J Parasit Dis (June & December 2009) 33(1&2):28–35

ORIGINAL ARTICLE

J P D

Helminth parasite spectrum in rodent hosts from bamboo growing areas of Mizoram, North-east India

C. Malsawmtluangi • V. Tandon

Received: 15 August 2009 / Accepted: 28 September 2009

Abstract In the northeastern state of Mizoram, India the rodent outbreak is periodic and coincides with bamboo (*Melocanna baccifera*) bloom causing a tremendous destruction to food crops that often results in famine. The present study was undertaken during the bamboo flowering period (2006–2008) to assess the parasite spectrum and load in the bourgeoning rodent population of the affected region. The survey results of the populations of 9 prevalent rodent species revealed that nematodes were the most dominant parasitic group followed by cestodes of the order Cyclophyllidea; however, the trematodes were found to be conspicuously missing. The nematodes harbored by the rodents belonged to the genera: *Syphacia, Aspicularis, Trichuris, Rictularia, Capillaria, Trichosomoides, Nippostrongylus, Hepatojarakus and Heterakis,* whereas the cestode genera included *Hymenolepis, Raillietina* and *Taenia. Hymenolepis diminuta* was the commonly encountered species. Only one acanthocephalan (*Moniliformis* sp.) could be collected during the entire study.

Key words Bamboo flowering, Rodent outbreak, Helminth parasites, Biological control

Introduction

Rodents are one of the most successful, abundant and destructive pests inflicting incalculable losses to standing crops, harvested crops on threshing floors, stored food grains, etc. (Singh et al. 1995). The wild rodents in particular, serve as reservoir hosts and have greater ability to harbor a number of helminth parasites that can be transmitted to human beings and other vertebrates (Oldham 1931), thus aiding in dissemination of these worms and causing zoonoses (Durden et al. 2000; Stojevic et al. 2004). The helminths of public health importance reported (Khalil 1986) from rodent hosts include species of *Trichinella, Angiostrongylus* and *Capillaria* (nematodes); *Hymenolepis, Rallietina* and *Echinococcus* (cestodes); and *Schistosoma, Paragonimus* and *Echinostoma* (trematodes).

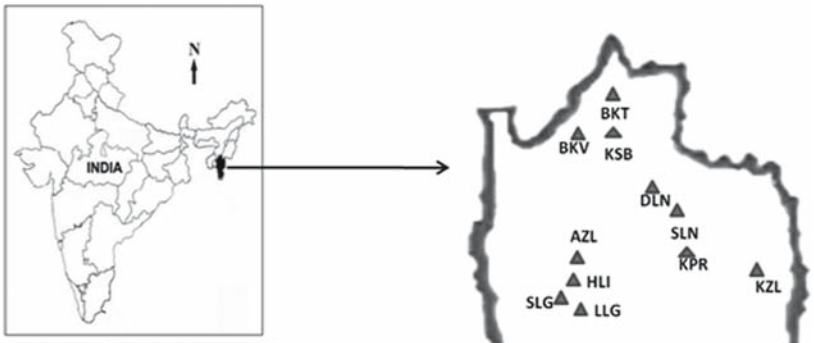
The rodent outbreak has been reported from various parts of the world (Pal 1993). Two types of ratadas, the rainfall and bamboo-flowering-associated rodent eruptions or outbreaks, have been prevalent in South America since the Spanish conquest in the 16th, century though the first record of ratadas associated with bamboo flowering and subsequent mast seeding at cycle of 30 years, appeared in literature since the late 1800s (Jaksic and Lima 2003). Outbreaks of '*Nuu khii*' (= rats of the bamboo flower), reported from the uplands of Laos (Singleton and Petch 1994; Schiller et al. 1999), are believed to be triggered by episodic and synchronized flowering and seeding of certain bamboo species as also reported from Japan (Numata 1970). In Mizoram, the hilly state of north-east India where 31% of the total forest area is covered by bamboo forests, the rodent outbreaks at the time of flowering of a bamboo species (*Melocanna baccifera*) caused tremendous destruction of food crops resulting in famine (Nag 1999). In this bamboo species the flowering locally known as 'Mautam', occurs periodically after every 48 ± 1 years and was expected to occur

