trematodes (Class Trematoda: Order Digenea)

***Artyfechinostomum malayanum* (Leiper, 1971) Railliet, 1925** (Echinostomatidae: Echinostomatinae): Body elongated, 5-11 mm long, 2-5 mm in width; collar spines 39 in number, with 5 spines in each corner group, 6-8 rows of posteriorly directed bluntly rounded spines present in antero-dorsal surface immediately posterior to collar; eggs 0.113-0.135 by 0.067-0.090 mm³². The ventral surface of the body is provided with a dense covering of posteriorly directed scale-like spines arranged in an overlapping fashion. Parasitic in intestine of pig. Locality: Assam, Meghalaya, Tripura.

***Calicophoron calicophorum* (Fischøeder, 1901) Näsmark, 1937** (Paramphistomatidae: Paramphistominae): Body slightly bent ventrally, 7-12 mm long, 4-5 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of calicophoron type (everted genital pillar, genital sphincter and sphincter papillae present¹⁰); acetabulum of calicophoron type {dorsal exterior circular muscle (d.e.c.m.) and ventral exterior circular muscle (v.e.c.m.) not divided into two parts, dorsal and ventral halves of exterior circular muscle (e.c.m.) practically identical¹⁰}; eggs 0.108-0.135 by 0.063-0.081 mm. The anterior region of the body up to the level of genital pore is provided with domed papillae arranged in a regular pattern of concentric rows. A single row of conspicuous round ciliated papillae encircles the oral rim. The tegument lining of the genital papilla exhibits a pattern of fine anastomosing ridges, which also continue on to the floor of the genital atrium²⁷. Parasitic in rumen of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***C. papillosum* (Stiles et Goldberger, 1910) Näsmark, 1937:** Body elongated, 7-10 mm long; 3-3.5 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type, terminal genitalium of papillogenitalis type (genital atrium provided with tegumental papillae on its wall; genital sphincter weakly developed, sphincter papilla well developed¹⁴); acetabulum of calicophoron type^{15,18,32}. Parasitic in rumen of cattle. Locality: Tripura.

***C. shillongensis* Roy et Tandon, 1995:** Body conical, 7-11 mm long, 3-6 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of shillongensis type (deep, enormous ventral atrium, weakly developed genital papilla and sphincter papilla³¹); acetabulum of calicophoron type; eggs 0.09-0.158 by 0.058-0.087 mm. The oral rim and buccal lining have 2-3 circles of closely arranged petaloid structures, each of which is provided with two or more conspicuous domed and ciliated elevations^{31,32}. Parasitic in rumen of goats. Locality: Meghalaya.

***Cotylophoron cotylophorum* (Fischoeder, 1901) Stiles et Goldberger, 1910:** Body elongated, 5-8 mm long, 3-4 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of cotylophoron type (genital sucker having clear delimiting membrane against tissues of body present¹⁰); acetabulum of cotylophoron type (d.e.c.m. and v.e.c.m. clearly separated from interior acetabular tissue by an obliquely running longitudinally branched muscle band¹⁰); eggs 0.108-0.140 by 0.054-0.067 mm^{11,20}. Parasitic in rumen of cattle, buffalo. Locality: Assam, Meghalaya, Tripura.

***Explanatum explanatum* (Crepling, 1847) Fukui, 1929:** Body curved ventrally, 8-11 mm long, 5-6 mm in width; Laurer's canal crossing excretory vesicle; pharynx of explanatum type (smooth internal surface, both anterior and posterior pharyngeal sphincters present¹⁰); terminal genitalium of explanatum type (genital sphincter absent, sphincter papilla present, radial musculator of genital atrium well developed¹⁰); acetabulum of explanatum type (d.e.c.m. divided into two parts, d.e.c.m.1 and d.e.c.m.2; limit towards d.e.c.m.2 very sharp and clear¹⁰); eggs 0.090-0.135 by 0.063-0.081 mm. The ventral surface of the body is provided with numerous large aciliate papillae. The regions around the genital pore and acetabulum have smaller pimple-like scattered papillae^{19,32}. Parasitic in bile ducts of cattle, buffalo. Locality: Assam, Meghalaya, Mizoram, Tripura.

***Paramphistomum epiclitum* Fischoeder, 1904:** Body elongated, ventrally bent, 6-10 mm long; 2-3.5 mm in width, Laurer's canal crossing excretory vesicle; pharynx of calicophoron type (internal surface of pharynx is lined by small domed papillae¹²); terminal genitalium of epiclitum type (wall of genitalium is semicircular in outline giving false impression of sucker)¹⁰; acetabulum of paramphistomum type (d.e.c.m. divided into two parts, i.e., d.e.c.m.1 and d.e.c.m.2¹⁰); eggs 0.135-0.144 by 0.072-0.089 mm. The rim of the mouth opening is encircled by two rows of non-smooth domed papillae. The tegument in the anterior part of the body up to the genital opening region is provided with aciliate, domed papillae arranged in rings^{14,17,32}. Parasitic in rumen of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***P. gracile* Fischoeder, 1901:** Body curved ventrally, 5-7 mm long, 2-3 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of gracile type (wall of genital atrium strongly and uniformly developed, with a delimiting membrane against body tissue¹⁰); acetabulum of paramphistomum type; eggs 0.113-0.135 by 0.063-0.072 mm. The anterior half of the body has domed, smooth papillae arranged in concentric rows^{14,17,20}. Parasitic in rumen of cattle. Locality: Tripura.

***P. ichikawai* Fukui, 1922:** Body conical, 5-10 mm long, 2-3.5 mm in width; Laurer's canal crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of ichikawai type (genital papilla very thick, sphincter papillae well developed¹⁰); acetabulum of pisum type (an obliquely longitudinal muscle band limits d.e.c.m.1 and ventral exterior circular muscles (v.e.c.m.) from inner acetabulum tissue¹⁰); eggs 0.099-0.135 by 0.054-0.081 mm^{14,17,32}. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Tripura.

