

## SPECTRUM OF HELMINTH PARASITES IN NORTH-EAST INDIA

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The review summarizes the work done to date, on the occurrence and distribution of helminth parasites among the various vertebrate groups, including humans in North-East India. Of the seven administrative states of the region, some have remained untouched from helminthiasis point of view; for others, there is scattered and scanty information available. Based on the reports that have appeared in the literature so far, helminth parasites recorded from fishes, amphibians, birds, livestock and humans are listed. Some of the parasite species recorded from these vertebrates, acquire added significance because of their zoonotic importance.

**Key words :** Helminths; North-East India; Zoonosis.

Introduction .....	57
Host groups explored for parasitic infections....	59
Fishes .....	59
Amphibia .....	59
Birds .....	63
Mammals.....	64
Conclusions .....	69
References .....	70

### INTRODUCTION

The diversity to helminth fauna in the Indian subcontinent is reflected in various surveys carried out from time to time by many-workers in different parts of the country. However, barring a countable scattered studies, the north-eastern region did not get much attention in this regard. This region, covering an area of 2,55,000 sq. km. (about 7.7% of the total geographic area of the country) is a distinct geographic unit. Presently comprising sever administrative states viz., Assam, Meghalaya, Arunachal Pradesh, Nagaland Manipur, Mizoram and Tripura (Fig. 1), the north-eastern region of India is a known area of high endemism with a rich diversity in its biocoenospectrum. I

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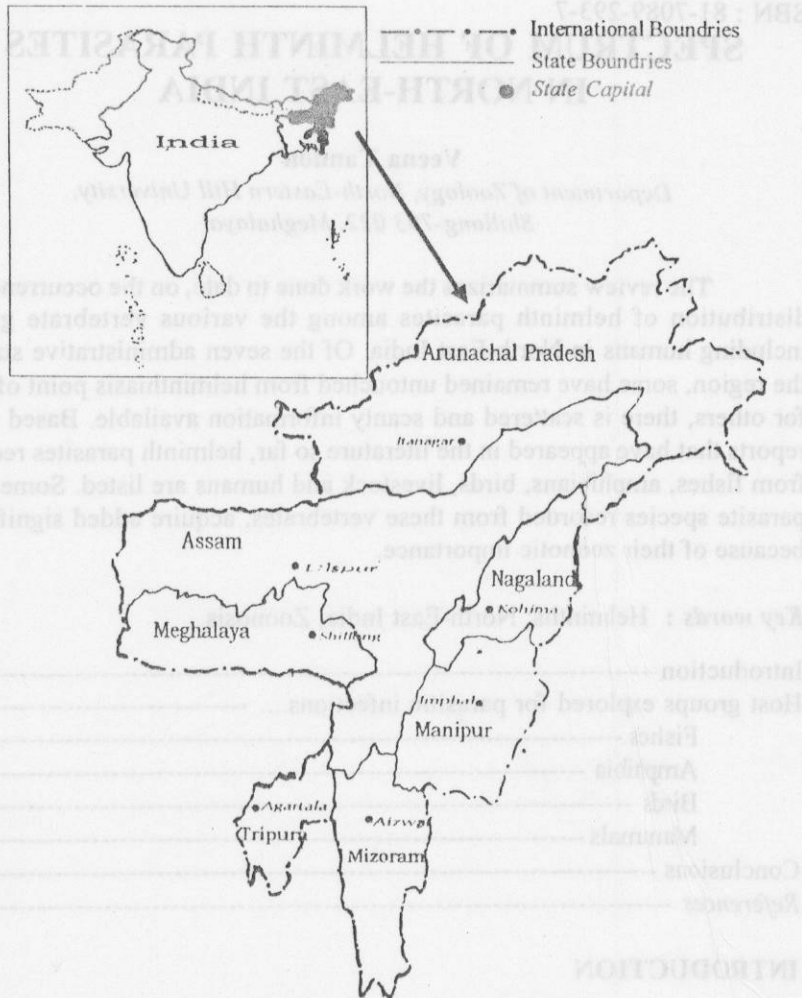


Fig. 1 : Map of North-East India (not to scale).

has a wide variation in topography ranging from plains of Brahmaputra valley to Meghalaya plateau and Himalayan mountain ranges and possesses a monsoon or super humid climate, though with considerable climate variation owing to its complex topography and size.