C. Malsawmtluangi • V. Tandon ✉
Department of Zoology, North-Eastern Hill University,
Shillong, Meghalaya - 793 022, India
e-mail: tandonveena@hotmail.com

during the period 2007–2009 after 1959 (Singh et al. 1995). According to the folk belief, the rodents feed on the large quantities of highly nutritious seeds of these dying bamboo trees, which, in turn, is believed to trigger a rapid increase in the birth rate of the rodents leading to the population explosion of the rats. Following depletion of the bamboo seeds, the huge populations of rats attack fields of paddy and vegetables causing huge losses and even venture into human dwellings attacking granaries, etc. Thus occurrence of famine in concurrence with the flowering phenomenon is a real happening and not merely a superstitious belief (John and Nadgauda 2002).

Several studies have been conducted on parasites of wild rodents from several parts of the world (e.g. Croatia, Argentina, Philippines and Malaysia, etc.) that reveal the occurrence of a rich parasite biodiversity including the endoparasitic helminth fauna (Stojcevic et al. 2004; Claveria et al. 2005; Hasegawa et al. 2005; Gomez Villafane et al. 2008) and ectoparasitic arthropod fauna as well (Nava et al. 2003). In India most of the studies (Balchandra and Ranade 1975; Singhvi and Johnson 1980; Niphadkar 1980; Johnson et al. 1987) carried out on the parasites of rodents revealed the presence of parasitic trematodes (Yamaguti 1971) belonging to six genera (*Schistosoma, Orientobilharzia, Brachylaima, Artyfechinostomum, Isthmiophora* and *Haplorchis*); 11 cestode species of six genera (*Mesocestoides, Raillietina, Mathevotaenia, Hymenolepis, Taenia* and *Sudarikovina*); the metacestode species *Cysticercus fasciolaris* (Yamaguti 1959a; Malhotra et al. 1984; Malhotra and Capoor 1987; Malhotra and Nanda 1988; Bhattacharya et al. 1998) and 17 nematode species under the genera *Trichuris, Capillaria, Syphacia, Subulura, Protospirura, Rictularia, Thelazia, Aspiculuris, Angiostrongylus, Heterakis* and *Brienlia* (Yamaguti 1959b; Gupta and Dutt 1981; Sood and Parshad 1981; Renapurkar et al. 1982; Tewari, 1982; Mandal and Choudhury 1984; Manna et al. 1985; Gupta and Trivedi 1988). Further studies (Mittal 1980; Gupta and Trivedi 1988; Somvanshi et al. 1995; Chahota et al. 1997; Junker et al. 1998; Seong et al. 1998) also reported the presence of *Capillaria hepatica* and the acanthocephalan *Moniliformis moniliformis* in *Rattus rattus* (Singhvi and Johnson 1981).

The present study records the parasite spectrum of rodent hosts in the region to asses the worm load in rodent population of the affected region.



HLI	Hlimen
SLG	Samtlang
LLG	Lungleng
AZL	Aizawl
KPR	Kepran
BKT	Bilkhawthlir
LLE	Lunglei
DLN	Darlawn
KSB	Kolasib
BKV	Bukvannei
KZL	Khawzawl
SLN	Sawleng

Fig. 1 Location of collection sites of rodent hosts in map of Mizoram

Materials and methods

A total of 278 rodents belonging to 6 genera and 9 species were collected from 12 different locations (Fig. 1, Table 1) including bamboo plantation, rice fields, house yards, grain godowns and the wild.

The organs viz. liver, intestine, lungs, urinary bladder and stomach from the freshly autopsied rats, were looked for recovery of helminth parasites. The parasites recovered were duly processed for suitable whole mount preparations following standard procedures. Generic identification of the parasites was done following standard reference works (Yamaguti 1959a, 1959b, 1961, 1971; CIH Keys to Nematodes 1–10; Khalil et al. 1994).