***Gastrodiscoides hominis* (Lewis et McConnell, 1876) Leiper, 1913 (Gastrodiscinae):** Body pyramidal, divided into anterior conical and posterior discoidal regions, 6-8 mm long, 4-5.5 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of watsonius type (pharyngeal bulb and secondary pharyngeal sac present¹⁰); acetabulum of watsonius type (c. m. units more strongly developed in exterior series, smaller and uniform in size in middle part of sucker¹⁰). The tegument surrounding the oral aperture is provided with papillae in 2-3 concentric rows. A conspicuous aggregation of raised, knob-like papillae is present in a circular fashion around the genital pore^{24,33}. Parasites of large intestine of pig, man. Locality: Assam, Meghalaya, Mizoram, Tripura.

***Homalogaster paloniae* Porier, 1883:** Body flat, ventrally papillated, 7-15 mm long, 4.5-6 mm in width; pharynx homalogaster type (pharyngeal bulb and secondary pharyngeal sphincter is present³³); terminal

genitalium of homologaster type (large genital papilla, strongly developed circular and longitudinal muscle fibre present beneath the area surrounding pores³³); acetabulum of homologaster type (v.e.c.m. divided into two groups, interior series increasing in unit size away from sucker rim³³); eggs 0.094-0.126 by 0.045-0.054 mm. The ventral surface of the body is covered with fleshy elevations arranged in longitudinal rows and the genital opening is surrounded by domed papillae³³. Parasitic in cattle, buffaloes. Locality: Assam, Meghalaya.

***Leiperocotyle meghalayensis* Roy et Tandon, 1990** (Orthocoeliinae): Body elongated, straight, 4-7.5 mm long, 2-3 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of cotylophoron type; acetabulum of streptocoelium type; eggs 0.113-0.144 by 0.067-0.081 mm. Anterior part of the body including genital opening region is provided with densely packed raised papillae. The tegument of the acetabular end is thrown in to convolutions and folds studded among which are present smooth-surfaced domed papillae in clusters of two or more^{16,28}. Parasitic in rumen of cattle. Locality: Meghalaya.

***Orthocoelium dawesi* (Gupta, 1958) Yamaguti, 1971**: Body elongated, 3-6 mm long, 1.5-2.5 mm in width; Laurer's canal do not cross excretory vesicle; pharynx of dicranocoelium type; terminal genitalium of dawesi type (presence of round to oval genital sphincter²¹); acetabulum of streptocoelium type; eggs 0.113-0.144 by 0.058-0.067 mm²¹. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***O. dicranocoelium* (Fischoeder, 1901) Yamaguti, 1971**: Body conical, 4.5-6 mm long, 1.5-2 mm in width; Laurer's canal not crossing excretory vesicle. Pharynx of dicranocoelium type (lip sphincter present¹⁰); terminal genitalium of gracile type; acetabulum of streptocoelium type; eggs 0.126-0.158 by 0.049-0.067 mm. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Tripura.

***O. dinniki* Eduardo, 1985**: Body conical, 4-6 mm long, 2.5-3 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of papillogenitalis type; acetabulum of streptocoelium type; eggs 0.113-0.158 by 0.067-0.070 mm. Smooth domed papillae are present in rings around the oral aperture²¹. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Meghalaya, Tripura.

***O. orthocoelium* (Fischoeder, 1901) Price et McIntosh, 1953**: Body conical, 9-12 mm long, 3.5-5 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of orthocoelium type (presence of a group of circular muscle units near anterior end forming anterior pharyngeal sphincter²⁰); terminal genitalium of orthocoelium type (thick genital papilla, well-developed genital sphincter and sphincter papilla present²¹); acetabulum of streptocoelium type {d.e.c.m. and v.e.c.m. units almost equal in size, dorsal interior circular muscle (d.i.c.m.) and ventral interior circular muscle (v.i.c.m.) units more in number than in exterior ones and relatively strongly developed interior circular series forming an arc-shaped curve¹⁰}; eggs 0.090-0.117 by 0.045-0.067 mm. The oral aperture is encircled by round, aciliate, button-like papillae arranged at a regular distance in between two ridges. The tegument surrounding the genital papilla is provided with tiny, irregularly scattered elevations^{21,32}. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***O. parvipapillatum* (Stiles et Goldberger, 1910) Eduardo, 1985**: Body elongated, 5-8.5 mm long, 2.5-3.5 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of dicranocoelium type; terminal genitalium of parvipapillatum type (genital fold provided with tegumental papillae²¹); acetabulum of streptocoelium type; eggs 0.090-0.158 by 0.058-0.090 mm. The tegument lining the genital atrium has blister-like papillae. Smooth papillae, in clusters of 2-4, also abound in the acetabular region, studded in between the radial tegumental folds of the sucker rim^{21,32}. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Tripura.

***O. scoliocoelium* (Fischoeder, 1904) Yamaguti, 1971:** Body conical, 3.5-5 mm long, 2-3 mm in width; pharynx of dicranocoelium type; terminal genitalium of scoliocoelium type (well-developed genital sphincter and sphinter papillae¹⁰); acetabulum of streptocoelium type; eggs 0.108-0.135 by 0.067-0.090 mm^{21,25}. Parasitic in rumen of cattle. Locality: Assam, Tripura.

***O. streptocoelium* (Fischoeder, 1910) Yamaguti, 1971:** Body conical, 4.5-7.5 mm long, 2-3.5 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of streptocoelium type (genital papilla thick, strongly developed sphincter papilla connected to well-developed genital sphincter¹⁰); acetabulum of streptocoelium type; eggs 0.108-0.117 by 0.053-0.067 mm. Several concentric rows of densely packed domed papillae abound in the circum-oral region and in the ventral region of the anterior half of the body^{21,32}. Parasitic in rumen of cattle, goat, sheep. Locality: Assam, Meghalaya, Nagaland.