Research into the parasitofauna in North-East India is at different levels. The earlier studies conducted in the region pertain to medico-veterinary aspects (Chandler, 1926-28; Endrejat, 1964) in the erstwhile Greater Assam. Though sporadic reports and descriptions of parasite species from fish or amphibian hosts appeared from scattered localities in the region, the more

complete and systematic study of the helminth parasitofauna began in the 1980s, with region-wise and host-wise surveys. However, the greatest amount of material has been studied with regard to only some groups of vertebrates—amphibia and livestock in particular, which have attracted considerable attention. While no work seems to have been done on this aspect in Arunachal Pradesh, there is scanty information available on the distribution and abundance of helminth parasites in respect of only some host groups from Mizoram, Manipur and Tripura states. The main objective of this review is to present a general and concise description of the helminth parasite spectrum in the animal and human hosts in North-East India based on the available information.

## HOST GROUPS EXPLORED FOR PARASITIC INFECTIONS

### Fishes

Of the piscine hosts, the cyprinoid fishes reveal an overall low prevalence of helminth infections, with nematodes emerging as the predominant group. However, in the siluroid fishes, parasitization by the monozoic cestodes is quite common. Caryophyllidean cestodes are widely distributed among the freshwater siluriform and cypriniform fishes of the world. Represented by about 126 species and 45 genera, the caryophyllids constitute approximately one-fourth of the cestode fauna of the freshwater fishes (Mackiewicz, 1972). Four species of the genus *Lytocestus*—*L. indicus* (Moghe, 1925) Woodland, 1962; *L. birmanicus* Lynsdale, 1956; *L. filiformis* (Woodland, 1923) Fuhrman and Baer, 1925 and *L. longicolis* Rama Devi, 1973, and *Djombangia penetrans* Bovien, 1926 have been reported from the catfish, *Clarias batrachus* in the north-eastern region (Chakravarty and Tandon, 1988). Another catfish, *Heteropneustes fossilis*, which also shares the same benthic habitat as *C. batrachus*, does not show a diversified parasitic infection and harbours only a single species of *Lytocestus*. All the caryophyllid species from *Clarias* exhibit a pattern of seasonal fluctuation in their occurrence; while the incidence of infection is low during the summer months, the peak period of prevalence is during late winter or early spring months. Based on the histopathological studies, *D. penetrans* is highly pathogenic, producing large nodules in the intestinal wall as a result of complete penetration (Chakravarty and Tandon, 1989).

### Amphibia

The north-eastern region of India has a rich diversity of anuran amphibian fauna. Of about 54 species of Anura reported from the region, 21

are endemic (Chanda, 1994). In view of the richness and endemism of this fauna of the region, occurrence of isolationist helminth infections is also expected. Diversity of helminth infra-communities of anuran amphibia from Meghalaya and Nagaland states has been well studied; while the helminth spectrum comprises 17 different parasite types occurring in Meghalaya, that in Nagaland reveals a total of 28 species (Tables 1,2).

The monogenean genus *Polystoma*, encountered only from and apparently restricted to the rhacophorid and hylid frogs dwelling in arboreal habitats, is so far recorded only from the north-eastern states in the Indian subcontinent (Diengdoh and Tandon, 1991; Imkongwapang, 1997). Though the prevalence of this polystomatid, *P. indicum* Diengdoh and Tandon, 1991 is quite low, the intensity of adult flukes in adult hosts is lower than that of the larval stages that occur in metamorphosing tadpoles (Dutta and Tandon, 2000).