Observations were recorded to calculate the prevalence and intensity of helminth infection in rodent hosts during the bamboo flowering period in the years 2006–2008. The parasitological terminology of Bush et al. (1997) has been used.

Prevalence (P) = the number of infected host with one or more individuals of a particular parasite species (or taxon) divided by number of hosts examined (expressed as percentage);

Intensity (of infection; I) = the number of individuals of a particular parasite species in a single infected host (expressed as a numerical range);

Mean intensity (of infection; mI) = the average intensity, i.e., the total number of parasites of a particular species found in a sample divided by the number of hosts infected; and

Abundance (A) = the total number of individuals of a particular parasite species in a sample of a particular host species divided by the total number of hosts (both infected and uninfected) of that species examined.

Results

The survey results revealed the presence of nematodes, cestodes of the cyclophyllidean group and one acanthocephalan species. The trematode parasites were virtually absent. The distribution data of the parasites recovered are presented in Tables 2 and 3.

Nine species of rodents viz. *Cannomys badius, Berylmys bowersi, B. mackenziei, Bandicota bengalensis, Niviventer fulvescence, Rattus rattus, R. nitidus, R. norvegicus* and *Mus musculus*, were examined for the parasites. The

Table 1 Collections sites of different rodent host in Mizoram

	Locality host	Hlimen	Samtlang	Lungleng	Aizawl	Kepran	Bilkhawthlir	Lunglei	Darlawn	Kolasib	Bukvannei	Khawzawl	Sawleng	Lab maintained
1.	*Rattus rattus*	+	+	+	-	+	+	+	+	-	-	-	+	-
2.	*R. nitidus*	+	-	+	-	+	+	-	+	-	-	+	+	-
3.	*R. norvegicus*	-	-	-	-	-	-	+	+	-	-	-	-	+
4.	*Mus* sp.	+	+	+	+	+	-	-	-	-	-	-	-	+
5.	*Berylmys mackenziei*	+	+	-	-	-	+	-	+	+	-	-	-	-
6.	*B. bowersi*	+	-	+	-	-	+	-	+	-	-	-	+	-
7.	*Bandicota bengalensis*	+	-	-	+	+	+	-	+	-	+	-	+	-
8.	*Niviventer fulvescens*	+	+	-	-	-	+	-	-	-	-	-	+	-
9.	*Cannomys badius*	+	-	-	-	-	-	-	-	-	-	-	-	-

cyclophyllidean cestode *H. diminuta* was found to be most prevalent in *R. norvegicus* (62.5%) and least in case of *Cannomys badius* (20%). No cestode was extracted from *M. musculu*s. The highest prevalence (12.5%) of *Hymenolepis* sp. was found in *R. norvegicus* while its highest mean intensity (7) and abundance (0.47) was recorded in *N. fulvescence*. *Raillietina* sp. was collected from 4 species of rodents and showed maximum prevalence (6.67%) and abundance (0.13) in *N. fulvescence* with highest mean intensity (3) in *R. nitidus*. The metacestode, *Cysticercus fasciolaris*, recovered from the liver, showed maximum prevalence in *R. norvegicus* (50%), with highest mean intensity (3.34) in *R. nitidus* and highest abundance (0.87) in *R. norvegicus*. Only one acanthocephalan, belonging to the family Moniliformidae, was recovered from a single *R. nitidus* specimen (Table 2).

Among the adenophorean nematodes, *Trichuris* sp. was collected only from *R. rattus* and *R. nitidus*, with highest prevalence, abundance and mean intensity found in the latter (6.25%, 2.5 and 0.15, respectively); *C. hepatica* was found to be most prevalent in *R. nitidus* (40.1%). The *C. hepatica* infection was always evident from the narrow white streaks abounding and spreading all over the liver tissue. Because of the worms being very fragile and entangled within the tissue, it was very difficult to recover intact whole worms. Hence, the mean intensity and abundance was not calculated, even though the intensity of this infection was always found to be high with numerous parasites. *Trichosomoides* sp. collected from the urinary bladder of rats showed highest prevalence (16.6%) in *Berylmys bowersi*, while highest mean intensity (6.67) and abundance (1) were recorded in *B. bengalensis* (Table 3).