***Olveria bos* Tandon, 1951 (Cladorchiinae):** Body conical, 6-9 mm long, 2.5-3 mm in width; oesophagus 'J' shaped; caeca with three coils; genital pore provided with genital sucker. The luminal surface of the pharynx has a crown of conical elevations. The tegument at the genital opening has a cluster of smooth cobble-stone like papillae^{33,34}. Parasitic in rumen of cattle. Locality: Assam, Meghalaya, Tripura.

***O. indica* Thapar et Sinha, 1945:** Body conical, 4.5-8.5 mm long, 2-4 mm in width; oesophagus 'J' shaped, caeca with two coils; terminal genitalium of papillogenitalis type; acetabulum of stichorchis type (d.e.c.m. and v.e.c.m. units very close to each other at the margin of acetabulum, i.c.m. spread over a large part of inner acetabular periphery¹⁰); eggs 0.099-0.135 by 0.054-0.072 mm²⁶. Parasitic in rumen of cattle. Locality: Assam, Meghalaya.

***Carmyerius spatiosus* (Brandes, 1898) Stiles et Goldberger, 1910 (Gastrothylacidae: Gastrothylacinae):** Body elongated, 7-11.5 mm long, 2.5-4 mm in width; pharynx of calicophoron type; terminal genitalium of gracile type; acetabulum of gastrothylax type. Concentric rows of ciliated papillae abound at the anterior extremity of the body, with a denser aggregation in the vicinity of the mouth. The ventral pouch opening is also provided with a cluster of cobblestone-like papillae. Clusters of 6-10 minute papillae are present between each radial fold of the acetabular rim³². Parasitic in rumen of goat, sheep. Locality: Tripura.

***Fischoederius cobboldi* (Poirier, 1883) Stiles et Goldberger, 1910:** Body elongated, 7.5-18 mm long, 5.5-8 mm in width; pharynx of calicophoron type; terminal genitalium of microbothrium type (genital sphincter considerable in size, well delimited from surrounding tissue, sphincter papillae fairly strongly developed¹⁰); acetabulum of gastrothylax type. The anterior region of the body including the rim of ventral pouch opening is provided with densely arranged conical papillae. Parasitic in rumen of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Tripura.

***F. elongatus* (Poirier, 1883) Stiles et Goldberger, 1910:** Body elongated, 6.5-21 mm long, 3-6 mm in width; pharynx of calicophoron type, terminal genitalium of elongatus type (genital papillae and median papillae provided with genital sphincter and ventral sphincter; tegumental papillae present only in median papilla³⁵); acetabulum of gastrothylax type; eggs 0.113-0.144 by 0.058-0.081 mm. Parasitic in rumen of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Gastrothylax crumenifer* (Creplin, 1947) Poirier, 1883:** Body elongated, 10.5-19 mm long, 5-7.5 mm in width; pharynx of calicophoron type; terminal genitalium of gracile type; acetabulum of gastrothylax type (inner cavity of acetabulum basin shaped, d.e.c.m. and v.e.c.m. displaying very large number of units, which exceeds that of units in d.i.c.m. and v.e.c.m.^{10,22}). Parasitic in rumen of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Tripura.

***Velasquezotrema tripurensis* Roy et Tandon, 1990** (Velasquezotrematinae): Body elongated, bent ventrally, 6-12 mm long, 2.5-4 mm in width; Laurer's canal not crossing excretory vesicle; pharynx of calicophoron type; terminal genitalium of tripurensis type (presence of domed papillae in the wall of protrusible ventral atrium, sphincter papillae weakly developed²⁷); acetabulum of gastrothylax type; eggs 0.108-0.158 by 0.054-0.090 mm. Tentaculate dome-shaped papillae are present in the anterior region of the body up to the ventral pouch opening; the rest of the body surface is provided with smooth, domed, scattered papillae³². Parasitic in rumen of cattle. Locality: Tripura.

***Eurytrema pancreaticum* (Janson, 1889) Looss, 1907** (Dicrocoeliidae: Eurytrematinae): Body flattened with ruffled margins and conical caudal appendage, 8.5-13 mm long, 5.5-9 mm in width; oral sucker larger than ventral sucker; eggs 0.027-0.045 by 0.022-0.036 mm; whole body surface covered with minute pointed spines^{29,32}. Parasitic in pancreatic duct of cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Tripura.

***Fasciola gigantica* Cobbold, 1858** (Fasciolidae: Fasciolinae): Body elliptical, flattened, 34-45 mm long, 8-12 mm in width; cephalic cone relatively short, 2.5-4.5 mm in length; entire body surface provided with densely packed dentate spines; eggs 0.126-0.158 by 0.058-0.090 mm. Flukes recovered from pigs revealed the presence of conspicuous button-like patches or shallow pits on the surface between oral and ventral suckers, each with a slightly raised distinct rim and irregularly perforated interior³². Parasitic in bile passages of liver in cattle, buffalo, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Fasciolopsis buski* (Lankester, 1857) Looss, 1899** (Fasciolopsinae): Body broadly ovate, elliptical with rounded posterior end, 33-58 mm long, 8-16 mm in width; eggs 0.144-0.171 by 0.081-0.094 mm. The tegument lining the buccal cavity is thrown into longitudinally running ridges and folds with tuberculated surface and provided with domed aciliate papillae in groups of 2-4. The ventral surface of the body is provided with backwardly directed broadly rounded scales³². Parasitic in large intestine of pig. Locality: Assam, Meghalaya.