**Table 1 :** Helminth parasites of anurans\* in Meghalaya.

Parasite	a	b	c	d	e	f	g	h	i	j
<b>Monogenea</b>										
<i>Polystoma indicum</i>	-	-	-	-	-	-	-	-	+	+
<b>Trematodes</b>										
<i>Haematoleuchus almorai</i>	+	+	-	-	-	-	-	-	-	-
<i>Gorgoderina ellipticum</i>	+	+	-	-	-	-	-	-	-	-
<i>Ganeo tigrinum</i>	+	+	-	+	-	-	-	-	-	-
<i>Halipegus mehransii</i>	+	-	-	-	-	-	-	-	-	-
<i>Pleurogenoides gastroporus</i>	+	-	-	-	+	-	-	-	-	-
<i>Diplodiscus amphichrus</i>	-	-	-	+	-	-	-	-	-	-
<i>Mesocoelium monas</i>	-	-	-	-	-	-	-	-	-	+
<b>Cestodes</b>										
<i>Baerietta baerxi</i>	+	-	-	-	-	-	-	-	+	-
<i>Plerocercoid larva</i>	+	-	-	+	-	-	-	-	+	-
<b>Nematodes</b>										
<i>Oswaldocruzia goezei</i>	+	-	-	-	-	+	-	-	-	-
<i>Oxysomatium macintoshii</i>	-	-	-	+	-	-	-	-	-	+
<i>Oxysomatium</i> sp.	+	-	-	+	+	+	+	+	-	-
<i>Rhabdias ranae</i>	-	+	-	+	-	-	+	-	+	+
<i>Aplectana</i> sp.	-	-	-	-	-	-	-	-	+	-

cont....

**Acanthocephala**

*Acanthocephalus bufonis* - - - - - + - - - - -

\* a - *Euphlyctis cyanophlyctis*, b - *Limnolectis limnocharis*, c - *Rana alticola*,  
 d - *Hoplobatrachus tigerina*, e - *Rana danielli*, f - *Bufo melanostictus*,  
 g - *Amolops afghanus*, h - *Philautus shillongensis*, i - *Rhacophorus nigropalmatus*, j - *Polypedates leucomystax*.

Of the parasitofauna of amphibia, the trematodes form the largest component in the spectrum. While most of the species recorded from the region are already known and occur elsewhere in the country, representatives of the genus *Cryptotropa* (Lecithodendriidae) and of *Batrachrotrema* (Opcoeliidae) are perhaps the first reports; both were recovered from ranid frogs of lotic habitats.

The cestode component of the spectrum is represented by a single adult form *Baerietta baeri* and a metacestode plerocercoid form; the latter inhabiting muscles of hind limbs or thoracic region of frogs, represents the larval stage of the pseudophyllidean cestodes (Miyazaki, 1991) and may have a zoonotic implication (Tandon and Impkongwapang, 1999). Of the eleven nematode species recorded, for many species identification was not possible either for want of more material or of male specimens. The occurrence of *Icosiella* sp. from the enteric location in its host (unpublished observation) is interesting since *Icosiella* spp. are known to occur as tissue parasites.

**Table 2 :** Helminth parasites of anurans\* in Nagaland.

Parasite	a	b	c	d	e	f	g	h	i	j	k	l	m
<b>Monogenea</b>													
<i>Polystoma indicum</i>	-	-	-	-	-	-	-	-	-	+	+	-	+
<b>Trematodes - adult</b>													
<i>Gorgoderina ellipticum</i>	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Diplodiscus amphichrus</i>	-	-	-	-	-	-	-	-	-	-	+	-	+
<i>Diplodiscus mehrai</i>	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Halipegus mehransis</i>	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Mesocoelium modas</i>	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Cryptotropa</i> sp.	-	-	-	+	-	-	-	-	-	+	-	-	-
<i>Ganeo tigrinum</i>	-	-	-	+	-	+	+	+	+	+	-	-	+
<i>Haematoloechus almorai</i>	-	-	-	+	-	+	+	+	+	+	-	-	+
<i>Pleurogenoides gastroporus</i>	+	-	-	-	-	+	+	+	+	-	-	-	-

cont....