The secernentean nematode, *Heterakis* sp. was encountered in 4 species of rodents and showed maximum prevalence, mean intensity and abundance (25%, 17.8 and 4.5, respectively) in *B. bengalensis*. *Rictularia* sp. collected from both *R. rattus* and *R. nitidus*, showed higher prevalence in the former (4.49%) while more abundance (5) and mean intensity (0.15) in *R. nitidus*. The oxyurid nematode *Syphacia* sp. showed highest prevalence in *R. nitidus* (9.37%), while its mean intensity and abundance were highest in *M. musculus* (13.5, 1.2). *Aspiculuris* sp. was recorded to occur only in *M. musculus* and *B. mackenziei* with higher prevalence in the latter (4.54%); however, its abundance (56) and mean intensity (1.27) were greater in *M. musculus*. *Nippostrongylus* sp. was found to be most prevalent in *R. nitidus* (23.43%) with its abundance being highest (4.93) in *M. musculus* and mean intensity, highest in *B. bengalensis* (45). The nematode *Hepatojarakus* sp. was collected from the bile passage and liver parenchyma of the host and showed highest prevalence in *R. rattus* (7.95%) but with maximum mean intensity (1.8) and abundance in *R. nitidus* (0.14).

In overall analysis, *R. rattus* harbored widest range of helminth parasites with the presence of 8 nematode and 4 cestode species followed by *R. nitidus* in which 8 nematode, 3 cestode and one acanthocephalan species were encountered.

Discussion

The present study gives the first overview on the parasitic fauna of rodents in bamboo-rich state of Mizoram, India reporting 14 species of helminths from 9 species of rats. A species of Hepatojarakus collected from the biliary passages of the liver and the liver parenchyma in the present study, was also reported by Sood and Parshad (1973) from four different rodent hosts, viz. B. bengalensis, Millardia meltada, Tatera indica and M. musculus batrianus. In another instance, 8 helminth species were found (Nama and Parihar 1976) from R. rattus rufescens. Saxena and Nama (1977) reported the occurrence of the genus Aspiculuris as the predominant nematode parasite of the common house rat R. rattus in Jodhpur contrary to the present findings that showed a low prevalence of Aspiculuris infection. Balachandra and Ranade (1978) reported the occurrence of 7 helminth species in R. rattus and Bandicota indica in Poona city with H. diminuta as one of the predominant species. The present observations are in conformity with this report. Singhvi and Johnson (1979) also worked on the population dynamics of nematode parasites of house rat. Gupta and Singla (1979) also reported the presence of a single specimen of H. diminuta from the intestine of a field rat Mus terricolor. Malhotra and Capoor (1987) also reported the occurrence of hymenolepid species in Indian rats, while Johnson et al. (1987) reported the presence of 9 helminth species in R. rattus, of which 6 were also found in the present study. Out of the 5 helminth species recovered from 3 different species of rodents, four (T. taeniaeformis, H. diminuta, Trichuris sp. M. moniliformis) are common to the present study (Singla et al. 2008). The helminth parasite diversity in Rattus sp. collected from wet market of Manila (Philippines) also included the same species of Hymenolepis, Taenia, Capillaria, Trichosomoides and Moniliformis as reported in