***Opisthorchis noverca* Braun, 1902** (Opisthorchiidae: Opisthorchiinae): Body elongated, flattened, 3.5-8.5 mm long, 2-3 mm in width; oral sucker larger than ventral sucker; caeca more or less straight, reaching up to posterior third of body; testes rounded or lobate, diagonal in position in posterior end of body; vitellaria in lateral fields with eight follicle groups; eggs 0.018-0.028 by 0.009-0.013 mm. Both dorsal and ventral surfaces are provided with densely packed posteriorly directed spines^{32,34}. Parasitic in liver of pig. Locality: Assam, Meghalaya, Mizoram, Nagaland.

***Schistosoma indicum* Montgomery, 1906** (Schistosomatidae: Schistosomatinae): Male: 8-14 mm long, 0.5-1 mm in width; testes clustered, 6-12 in numbers, close behind ventral sucker. The antero-ventral region of the body up to the gynaecophoric canal has scattered, minute unciliate papillae; the tegument covering the oral and ventral sucker and also that lining the mouth is densely spinose; the posterior region of the body has a wavy contour and domed papillae, each with 12-18 spine-like elevations on its surface; the gynaecophoric canal is also provided with spines and pits. Female: thinner than male, 8.04-11.52 mm long, 0.18-0.22 mm in width; eggs 0.065-0.112 by 0.020-0.037 mm^{30,32}. The whole body is provided with spines and minute unciliate papillae and pits; Parasitic in mesenteric veins of cattle, buffalo. Locality: Assam, Meghalaya, Mizoram, Tripura.

Nematodes (Phylum Nematoda)

***Ascaris suum* Geoe, 1782** (Secernentea: Ascaridida: Ascaridoidea: Ascarididae: Ascaridinae): Body large, having three semicircular lips at anterior end, each lip bearing on its inner surface a row of minute denticles. Male; 185-210 mm long; caudal papillae 70-75 pairs, spicules equal in size, dorsoventrally

flattened. Female: 215-320 mm long; vulva opening near anterior third of body; eggs 0.06-0.07 by 0.04-0.05 mm¹³. Parasitic in intestine of pig. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Pseudocruzia orientalis* (Maplestone, 1930) Wolfgang, 1953** (Ascaridida: Cosmocercioidea: Kathlaniidae: Cruziinae): Body thicker in middle, cephalic extremity separated from rest of body by marked constriction; head with three subtriangular lips separated from one another by subsidiary lobes. Male: 15.0 mm long; tail conical, with small caudal alae. Female: 16-18 mm long; vulva opening near middle of body; eggs 0.10-0.11 by 0.05-0.06 mm¹³. Parasitic in intestine of pig. Locality: Assam, Meghalaya.

***Seteria bernardi* Railliet et Henry, 1911** (Spirurida: Filarioidea: Onchocercidae: Setariinae): Male: 95 mm long; left spicule longer than right, having tubular proximal and distal membranous portions. Female: 105-120 mm long, having spirally coiled tail with many short spines; vulva opening in oesophageal region¹³. Parasitic in peritoneal cavity of pig. Locality: Meghalaya.

***S. cervi* (Rudolphi, 1819) Baylis, 1936**: Male: 30-60 mm long; left spicule longer than right, having twisted distal portion. Female: 40-120 mm long, tail ending in a knob; vulva opening near anterior end¹³. Parasitic in peritoneal cavity of cattle, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***S. digitata* (Linstow, 1906) Railliet et Henry, 1911**: Body long, tapering towards hind end, latter spirally coiled; mouth surrounded by a circular ring that bears dorsal, ventral and lateral prominences. Male: 42-52 mm long; spicules unequal, right spicule short, curved ventrally. Female: 72-96 mm long; tail bent dorsally into loose spiral, terminating in spiral terminal knob, bearing 1-2 circlets of spikes; vulva projecting slightly above body surface in oesophageal region; eggs 0.45-0.59 by 0.28-0.36 mm¹³. Parasitic in peritoneal cavity of cattle. Locality: Meghalaya.

***Gnathostoma doloresi* Tubangui, 1925** (Spirurida: Gnathostomatoidea: Gnathostomatidae: Gnathostomatinae): Body stout, globular cephalic bulb present following large trilobed lips armed with 8-9 rows of backwardly directed spines; whole body provided with transverse rows of backwardly spines. Male 26-28 mm long; tail with papillae-like termination; four pairs of large, stout lateral caudal papillae present; spicules unequal. Female: 30-44 mm long, having blunt tail surrounded by large cuticular inflation; vulva opening behind middle of body. Parasitic in stomach of pig. Locality: Meghalaya.

***Ascarop dentata* (Linstow, 1904)** (Spiruroidea: Spirocercidae: Ascaropsinae): A Cervical ala present only on left side of body; buccal capsule provided with a pair of teeth anteriorly; wall of pharynx strengthened by thickenings in the form of a triple or quadruple spiral. Male: 20-25 mm long. Female: 20-55 mm long¹³. Parasitic in stomach of pig. Locality: Meghalaya.

***A. strongylina* (Rudolphi, 1809)**: Small-sized worm having long pharynx. Male: 10-21 mm long; right caudal ala about twice as large as the left; 4 pairs of precloacal papillae and 1 pair of postcloacals situated asymmetrically; left spicule longer than right. Female: 16-20 mm long, red in colour; eggs 0.034-0.039 by 0.020 mm¹³. Parasitic in stomach of pig. Locality: Meghalaya.

***Physocephalus sexalatus* (Molin, 1860) Diesing, 1861**: Small-sized worm; mouth tooth less; cuticle of anterior extremity slightly inflated in region of pharynx followed by three cervical alae on either side. Male: 6-13 mm long; caudal alae narrow, symmetrical; spicules unequal. Female 13-23 mm long; eggs 0.034-0.039 by 0.015-0.017 mm¹³. Parasitic in stomach of pig. Locality: Meghalaya.