<i>Batrachotrema</i> sp.	+	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Mehraorchis ranarum</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<b>Trematodes- metacercaria</b>														
<i>Cathaemasia</i> sp.	-	-	-	-	-	-	-	-	-	+	+	+	+	+
<i>Proalarioides</i> sp.	-	-	-	-	-	-	-	-	-	+	+	+	+	+
<b>Cestodes</b>														
<i>Bareietta baeri</i>	-	-	-	-	-	-	-	-	-	+	-	+	-	-
Plerocercoid sp.1	-	-	-	-	-	-	-	-	-	+	+	+	+	+
<b>Nematodes</b>														
<i>Alpectana</i> sp.1	+	+	-	-	+	+	-	-	-	+	+	-	+	+
<i>Aplectana</i> sp.2	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<i>Oxysomatium</i> sp.	+	+	-	+	+	+	+	+	+	+	-	+	+	+
<i>Cosmocercella</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<i>Rhabdias ranae</i>	+	+	-	-	-	-	-	-	-	+	+	+	+	+
<i>Oswaldocruzia goezei</i>	-	-	-	-	-	-	-	-	-	+	+	+	+	+
<i>Ophidascaris</i> sp.	-	-	-	-	-	-	-	-	-	+	+	+	+	+
<i>Ampliaecum</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Icosiella</i> sp.1	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Icosiella</i> sp.2	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<i>Kalicephalus</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<b>Acanthocephala</b>														
<i>Acanthocephalus bufonis</i>	-	-	-	+	-	-	-	-	-	+	+	-	-	-

\*a - *R. khare*, b - *R. nagalandensis*, c - *R. liebigii*, d - *Rana* sp., e - *L. mawphlangensis*, f - *L. limnocharis*, g - *H. tigerinus*, h - *E. cyanophlyctis*, i - *A. afghanus*, j - *H. nectens*, k - *R. nigropalmatus*, l - *R. reinwardtii*, m - *P. leucomystax*.

From the apodan, *Ichthyopsis glutinosa* only one helminth type, the nematode *Oswaldocruzia goezei* has been encountered (Diengdoh, 1989). The acanthocephalan, *Acanthocephalus bufonis* is so far the only species known to represent the group and reported from the north-eastern region.

Helminths with indirect life cycles predominate in the depauperate helminth fauna of amphibia (Aho, 1990; Muzzal, 1991). It seems that the general prevalence pattern of helminth infections in amphibian hosts is influenced by more than any other factor, the ecology of the individual host species.

Nematodes emerge as the more predominant group among the amphibian hosts with a terrestrial or semi-aquatic life in comparison to trematode parasites which predominate in hosts with more aquatic habitat.

### Birds

The information relating to the helminth parasite fauna of avian hosts from the north-eastern region of the country is mainly limited to birds of food value (Tables 3, 4). The parasite spectrum of poultry (*Gallus gallus domesticus*), in view of their economic importance has been studied and well documented for Assam and Meghalaya (Endrejat, 1964; Gogoi, 1974; Gogoi and Hazarika, 1977; Gogoi and Chaudhuri, 1981; Yadav and Tandon, 1988, 1991). Likewise, domestic pigeon (*Columba livia domestica*) is a popular source of meat among the rural folk of Assam. Its helminth faunal load was studied by Gogoi *et al.* (1984). Gogoi and Islam (1989) also described a new species of nematode parasite, *Excisa columbi* from pigeon.

**Table 3 :** Helminth parasites of poultry (*Gallus gallus domesticus*) in North-East India.

Parasite	Assam	Meghalaya
<b>Trematodes</b>		
<i>Echinostoma revolutum</i>	+	+
<i>Prosthogonimus pellucidus</i>	+	-
<i>Catantropis indicus</i>	+	+
<b>Cestodes</b>		
<i>Raillietina tetragona</i>	+	+
<i>R. echinobothrida</i>	+	+
<i>R. cesticillus</i>	+	+
<i>R. dattai</i>	+	-
<i>R. assamensis</i>	+	-
<i>Amoebotaenia sphenoides</i>	+	-
<i>A. yamagutii</i>	+	-
<i>Hymenolepis contaniana</i>	+	-
<i>H. carioca</i>	+	+
<i>H. rugosa</i>	+	-
<i>H. macracanthos</i>	+	-
<i>H. clausa</i>	+	-
<i>Davainea proglottina</i>	+	-
<i>Cotugnia</i> sp.	+	- cont.....