Table 2 Distribution of cestodes and acanthocephala in rodents hosts

Parasite	Host	No. of host examined	No. of hosts infected	Prevalence %	Mean intensity	Abundance
Cestoda: Cyclophyllidea:						
Hymenolepis diminuta	*R. rattus*	88	28	31.80	4.64	1.47
	R. nitidus	64	10	15.60	4.00	0.62
	R. norvegicus	8	5	62.50	6.20	3.87
	B. mackenziei	22	8	36.37	2.80	1.04
	B. bowersi	12	4	33.34	1.84	0.94
	B. bengalensis	20	5	25.00	3.20	0.80
	N. fulvescens	15	4	26.67	7.25	1.94
	C. badius	5	1	20.00	5.00	1.00
Hymenolepis sp.	*R. rattus*	88	2	2.28	3.50	0.07
	R. norvegicus	8	1	12.50	1.00	0.12
	B. bengalensis	20	2	10.00	2.50	0.25
	N. fulvescens	15	1	6.67	7.00	0.47
	M. musculus	44	1	2.28	5.00	0.11
Raillietina sp.	*R. rattus*	88	2	2.27	1.50	0.03
	R. norvegicus	64	2	3.12	3.00	0.09
	B. bengalensis	20	1	5.00	2.00	0.10
	N. fulvescens	15	1	6.67	2.00	0.13
Cysticercus fasciolaris	*R. rattus*	88	26	29.50	1.30	0.38
	R. nitidus	64	12	18.75	3.34	0.62
	R. norvegicus	8	4	50.00	1.75	0.87
	B. mackenziei	22	9	40.90	1.34	0.54
	B. bowersi	12	2	16.67	1.00	0.16
	B. bengalensis	20	6	30.00	1.16	0.35
	N. fulvescens	15	1	6.67	1.00	0.06
	M. musculus	44	2	4.54	1.00	0.04
Acanthocephala						
Moniliformis sp.	*R. nitidus*	64	1	1.56	15.00	0.23

rats of Mizoram (Claveria et al. 2005). However the wild rodents from the Endau Rompin National Park (Malaysia) were found to harbor a rich worm diversity that included 23 nematode, 3 cestode and 2 trematode species and in addition one pentastomid species (Syed-Arnez and Zain 2006).

The occurrence of a wide range of parasites in *R. rattus* and *R. nitidus*, as revealed in the present survey, may be attributed to the fact that both these rodents species were collected mostly in proximity to human dwellings where chances of contact with the intermediate host such as grain beetle and other insects is very high. In contrast to *Rattus* sp. the rodent *C. badius*, which was always collected directly from the bamboo forests and surrounding areas far from human habitations, harbored a low range and minimum parasite load.

The absence of the trematodes in the parasite spectrum may be attributed to the fact that trematodes need aquatic molluscan intermediate hosts for completion of their life cycle and the terrestrial habitat of rodents removed the possibilities of such infection.

Among the helminth parasites, *Capillaria hepatica* and the metacestode of *Taenia* sp. showed a considerably high prevalence (up to 50%) in several of the host species surveyed. A very high prevalence of the *Taenia* metacestode and 100% infection of *Capillaria hepatica* (both exhibiting high parasitemia) have been reported in *Rattus* sp. in the Philippines (Claveria et al. 2005). In view of their tissue damaging effect and common occurrence, these two parasites can be tested for their potential as biological control agents for rodent pests as also suggested by Singleton and McCallum (1990).