***Globocephalus connorfili* Lane, 1922** (Strongylida: Ancylostomatoidea: Ancylostomatidae: Ancylostomatinae): Small-sized worm; mouth opening subdorsally, having a pair of triangular teeth; buccal capsule funnel shaped with external chitinous ring. Male: 3.5-5 mm long; bursa well developed; spicules slender, equal in size, accessory piece present. Female: 4-7.5 mm long, having pointed tail; vulva

opening slightly posterior to mid-body; eggs 0.05-0.06 by 0.030-0.036 mm¹³. Parasitic in intestine of pig. Locality: Meghalaya, Nagaland, Tripura.

***Bunostomum trigonocephalum* (Rudolphi 1808) Railliet, 1902** (Ancylostomatidae: Bunostomatinae): Anterior end bent dorsally; buccal capsule opening anteriorly. Male: 12-17 mm long; bursa with asymmetrical dorsal lobe; spicules slender, alate, slightly twisted. Female: 12-26 mm long, tail tapering to point; vulva opening little ahead of middle of body; eggs 0.06-0.08 by 0.04-0.05 mm¹³. Parasitic in intestine of sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Bourgelatia diducta* Railliet, Henry et Bauche, 1919** (Strongyloidea: Chabertiidae: Oesophagostominae): Small-sized worm having striation throughout length of body; buccal capsule cylindrical and shallow, its thick wall divided into anterior and posterior portions. Male: 8-12 mm long; bursa well developed; spicules long, equal, having transverse alae. Female: 10-13.5 mm long, having one pair caudal papillae; vulva opening near anus; eggs 0.04-0.05 by 0.027-0.036 mm¹³. Parasitic in caecum, colon of pig. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Oesophagostomum aspersum* Railliet et Henry, 1913** (Oesophagostominae): Mouth-collar in form of truncated cone, marked off by well-defined groove posteriorly; cephalic vesicle inflated; external corona radiatum present. Male: 11-17 mm long; bursa well developed; spicules paired, equal in size. Female: 15.0-17.0 mm long; tail tapering abruptly; vulva opening little away from posterior end of body; eggs 0.06-0.08 by 0.03-0.04 mm¹³. Parasitic in large intestine of goat, sheep. Locality: Assam, Meghalaya, Mizoram.

***O. columbianum* (Curtice, 1890) Railliet et Henry, 1913**: Anterior end curved dorsally, cervical groove extend around the ventral surface of the lateral aspects of the body. Lateral alae originating immediately behind cervical groove, extending almost whole length of body. Male 12-17 mm long; having well-developed bursa, spicules equal; alate with blunt tips. Female: 15-22 mm long; vulva opening little anterior to anus; eggs 0.064-0.069 by 0.02-0.04 mm¹³. Parasitic in colon of goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***O. dentatum* (Rudolphi, 1803) Molin, 1861**: Pair of cervical papillae symmetrically placed behind middle of oesophagus, possessing bristle-like terminations; two corona radiata present. Male: 8-10 mm long; spicules equal in size, alate with blunt tips; Gubernaculum present. Female: 8-14 mm long, vulva little anterior to anus; eggs 0.050-0.055 by 0.027-0.030 mm¹³. Parasitic in large intestine of pig. Locality: Meghalaya.

***O. radiatum* Travassos et Vogelsang, 1932**: Medium-sized worms, anterior end bent like hook; lateral alae well developed, beginning at cervical groove, extending up to posterior end of body; leaf-crowns present; cervical papillae situated at mid level of oesophagus. Male: 9-17 mm long; bursa well developed; spicules equal in size; alate; gubernaculum present. Female: 13-22 mm long; strait tail tapering to sharp point; vulva opening in front of posterior end; eggs 0.05-0.07 by 0.02-0.03 mm¹³. Parasitic in colon of cattle. Locality: Assam, Meghalaya, Tripura.

***Stephanurus dentatus* Diesing, 1839** (Strongyloidea: Syngamidae: Stephanurinae): Medium-sized worms, having circular mouth with external corona radiata; buccal capsule cup shaped. Male: 20-30 mm long; bursa short; spicules equal in size, with transversely striated alae; heart-shaped gubernaculum present. Female: 30-45 mm long; body bent ventrally; short tail; vulva opening in front of anus; eggs 0.08-0.09 by 0.05-0.06 mm¹³. Parasitic in perirenal fat, in or near kidneys in pigs. Locality: Assam, Meghalaya, Mizoram, Tripura.

***Haemonchus contortus* (Rudolphi, 1803) Cobb, 1898** (Trichostrongyloidea: Trichostrongylidae: Haemonchinae): Filiform worm, anterior tip with numerous symmetrically arranged longitudinal cuticular

ridges. Male: 10-20 mm long; bursa with symmetrical lateral lobes; short spicules, each provided with small barb on its outer surface; gubernaculum present. Female: 18-30 mm long; sharply pointed tail; vulva opening at posterior region of body; eggs 0.050-0.069 by 0.02-0.04 mm¹³. Parasitic in abomasum of cattle, goat, sheep. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Mecistocirrus digitatus* (Linstow, 1906) Railliet et Henry, 1912** (Mecistocirrinae): Body markedly attenuated, tapered anteriorly, cervical papillae prominent; small buccal capsule containing a lancet-like curved tooth; body cuticle with fine transverse striations, bearing about thirty longitudinal ridges. Male: 17-31 mm long; bursa well developed, having two lateral and one dorsal lobes; long, slender spicules having funnel-shaped head. Female: 16-43 mm long; tail conical; vulva opening near posterior extremity; eggs 0.09-0.11 by 0.050-0.059 mm¹³. Parasitic in abomasum of cattle. Locality: Assam, Meghalaya, Mizoram, Nagaland, Tripura.