**Nematodes**

<i>Ascaridia galli</i>	+	+
<i>Heterakis gallinae</i>	+	+
<i>Acuaria spiralis</i>	+	-
<i>Capillaria</i> sp.	+	-
<i>Capillaria annuata</i>	-	+
<i>C. contorta</i>	-	+

**Table 4:** Helminth parasites of pigeon (*Columba livia domestica*) in Assam.

Trematodes	Cestodes	Nematodes
<i>Echinostoma revolutum</i>	<i>Raillietina michaelsoni</i>	<i>Caillaria columbae</i>
<i>Echinoparyphium recurvatum</i>	<i>R. fragilis</i>	<i>Ascaridia columbae</i>
<i>Metaechinostoma amurensis</i>	<i>R. johri</i>	<i>Strongyloides</i> sp.
<i>Paratanaisia bragai</i>	<i>Hymenolepis rugosa</i>	<i>Filaria</i> sp.
<i>Hypoderma conoideum</i>	<i>H. macracanthos</i>	<i>Excisa columbi</i>
	<i>H. clausa</i>	<i>Cotugnia</i> sp.

Gogoi and Chaudhuri (1982) contributed to the biology of the fowl cestodes, *Raillietina* spp. They (Gogoi and Chaudhuri, 1983, 1985) also described two new species, *Raillietina (Paroniella) assamensis* and *Amoebotaenia yamagutii*, both from the intestine of domestic fowl.

A digenetic trematode, *Opisthorchis brahminii* has also been reported from the liver of wild brahmini duck, *Tadorama ferruginea* in Assam (Gogoi *et al.*, 1982).

The occurrence of the caecal nematodes *Capillaria annulata* and *C. contorta*, reported from poultry in Meghalaya, forms the only Indian record of these species (Yadav and Tandon, 1988).

**Mammals**

Among mammals (excluding humans), livestock (cattle, buffaloes, goats, sheep and pigs) have been explored (Tables 5, 6). The prevalence of helminth infections in the livestock is quite high in the north-eastern region of the country, the spectrum being the richest in Assam. While the status of trematodiasis has been studied in several states of the region, reports of other helminthic infections are confined mainly to Assam and Meghalaya.

Of the 31 species of digenetic flukes reported from cattle, buffalo, goat, sheep and pigs in this region, three species viz., *Calicophoron shillongensis*, *Leiperocotyle meghalayensis* and *Velasquezotrema tripurensis* have been described as new species from the North-East, while two species,

**Table 5:** Helminth parasites of bovine and ovine hosts\* in North-East India.

Parasite	Assam		Meghalaya		Nagaland		Mizoram		Tripura		
	C	G/S	C	G/S	B	C	G/S	C	G/S	C	G/S
<b>Trematodes</b>											
<i>Paramphisomum epiclitum</i>	+	+	+	+	+	+	-	+	-	-	+
<i>P. ichikawai</i>	+	-	-	-	-	-	-	-	-	-	+
<i>P. gracile</i>	-	-	-	-	-	-	-	-	-	-	+
<i>Calicophoron calicophorum</i>	+	+	+	-	+	+	-	-	+	-	+
<i>C. papillosum</i>	-	-	-	-	-	-	-	-	-	-	+
<i>C. shillongensis</i>	-	-	-	+	-	-	-	-	-	-	-
<i>Cotylophoroncotylophorum</i>	+	-	+	-	+	-	-	-	-	-	+
<i>Explanatum explanatum</i>	+	-	+	-	+	-	-	-	+	-	-
<i>Orthocoeilium orthocoeilium</i>	+	+	+	+	-	+	-	+	-	-	-
<i>O. dicranocoeilium</i>	+	+	+	-	-	-	-	-	+	-	+
<i>O. dawesi</i>	+	+	+	+	-	-	-	-	+	-	+
<i>O. scolicoeili</i>	+	+	-	-	-	-	+	-	-	-	+
<i>O. streptocoeilium</i>	+	+	+	+	-	-	-	-	-	-	-
<i>O. parvipapillatum</i>	+	+	-	-	-	-	-	-	-	+	+
<i>O. dinniki</i>	+	-	-	-	-	-	-	-	-	-	+
<i>Lyperocotyle meghalayensis</i>	-	-	+	-	-	-	-	-	-	-	-
<i>Olveria indica</i>	+	-	+	-	-	-	-	-	-	-	-
<i>O. bos</i>	+	-	+	-	-	-	-	-	-	-	+
<i>Homalogaster paloniae</i>	+	-	+	-	+	-	-	-	-	-	-
<i>Gastrothylax crumenifer</i>	+	+	+	+	+	-	-	+	-	+	-
<i>Fischoederius elongatus</i>	+	+	+	+	+	+	-	+	+	+	+
<i>F. cobboldi</i>	+	+	+	-	+	-	-	-	-	-	-
<i>Carmyerius spatiosus</i>	-	-	-	-	-	-	-	-	-	-	+
<i>Velasquezotrema tripurensis</i>	-	-	-	-	-	-	-	-	-	-	+
<i>Fasciola gigantica</i>	+	+	+	+	+	+	-	+	-	+	+
<i>Eurytrema pancreaticum</i>	+	-	+	+	+	-	-	-	-	+	-
<i>Opisthorchis noverca</i>	-	-	+	-	-	-	-	-	-	-	-
<i>Schistosoma indicum</i>	+	-	+	-	+	-	-	+	-	-	-
<i>S. spindale</i>	+	+	-	-	-	-	-	-	-	-	-
<i>S. nasale</i>	+	+	-	-	-	-	-	-	-	-	-