Table 3 Distribution of nematodes in rodent hosts

Parasite	Host	No. of host examined	Prevalence %	Mean intensity	Abundance
Nematoda:					
Adenophorea:					
Trichuroidea					
Trichuris sp.	*R. rattus*	88	1.13	1.00	0.01
	R. nitidus	64	6.25	2.50	0.15
Capillaria hepatica	*R. rattus*	88	29.54	-	-
	R. nitidus	64	40.10	-	-
	B. mackenziei	22	31.80	-	-
	B. bowersi	12	16.60	-	-
	N. fulvescens	15	40.00	-	-
		44	2.27	-	-
Trichosomoides sp.	*R. rattus*	88	5.68	3.20	0.18
	R. nitidus	64	1.56	1.00	0.01
	R. norvegicus	8	12.50	3.00	0.37
	B. mackenziei	22	9.09	1.00	0.09
	B. bowersi	12	16.60	1.50	0.25
	B. bengalensis	20	15.00	6.66	1.00
	N. fulvescens	15	6.67	1.00	0.06
Secernentea:					
Heterakoidea:					
Heterakis sp.	*R. rattus*	88	7.95	4.85	0.38
	R. nitidus	64	7.81	2.80	0.21
	B. mackenziei	22	4.54	2.00	0.09
	B. bengalensis	20	25.00	17.8	4.45
Rictularioidea:					
Rictularia sp.	*R. rattus*	88	4.49	1.00	0.04
	R. nitidus	64	3.12	5.00	0.15
Oxyuroidea:					
Syphacia sp.	*R. rattus*	88	7.95	6.10	0.48
	R. nitidus	64	9.37	4.67	0.43
	B. mackenziei	22	4.54	7.00	0.31
	M. musculus	44	9.09	13.50	1.20
Aspiculuris sp.	*B. mackenziei*	22	4.54	3.00	0.13
	M. musculus	44	2.27	56.00	1.27
Trichostrongyloidea:					
Nippostrongylus sp.	*R. rattus*	88	15	17.04	4.62
	R. nitidus	64	15	23.43	3.98
	R. norvegicus	8	1	12.50	0.62
	B. mackenziei	22	4	18.18	1.90
	B. bowersi	12	1	8.34	0.84
	B. bengalensis	20	1	5.00	2.25
	M. musculus	44	7	15.9	4.93
Hepatojarakus sp.	*R. rattus*	88	7	7.95	0.12
	R. nitidus	64	5	7.81	0.14
	B. mackenziei	22	1	4.54	0.04
	B. bengalensis	20	1	5.00	0.05
	M. musculus	44	1	2.27	0.02
	N. fulvescens	15	1	6.67	0.06

Acknowledgements This work was supported by All India Co-ordinated Project on Capacity Building in Taxonomy: Research on Helminths (AICOPTAX; MoE&F, GOI), DSA (UGC-SAP) Program in Zoology, and UPE program in School of Life Sciences at NEHU, Shillong.

References

Anderson RC, Chaubaud AG, CIH (1974–1983) Keys to the nematode parasite of Vertebrates. Commonwealth Agriculture Bureaux, England Eds Nos 1–9

Balachandra DV, Ranade DR (1975) Some observations on helminth parasites of rats from Poona city. In: Proceedings of the Indian Science Congress, Delhi, Part III, Group B pp 212

Balachandra DV, Ranade DR (1978) A preliminary Survey of helminth parasites of rats from Poona City. *Indian Veterinary J,* 55:175–176.

Bhattacharya D, Sikdar A, Sarma U, Ghosh AK, Biswas G (1998) Concurrent infection of *Capillaria hepatica* and *Cysticercus fasciolaris* in rat (*Rattus rattus*), a preliminary note. *Indian Veterinary, J* 75:486

Bush O, Lafferty AD, Lotz JM, Shostak AW (1997) Parasitology meets ecology in its own term: Margolis et al revisited, Lawrence. *J Parasitol,* 83:575–583

Chahota R, Asrani RK, Katoch RC, Jitendra KP (1997) Hepatic capillariasis in a wild rat (*Rattus rattus*). *J Veterinary Parasitol,* 11:87–90

Claveria FG, Causapin J, de Guzman MA, Toledo MG, Salibay C (2005) Parasite diversity in *Rattus* spp caught in wet markets. *Southeast Asian J Trop Med Public Health,* 36: Suppl 4

Durden LA, Hu R, Oliver JH Jr, Cilek JE (2000) Rodents' ectoparasites from two locations in Northwestern Florida. *Vector Ecology,* 25:222–228

Gomez Villafane IE, Robles MR, Busch M (2008) Helminth communities and host- parasite relationships in argentine brown rat (*Rattus norvegicus*). *Helminthologia,* 45(3):126–129

Gupta NK, Dutt K (1981) On the morphology of *Syphacia stroma*, a nematode parasite of rodents. *Res Bull Panjab University,* 30:65–69

Gupta NK, Singla SL (1979) On *Hymenolepis diminuta* (Rudolphi, 1819)- A tapeworm of rat in Dhuri (Punjab). *Res Bull (Science) Panjab University,* 30:83–86