***Strongyloides papillosus* (Wedl, 1856) Ransom, 1911** (Rhabditida: Rhabditoidea: Strongyloididae): Female: 3-4 mm long, having six lips in mouth; cuticle finely striated; vulva situated at 60% of total length from anterior end of body; eggs 0.040-0.060 by 0.020-0.025 mm. Parasitic in intestine of goat, mithun. Locality: Meghalaya, Arunachal Pradesh¹.

***Trichuris globulosa* (Linstow, 1901) Ransom, 1911** (Adenophorea: Enoploida: Trichuroidea: Trichuridae: Trichurinae): Body slender, anterior oesophageal region constituting two-third to three-quarters of its length; cuticle inflated as tiny vesicle-like structures one on either side of head; ventral longitudinal bacillary band composed of numerous unicellular subcuticular glands with rod-like processes. Male: 58-72 mm long, having single expanded spicule. Female: 60-78 mm long, posterior end bluntly rounded; vulva opening at junction of anterior slender and posterior stout portions¹³. Parasitic in caecum of goat, sheep. Locality: Assam, Meghalaya, Mizoram, Tripura.

***T. ovis* (Abildgaard, 1795) Smith, 1908**: Male: 44-78 mm long, having single spicule; spicule sheath bearing slightly stretched globular expansion at its distal end. Female: 58-85 mm long, vulva opening at junction of anterior oesophageal and posterior stout reproductive portions¹³. Parasitic in caecum of sheep. Locality: Meghalaya.

Epidemiology

Appearance of helminth infections and epidemiology are closely related to the food habit and nature of living of animals and ecology of intermediate hosts (snails, crabs, insects, fishes etc.). Frequent rains, high humidity and moderate temperature can predict a hyperendemic infection in herbivorous animals, because of the possibility of exposure to infective stages of helminths being more during the rainy season. Among trematodes the prevalence of *Eurytrema pancreaticum*, *Fasciola gigantica*, *Explanatum explanatum*, *Gastrothylax crumenifer* and *Schistosoma indicum*, in ruminant in Northeast India³⁶ differs from that recorded in other parts of India and also in other countries³⁷⁻⁴⁰, which may be due to different agroclimatic conditions prevailing in the region. All the four species of trematodes recorded from pigs viz. *Artyfechinostomum malayanum*, *Fasciolopsis buski*, *Gastrodiscoides hominis* and *Oopisthorchis noverca* are zoonotically important and prevalence of these species in the region bears an epidemiological significance too, since except *O. noverca*, all of them have been reported from human hosts in the region⁴¹⁻⁴³. Although at present no data is available for human fascioliasis and eurytremaeosis in the region, the zoonotic potential of *E. pancreaticum* and *F. gigantica* cannot be ignored⁴⁴. A high prevalence of fascioliasis (40-60%) throughout the year as recorded in Northeast India^{36,45} is suggestive of the fact that essential requirements for the completion of the life cycle of the fluke, i.e., high moisture, moderate temperature and availability of the snail intermediate host, are continually fulfilled in the region. Similar trends of infection have also been recorded in several places in India⁴⁶, Puerto Rico⁴⁷, Pakistan⁴⁸ and USA⁴⁹. Highest prevalence of *E. pancreaticum* as observed during winter in the region can be attributed to an increase in the availability of the insect second intermediate hosts, i.e., grasshoppers⁵⁰ and

recruitment of infection during the preceding summer/early autumn months. Higher prevalence and intensity of *A. malayanum*, *F. buski* and *G. hominis* in pigs during late summer³⁶ indicates the emergence of a larger number of cercariae from snail hosts during late spring, thus resulting in a higher prevalence of mature worms during late summer.

The variations pertaining to the prevalence and seasonal fluctuations of the various fluke species in a particular region can be attributed to the presence or absence of the intermediate host species in that area. The biology of the larval stages of flukes, and also of the snail hosts, is influenced to a great extent by ecological factors such as temperature, water quality and speed of water currents, etc.⁵¹⁻⁵³. *O. noverca* is a common liver fluke of dog, swine and man, though it can also parasitise the pancreas of pigs. The parasite has also been recorded from the liver of a cow in Meghalaya⁵⁴.

Of the nematode species recorded from pigs in the region^{55,56}, *Ascaris suum*, *Bourgelatia diducta* and *Oesophagostomum dentatum* revealed a high frequency of occurrence. The overall rate of infection was found to be higher (76.42%) in the low-altitude regions than in the high-altitude (62.50%). Further there seems to be a seasonal fluctuation in the occurrence of these worms, with highest level of infection (73.2%) during autumn and lowest, during winter⁵⁶. Cattle harbored several species of nematodes, of which *Setaria digitata* is the most commonly occurring species in the region^{57,58}. With 6 species of nematodes parasitizing goats, *Haemonchus contortus* (52.7%) followed by *Bunostomum trigonocephalum* (41.7%) emerged as the most prevalent species⁵⁹. The occurrence of *Setaria cervi* in goats in Tripura⁶⁰ seems significant, as the infection in abnormal hosts causes serious pathogenic manifestations.

Regarding metacestodiasis (infections of larval stages of cestodes), the hydatid cyst infection occurs throughout the world because of its ability to adapt to a variety of domestic and wild intermediate hosts⁶¹⁻⁶³. A higher rate of infection was recorded among cattle (7.52%) than in goats (3.34%) and pigs (2.33%) in Northeast India⁶³. A higher incidence of the diseases has been also recorded in cattle than in other animals in different regions of the world^{64,65}. Prevalence of fertile cysts in goats (73-76%) was higher than in cattle (16.6-23.95%) and pigs (20-33%) in the region. Higher rate of fertile hydatid cysts in goats was also observed in neighbouring Pakistan⁶⁶ and North Jordan⁶⁷. The fertile hydatid cysts occurring in the slaughtered animals provide a ready source of infection to canine hosts, which harbor the adult form of the worm *Echinococcus granulosus*. The prevalence of *Cysticercus tenuicollis* (1.43%, 5.26% & 21.56% respectively) among cattle, pigs and goats of *C. bovis* (5.73% & 2.6%) among cattle and goats and of *C. cellulosae* (7.01%) among pigs indicates the potent source of *Taenia* infection to the consumers of beef, mutton and pork in the region⁸.