cont.

**Metacestodes**

<i>Hydatid cyst</i>	+	+	+	+	+	+
<i>Cysticercus bovis</i>	+	+	+	+	+	-
<i>C. tenuicollis</i>	+	+	-	+	+	+
<i>C. cellulosae</i>	-	-	-	-	-	-

**Nematodes**

<i>Haemonchus contortus</i>	+	+	+	+		
<i>Bunostomum columbianum</i>	-	+	-	+		
<i>Oesophagostomum columbianum</i>	-	+	-	+		
<i>O. aspersum</i>	-	-	-	+		
<i>O. radiatum</i>	-	-	+	-		
<i>Mecistocirrus digitatus</i>	+	-	+	-		
<i>Setaria digitatus</i>	-	-	+	-		
<i>Setaria cervi</i>	-	-	-	-	-	+
<i>Trichuris globulosa</i>	-	-	-	+		
<i>T. ovis</i>	-	-	-	+		
<i>Neoascaris</i> sp.	+	-	-	-		
<i>Strongyloides</i> sp.	+	-	-	-		

\* C - Cattle, B - buffalo, G/S - goat/sheep.

*Orthocoelium parvipapillatum* and *O. dinniki* have not been reported so far from other parts of the country (Roy and Tandon, 1989a, 1990a,b, 1995, 1996). *Fasciolopsis buski*, *Gastrodiscoides hominis*, *Opisthorchis neverca* and *Artyfechinostomum sufraryfex* (= *A. malayanum*), which have been reported from swine hosts in one or the other state of the region, all have zoonotic importance (Chandra, 1984; Roy and Tandon, 1992b). *Fasciola gigantica*, commonly occurring in ruminant hosts, has been reported from pigs as accidental parasite and so is *O. neverca* from cattle (Roy and Tandon, 1992c). The livestock in the region also has *Schistosoma* spp. infection (Rajkhowa *et al.*, 1992). Though adult cestodes of these hosts have not been studied systematically, the prevalence of metacestode infection has been investigated. The occurrence of *Cysticercus bovis* among the beef cattle reveals a potent source of *Taenia* infection in the region. While the hydatid cyst occurs in cattle, goat/sheep and pigs in all the states surveyed, *C. tenuicollis* infection was not found in pigs from Mizoram and cattle from Nagaland. Likewise, goats from Mizoram were found free from *C. bovis* infection (Roy and Tandon, 1989b).