Gupta SP, Trivedi KK. (1988) Nematode parasites of vertebrates. On a new spirurid, *Protospirura srivastavai* sp. nov. (Family: Spiruridae Oerley, 1885) from a field mouse, *Mus platythrix* from Udaipur, Rajasthan. *Indian J Helminthol,* 39:153–159

Jaksic FM, Lima M (2003) Myths and facts on ratadas: Bamboo blooms, rainfall peaks and rodent outbreaks in South America. *Austral Ecology,* 28:237–251

John CK, Nadgauda RS (2002) Bamboo flowering and famine. *Curr Sci,* 82:261–262

Johnson S, Singhvi A, Mathur CS. (1987) Host-parasite system in the house rat *Rattus rattus*. *Indian Rev Life Sci,* 7:235–261

Junker V, Voss M, Kubber-Heiss A, Prosi H (1998) Detection of *Capillaria hepatica* in house mice (*Mus musculus*) in Austria. *Tagung der Osterreichischen Gesellschaft fur Tropenmedizine und Parasitologie,* 20:137–143

Khalil LF (1986) The helminth parasites of rodents and their importance. In: Proceedings of the 2nd Symposium on Recent Advances in Rodent Control. Kuwait 141–149

Khalil LF, Jones A, Bray RA (1994) Keys to the Cestode Parasites of Vertebrates. Commonwealth Agricultural Bureaux. England

Malhotra SK, Capoor VN (1987) Bynomics and taxanometry of *Hymenolepis himalayii* from an Indian rat. *Revista Di Parasitologia,* 45:33–40

Malhotra SK, Nanda S (1988) *Sudarikovina multitesticulata* n. sp. (Cestoidea: Cyclophyllidae) from *Mus musculus* of Allahabad, India. *Japanese J Parasitol,* 33:93–98

Malhotra SK, Sawada I, Capoor VN (1984) A report on the occurrence of larval forms of *Hydatigera* (Cestoda: Taeniidae) from rats in Garhwal Himalaya. *Japanese J Parasitol,* 33: 93–98

Mandal D, Choudhury A (1984) A new record of *Brienlia booliati* Singh and Ho, 1973 (Filaroidea: Onchocercidae) from the wild rats of Sunderban forests. *Indian J Parasitol,* 8:333–335

Manna B, Date C, Dey S (1985) On a new species of the genus (*Aspicularis paraspicularis*) from white mice *Mus musculus*. *Indian Animal Health,* 24:1–3

Mittal RP (1980) Frequency and intensity of nematodes in rats and mice of Meerut Division, U.P. *Indian J Parasitol,* 3 (Supplement) 130.

Nag S (1999) Bamboo, rats and famines: Famine relief and perceptions of British paternalism in Mizo Hills (India). *Environ History,* 5:245–252

Nama HS, Parihar A (1976) Quantitative and qualitative analysis of helminth fauna in *Rattus rattus rufescens*. *J Helminthol,* 50:99–102

Nava S, Lareschi M, Voglino D (2003) Interrelationship between ectoparasites and wild rodents from Northeastern Buenos Aires Province, Argentina. *Memorias do Instituto Oswaldo Cruz,* 98(1):45–49

Niphadkar SM (1980) Study on the helminthic infection of *Bandicota bengalensis* in Bombay with relation to domestic animals and human health. *Indian J Parasitol,* 3 (Supplement)130

Numata M (1970) Conservational implications of bamboo flowering and death in Japan. *Biological Conservation,* 2:227–229

Oldham JN (1931) The helminth parasites of common rats. *J Helminthol,* 9:49–60.