Molecular diagnosis

Immunological procedures are based on measurement of one or more components of specific immune response directed to parasite antigens or based on the detection of parasite antigens in body fluids. Helminth parasites produce long standing chronic infections resulting in elevated levels of serum antibodies that are generated during the course of infection. These raised antibodies provide a strong basis for the development of sensitive and specific serodiagnostic methods for parasite detection. A number of immunological techniques have been developed that are based on the detection of helminth antibodies. The major specific antibodies detected are IgE, IgG, IgA and IgM. Although testing for antibody has been in practice, major emphasis is now focused on methods designed to detect circulating parasite antigen or parasite-specific immune complexes. This offers better advantages of distinguishing active infection from past experience or recovered cases. At present most commonly used serological methods are: Immunoelectrophoresis, based on arc-5 (IEP-5); Double diffusion (DD); Passive haemagglutination (PHA); Latex agglutination (LA); Bentonite flocculation (BFT); Indirect immunofluorescence antibody test (IFAT); Western blotting (WB); Enzyme-linked immunosorbent assay (ELISA); Enzyme-linked immunoelectrotransfer blot assay (EITB); Polymerase Chain Reaction (PCR) and DNA probe hybridization⁶⁸⁻¹⁰¹.

Immunoelectrophoresis carried out on *Taenia saginata*, *Cysticercus* sp., *Fasciola hepatica*, *Paramphistomum* sp. and *Ascaris suum* revealed that antisera obtained by infecting 0.5 ml each of these antigens (helminth) and the same amount of complete Freund's adjuvant into rabbits led to formation of large number of precipitin arcs in homologous antigen-antibody reactions. This experiment gave an important method for identifying species through immunological diagnosis⁶⁸.

ELISA using cysteine proteinases (digestive enzymes of parasites) for immunodiagnosis of parasitic diseases like fascioliasis, schistosomiasis and paragonimiasis has proved to be a good and sensitive diagnostic tool⁶⁹⁻⁷¹. Purification of cysteine proteinases is a time-consuming complex process. However, it is observed that the cysteine-capture ELISA could detect anti-cysteine proteinase antibodies without the need for purified cysteine proteinases. Ikeda⁷² developed an ELISA using chicken cystatin as a capture agent for the immunodiagnosis for fascioliasis and paragonimiasis and detected specific antibodies to fluke's cysteine proteinases. ELISA test for antigenicity of nine major fractions (namely F1 to F9) of *Gigantocotyle explanatum* extract using sera from *G. explanatum*-infected buffalo revealed that F1 and F2 were most antigenic. The antigenic molecules of each fraction were mostly in the low molecular weight ranging from <14 to >94 kDa with the polypeptides in the range of >14, 14, 18, 21-25 and 34-36 kDa⁷³. Immunogenicity of excretory/secretory (ES) metabolic products and somatic extract of *Gastrothylax crumenifer* was evaluated by immunoblotting and ELISA using sera raised against ES and somatic antigens in rabbits and the presence of 22 and 27 antigenic polypeptides, respectively was revealed. Of these, only 11 and 13 antigenic polypeptides were specific to ES and somatic extract, respectively⁷⁴, thus opening the possibility of acting as immunodiagnostic tool.

Itagaki *et al.* studied the ITS2 sequence of DNA derived from eggs of *Calicophoron calicophorum*, *Orthocoelium streptocoelium* and *Homalogaster paloniae* through PCR-RFLP based on rDNA ITS2 marker and showed that the sequence difference between species was 4.2-5.3%. Thus it is possible to identify these species on the basis of difference in the restriction sites of AccII on the ITS2 sequence⁷⁵.

Presence of parasite-specific IgG and IgE antibodies in the serum is a strong indicator of infection caused by *Opisthorchis viverrini*, especially IgE level whose mean value was almost 20 times higher in infected hosts than normal controls. Sirisinha *et al.*⁷⁶ showed that it is possible to detect as little as 0.1ng of *O. viverrini* antigen in the patient's faeces through monoclonal antibody-based ELISA. Further, when a specific *O. viverrini* DNA probe is used in a dot blot hybridization of parasite DNA, the labeled probe can detect DNA released from as few as five *O. viverrini* eggs. Thus, both approaches were highly specific.

Cathepsin LI (CLI), an immunogenic cysteine proteinase secreted by juvenile and adult *F. hepatica* can specifically stimulate host's immune system to produce IgG4 as detected by ELISA (CLI-IgG4-ELISA) test. It was observed that 7-140 kDa ES antigens of *F. hepatica* could discriminate infected and non-infected sheep with 100% sensitivity and 100% specificity through ELISA test⁷⁷.

A PCR-based procedure for detection of *O. viverrini* in snail and fishes was developed by Maleewong *et al.*⁷⁸. The procedure was based on primers designed from a pOV-A6 specific probe sequence giving a 330 base-pair product. The PCR can detect as little as a single cercaria infection in a snail or a single metacercaria in a fish with 100% positivity rate for infected snails or fishes. The method did not yield a 330 base-pair amplified product with other digenean flukes' DNA, such as *Echinostomum malayanum*, *F. gigantica*, animal schistosomes, *Paragonimus* spp and *Haplorchis* sp., thus providing a great potential for application in epidemiological survey of snail and fish parasites.