The nematode spectrum in the livestock from the region is quite diversified. With eleven species occurring in pigs, *Ascaris suum*, *Oesophagostomum dentatum* and *Bourgelatia diducta* are the commonly

occurring species, the first being the most prevalent one (Dev Sarma and Gogoi, 1986; Yadav and Tandon, 1989a). Filarial infection of *Setaria bernardi* in pigs has also been recorded from Meghalaya (Yadav and Tandon, 1989d). *Gnathostoma hispidum* is yet another species of zoonotic significance. In goats, from which six nematode species are known to occur, strongylids emerge as the most prevalent nematodes (Yadav and Tandon, 1989b). All the nematode species encountered are common parasites of goats/sheep of different climatic areas of the world. However, species of *Trichostrongylus*, *Ostertagia*, *Cooperia*

**Table 6 :** Helminth parasites of pigs (*Sus scrofa*) in North-East India.

Parasite	Assam	Meghalaya	Nagaland	Mizoram	Tripura
<b>Trematodes</b>					
<i>Gastrodiscoides hominis</i>	+	+	-	+	-
<i>Gastrodiscus aegypticus</i>	+	-	-	-	-
<i>Fasciolopsis buski</i>	+	+	-	-	-
<i>Opisthorchis neverca</i>	+	+	+	-	-
<i>O. tenuicollis</i>	+	-	-	-	-
<i>Artyfechinotomum</i> <i>sufartayfex</i> (= <i>A. malayanum</i> )	+	+	-	-	-
<b>Metacestodes</b>					
<i>Hydatid cyst</i>	+	+	+	+	+
<i>Cysticercus tenuicollis</i>	+	-	+	+	-
<i>C. cellulosae</i>	+	-	+	+	+
<b>Nematodes</b>					
<i>Ascaris suum</i>	+	+	-	-	-
<i>Physocephalus sexalatus</i>	+	+	-	-	-
<i>Ascarops strongylina</i>	+	+	-	-	-
<i>A. dentata</i>	-	+	-	-	-
<i>Gnathostoma hispidum</i>	-	+	-	-	-
<i>Globocephalus connorfili</i>	-	+	-	-	-
<i>Pseudocruzia orientalis</i>	-	+	-	-	-
<i>Bourgelatia diducta</i>	-	+	-	-	-
<i>Oesophagostomum</i> sp.	+	-	-	-	-
<i>Oesophagostomum</i> <i>dentatum</i>	-	+	-	-	-
<i>Stephanus dentatus</i>	-	+	-	-	-

cont...

<i>Setaria bernardi</i>	-	+
<i>Metastrongylus apri</i>	-	+
<i>Trichuris suis</i>	+	-
<i>Simonsia paradoxa</i>	+	-
<b>Acanthocephala</b>		
<i>Marcracanthorhynchus</i>	+	+
<i>hirudinaceus</i>		

and *Strongyloides* which have commonly been reported from other parts of India and the world, have not been encountered from Meghalaya. Among cattle, *Setaria digitata* is the most commonly occurring species in the region (Borkakoty *et al.*, 1984; Yadav and Tandon, 1989c). The reported occurrence of *Setaria cervi*, a common filaroid worm of bovine hosts from Tripura goats seems significant (Yadav *et al.*, 1988), because *Setaria* infections in abnormal hosts are known to cause serious pathogenic manifestations.

Among human infections, the digenetic trematode infections of cattle with *F. gigantica* in the bile passages and *E. pancreaticum* in the pancreatic duct of pigs with *O. noverca* in the liver and *A. surfrartyfex*, *F. buski* and *G. hominis* in the intestine are significant owing to their zoonotic potential (Kumar, 1980; Sharma and Gogoi, 1986; Roy and Tandon, 1992b). Except for *O. noverca*, all the other three species have been reported from human subjects in Assam (Lane, 1915; Buckley, 1939; Stoll, 1947; Bandopadhyay and Nandy, 1986). Diastomiasis due to *Fasciola hepatica* and *Clonorchis sinensis* has been reported from human subjects in Assam (Mahanta *et al.*, 1995a; Narain *et al.*, 1997). Detection of heterophid eggs in human stools also indicates the prevalence of *Heterophyes* or *Metagonimus* infection in the region (Mahanta *et al.*, 1995b). For cercarial dermatitis occurring among the paddy field workers in Assam, *Schistosoma spindale* has been implicated (Narain *et al.*, 1994, 1998). Paragonimiasis, which is more prevalent in China, Japan, Korea and Philippines where crabs (the second intermediate host) are often consumed raw, has been recorded from tiger, dog, cat, mongoose etc. from various parts of India, too (see Blair *et al.*, 1999). Chandler and Read (1961) had indicated Bengal, Assam and some other parts of the country as endemic foci of human paragonimiasis. Recently, infection of *Paragonimus westermani* has been reported in a sizable population of Manipur (Razaque *et al.*, 1991; Singh *et al.*, 1993).