Pal A (1993) Rodent pests of North Eastern states and their management. P.G. Dip. Dissertation, National Plant Protection Training Institute (NPPTI), Hyderabad, India

Renapurkar DM, Bhopale MK, Limaye LC, Sharma KD (1982) Prevalence of *Angiostrongylus cantonensis* infection in commensal rats in Bombay. *J Helminthol,* 56: 345–349

Saxena A, Nama HS (1977) On the occurrence of *Aspiculuris*

(*Paraspiculuris*) *pakistanica* Akhtar, 1955 (Nematoda: Oxyuridae) in house rat. *Geobios,* 4:243–244

Schiller JM, Douangboupha B, Bounnaphol O (1999) Rodents in agriculture in Lao PDR - a problem with an unknown future. In: Ecological-based management of rodent pests. ACIAR Monograph No. 59. Australian Centre for International Agricultural Research, Canberra. Edited by Singleton GR, Hinds LA, Leirs H, Zhang Z. 372–387.

Seong JK, Yun YM, Han JH, Lee J, Oh YS (1998) Spontaneous infection of *Capillaria hepatica* in wild rats (*Rattus norvegicus*) of Korea. *Korean J Veterinary Res,* 38:600–605

Shintoku Y, Kimura E, Kadosaka T, Hasegawa H, Kondo S, Itoh M, Islam MZ (2005) *Strongyloides ratti* infection in the large intestine of wild rats, *Rattus Norvegicus*. *J Parasitol,* 91: 1116–21

Singh YP, Gangwar S, Kumar D, Khushwaha RV, Azad Thakur NS, Kumar M (1995) Rodent pests and their management in the northeastern hill region. Research Bulletin No 37, ICAR Research Complex for NEH Region, Barapani, Meghalaya. pp. 35

Singhvi A, Johnson S (1979) Population dynamics of the nematode parasites of the house rat *Rattus rattus*. *Revista Brasilaria Biologica,* 39:43–52

Singhvi A, Johnson S (1980) Ecology of the helminth parasites of the house rat, *Rattus rattus*. The temporal segregation. *Indian J Parasitol,* 3 (Supplement) pp 89

Singhvi A, Johnson S (1981) The distribution of *Monoliformis monoliformis* (Archiacanthocephala: Acanthocephala). *Revista di Parasitologia,* 42:45–54

Singla LD, Singla N, Parshad VR, Juyal PD, Sood NK (2008) Rodents as reservoirs of parasites in India. *Integrative Zoology,* 3:21–26

Singleton GR, McCallum HI (1990) The potential of *Capillaria hepatica* to control mouse plagues. *Parasitology Today,* 6: 190–193

Singleton GR, Petch DA (1994) A review of the biology and management of rodent pests in Southeast Asia. ACIAR Technical Report No. 30. Canberra, Australian Centre for International. *Agricultural Res,* pp *65*

Somvanshi R, Bhattacharya D, Laha R, Rangarao GSC (1995) Spontaneous Capillaria hepatica infestation in wild rats (*Rattus rattus*). *Indian J Veterinary Pathol,* 19:44–45

Sood ML, Parshad VR (1973) *Hepatojarakus bandicoti* sp. nov. from rodents in Punjab, India. *Parasitology* 66:19–21

Sood ML, Parshad VR (1981) A reference list of nematode parasites from the Indian rodents. *Res Bull Panjab University,* 29:35–38

Stojcevic D, Mihaljevic Z, Marinculic A (2004) Parasitological survey of rats in rural regions of Croatia. *Veterinární Medicína,* 49(3):70–74

Syed-Arnez ASK, Mohd Zain SN (2006) A study on wild rats and their endoparasite fauna from the Endau Rompin National Park, Johor. *Malaysian J Sci,* 25(2):19–39

Tewari MK (1982) *Heterakis pandei* n. sp. from the intestine of *Rattus rattus* of Lucknow, India. *Indian J Parasitol,* 6: 299–301

Yamaguti S (1959a) Systema Helminthum. Vol. II- Cestodes of Vertebrates. Interscience Publishers Inc. New York

Yamaguti S (1959b) Systema Helminthum. Vol. III- Nematodes of Vertebrates. Interscience Publishers Inc. New York

Yamaguti S (1961) Systema Helminthum. Vol.V- Acanthocephala of Vertebrates. Interscience Publishers Inc. New York

Yamaguti S (1971) Synopsis of the digenetic trematodes of vertebrates, Vol I & II. Keigaku Publishers, Tokyo