ELISA and immunoblot are particularly important among the immunological tests used for the diagnosis of swine cysticercosis. Highest detection rate (51%) was observed by immunoblot test followed by ELISA (37%)⁷⁹. Tsang *et al.*⁸⁰ showed that low molecular weight glycopeptides of *T. solium* react with the majority (13 kD=59%; 14 kD=48%; 18 kD=70%; 21 kD=82%; 24 kD=94%) of human sera from patients with cysticercosis. Larval antigens of *T. crassiceps* used by Pinto *et al.*⁸¹ for diagnosis of swine

and human cysticercosis revealed the occurrence of five absolutely specific peptides (25-23 kD, 22 kD, 21 kD, 20-19 kD and 14 kD), which reacted only with positive control sera and did not react with negative sera or with the sera responsible for cross reaction. 84.5% positive sera reacted with at least one of these peptides. Immunoblot test using *T. crassiceps* antigen against swine cysticercosis showed 96.6% specificity and 100% sensitivity⁸¹.

Immunodiagnosis of cystic echinococcosis is considered to be a useful tool that can also confirm clinical findings based on the identification of cyst structures by imaging techniques such as ultrasonography⁸²⁻⁸⁵. *E. granulosus* hydatid cyst fluid (HCF) is the usual source of antigenic material for immunodiagnostic assay⁸⁵. However, there are difficulties associated with the currently available tests due to lack of sensitivity, specificity and cross-reactivity with antibodies of other taeniid cestodes using HCF antigens. The sensitivity and specificity of enzyme-linked immunoelectrotransfer blot (EITB) for diagnosis of hydatid disease in sheep were found to be 88% and 84%, respectively, whereas the corresponding rates for ELISA were 60% and 94%, respectively⁸⁶. In this context, recently it has been observed that a novel cDNA, termed as EpCI, isolated by immunoscreening from *E. granulosus* cDNA library, subcloned into a pET vector and expressed as fusion proteins tagged with GST and affinity purified against the GST tag, achieved sensitivity and performance at the rate of 92.2 and 95.6%, respectively for serodiagnosis of human and animal hydatidosis^{87,88}.

Different serodiagnostic methods (e.g. IFAT, ELISA etc.) are in use to detect strongyloidiasis-specific antibodies⁸⁹⁻⁹¹, but such tests show cross-reactivity with schistosomes, filariae, hookworm, *Ascaris lumbricoides*, *Trichuris trichiura* and *Echinococcus*⁹²⁻⁹⁴. Several antigenic components including ES proteins of *Strongyloides stercoralis* were detected by infected human sera^{95,96}. Experiments on antigenicity of *S. ratti*, *S. venezuelensis* and *S. stercoralis* suggest that the rodent *Strongyloides* species might be used as antigen sources for the diagnosis of human strongyloidiasis instead of *S. stercoralis*⁹⁷. A comparative analysis involving the three most commonly used serodiagnostic methods, WB, ELISA and IFAT, using *S. ratti* larval antigenic extract to detect serum IgG revealed a high rate of sensitivity (96%, 100% & 90%, respectively) and specificity (96%, 98% & 100%, respectively) in human strongyloidiasis. In case of positive ELISA and negative IFTA results, diagnosis can be confirmed by WB technique, which can recognize as many as 11 immunodominant antigenic components of *S. ratti* larval extract⁹⁸. Several recombinant clones from a cDNA library prepared from the infective stage of *S. stercoralis* revealed that recombinant proteins are more reactive than larval somatic antigen with no cross reactivity with filarial or intestinal nematode infection. Recombinant antigens can detect parasite specific IgE and IgG4 antibodies in *Strongyloides*-infected patients⁹⁹.

Visceral larval migrans (VLM) is a clinical syndrome caused by *Toxocara* spp, particularly in children. Since it is difficult to detect the larvae in tissues, diagnosis is mostly based on serology by ELISA and WB technique using larval ES product; however, cross reaction is reported with sera from *Ascaris suum* infected hosts¹⁰⁰. The ELISA method also showed high rate of sensitivity (93%) and specificity (98%) for serodiagnosis of gnathostomiasis when crude extract of adult *Gnathostoma doloresi* was used¹⁰¹.

Advance towards development of vaccine

Helminth parasites excrete or secrete a variety of molecules through their specialized excretory or secretory (ES) organs and cuticle/integument into mammalian hosts. These ES molecules of parasites are found to be the source of antigens for immune system of the host. In some host-parasite systems ES antigens may induce host-protective immune responses and this source of protective antigens has been utilized in successful vaccination against helminth infections, e.g. vaccine against trichurid nematodes and metacystode stage of cestodes¹⁰². Immunochemical identification of protective antigens and their production by recombinant DNA technology has been uniquely successful in the Taeniidae compared with other eukaryotes¹⁰³. Vaccination with the resultant products causes strong protective immunity after natural infection. Antigens from oncosphere cause strong cross immunity between *Taenia* species and

immunity is largely antibody mediated as evidenced by passive and maternal transfer of immunity. 45W antigen (glutathione-s-transferase) of *T. solium*, isolated as a recombinant protein from *Escherichia coli*, is found to be highly effective as it can protect the animal for a period of 1 year. Four more antigens T016k & T018 (from *Taenia obis*) and TSA9 & TSA18 (from *T. saginata*) were found to be highly protective as the vaccine gave >94% and 98% protection in cattle and sheep, respectively. Synthetic peptides from the sequences of these Taeniidae antigens induce antibody but not protection, indicating that the protective epitopes seemed conformational. Recently, however, reasonable levels of protection were induced experimentally in piglets exposed to natural *T. solium* challenge using synthetic peptides based on protein sequences of the murine parasite, *Taenia crassiceps*¹⁰⁴.

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