Of the cestode parasites in the region, the most commonly reported species from human hosts are *Taenia solium* and *T. saginata*. The pseudophyllidean cestode, *Diphyllobothrium latum*, naturally occurring in dogs in Assam, has zoonotic significance (Gogoi and Lahkar, 1983).

The nematode parasite spectrum in human hosts has been found to comprise *Ascaris lumbricoides*, *Ancylostoma* sp., *Enterobius vermicularis*, *Strongyloides stercoralis* and *Trichuris trichiura* as the prevalent species in Assam (Mahanta and Lahkar, 1983; Mahanta *et al.*, 1996b). Besides, filarial (*Wuchereria bancrofti*) infection is prevalent among the tea workers, descendents of tribal migrated population (from Orissa, Bengal, Uttar Pradesh and South India) in tea estates of Upper Assam (Dutta *et al.*, 1995; Khan *et al.*, 1998a, b, c; Prakash *et al.*, 1998). There is also a report of eye infestation by *Thelazia* sp. (Mahanta *et al.*, 1996a). Most of the members of this nematode genus are known to occur in cattle, sheep, goats, buffalo, dog, rabbit and deer. Chandler (1926-28) reported that while the entire north-western and Deccan part of India was free from hookworm infection, a high incidence of it occurred in Bihar, Orissa and some parts of (erstwhile) Assam state; the degree of infection was low and the intensity light in the hills of Assam. Recent studies in Assam, even after a gap of nearly six decades, still show a high prevalence of hookworm infection in human populations, particularly those in tea gardens (Regional Medical Research Centre, N.E. Region, ICMR, Assam, 1993: Annual Report). Coprological examination of selected rural communities in Meghalaya revealed the occurrence of single or multiple nematode species infections involving *Necator americanus*, *A. lumbricoides* and *T. trichiura* (Lyndem *et al.*, 1998). The ambient climatic conditions of summer months in the rural subtropical high rainfall area of Meghalaya are better suited for transmission and recruitment of infection in comparison to cold winter months when no egg development takes place (Tandon *et al.*, 1998). Single or multiple-species infections of intestinal nematodes viz., *A. lumbricoides*, *T. trichiura*, *E. vermicularis* and hookworm (*Nector/Ancylostoma*) prevail in Manipur also (Dhanchand and Anand, 1997).

### CONCLUSIONS

Survey of helminth parasites prevailing in the north-eastern region of India is far from complete. Considering the vast area lying still unexplored, diversified habitats and faunal endemism of the region, a large number of helminth species, many of them isolationist, are expected to be occurring in the region and awaiting recognition. There is a need to gain much more information about the prevalence and diversity of helminth infection in piscine, amphibian, reptilian, avian and mammalian hosts (including man) in all the states of the region, with particular emphasis on the locales with hilly terrains of Arunachal Pradesh, Mizoram, Nagaland and Manipur.

The public health and economic impact of meat- and fish-borne zoonoses of helminthic origin is considerable in terms of morbidity

(or mortality) in humans as well as losses due to reduced productivity in animals and condemnation of parasitised fish or meat. Food practices (such as consumption of aquatic plants growing in contaminated water, uncooked or inadequately cooked fish, amphibians, crustaceans, insects and snails) prevailing in certain societies of the region would facilitate transmission of many of these infections (e.g. species of *Clonorchis*, *Opisthorchis*, *Paragonimus*, intestinal flukes, metacestodes and adult cestodes, and *Gnathostoma* to name a few). The epidemiology and biology of helminths in animal and human hosts need to be studied in conjunction with different physiographic and ambient climatic conditions for evaluating their zoonotic potential, if any.

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