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NEW HOST RECORD OF SOME GASTROINTESTINAL PARASITES OF IRRAWADDY SQUIRREL (*CALLOSCIURUS PYGERYTHRUS*) FROM CHITTAGONG, BANGLADESH

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Abstract: Gastrointestinal (GI) tract of 60 Irrawaddy squirrels (*Callosciurus pygerythrus*) were collected between September 2013 and August 2014 from four different spots of Chittagong University campus and its adjacent areas to study the ento-helminth fauna. Eight different parasite species were identified - one belonging to Cestoda and represented by *Hymenolepis diminuta*, and the remaining seven were to Nematoda *viz., Strongyloides callosciurus*, *Trichuris ovis*, *Monodontus* sp., *Cyclodontostomum purvisi*, *Moguranema nipponicum*, *Ascarops talpa* and *Syphacia obvelata*. The nematodes were found as dominant species most preferably inhabiting the small intestine. The present host is the new host record for all of these parasites and *S. callosciurus, T. ovis*, *Monodontus* sp., *M. nipponicum* and *A. talpa* are the new records for Bangladesh too. All these parasites have very wide host specificity, though most of them are restricted to various rodent hosts but *H. diminuta* and *S. callosciurus* were found to have more wider specificity, including other vertebrates too. All identified parasites might have been acquired from the environment where the host inhabits, since host specificity perspective no parasites were found to be specific to the present host. *H. diminuta* and *Syphacia obvelata* might have zoonotic role to other wild animals and human and vice versa.

Key words: Irrawaddy squirrel, Rodents, Helminths, Zoonosis, Host specificity

INTRODUCTION

Squirrels, member of the family Sciuridae, are small or medium size rodents and indigenous to the Americas, Eurasia, and Africa, and have been introduced to Australia (Seebeck 2013). In Bangladesh nine species of squirrels have been recorded by Ahmed *et al.* (2009) though Antara *et al.* (2015) reported 8 species. The Irrawaddy squirrel (*Callosciurus pygerythrus* Geoffroy Saint Hilaire, 1931), the host animal of the present study, is a medium sized, elongated and dark brown squirrel widely distributed in northeastern South Asia, southern China and western Southeast Asia at elevations of 500 to 1,560 metres. In Bangladesh, this squirrel is common almost all over the country but very widely distributed in riverine and mixed forest and near village (Menon 2003; IUCN Bangladesh

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2015). Though globally it is considered vulnerable (VU) but in Bangladesh not yet considered threatened (IUCN Bangladesh 2015). However, the naturalization of squirrel present various issues, such as damages to agriculture and forestry and competition with other sciurids (Thorington *et al.* 1966). Not only that, from a number of works done around the globe it has been anticipated that both the native and introduced squirrel species might have negative role in various diseases and population decline to other wild animals (Shinozaki *et al.* 2004 a, b, Rushton *et al.* 2006, Sato *et al*. 2007, Sainsbury *et al.* 2008), perhaps, because of various disease mediated competition (Khodakevich *et al.* 1986, Anonymous 2003, Dozieres *et al.* 2010, Bertolino and Lurz 2013). As for instance, the Pallas's squirrel (*Callosciurus erythraeus*), also known as Asian red bellied squirrel, introduced into so many countries such as Japan, Argentina and three European countries (Belgium, France and the Netherlands) because of its aesthetic value and also under international pet trade (Palmer *et al.* 2007, Bertolino 2009), was found to be a potential carrier of the pathogens of some infectious diseases that can affect humans as well as domestic and native wild mammals (Bertolino and Lurz 2013). Therefore, like other squirrel species of the world, the Irrawaddy squirrel may also be a potential carrier of pathogens of some infectious diseases that can affect humans as well as domestic and native wild animals as they live at the vicinity to human and other animals' habitation. Parasitological investigations on this species is very rare in literature, so this animal was selected as an interesting host not only to fill the gap of knowledge but also to evaluate its role as a host of specific or acquired parasites from the community where it really belongs to.

MATERIAL AND METHODS

Chittagong University campus and its adjacent areas were selected as study area and the study was done between September, 2013 and August, 2014. After a pre-surveillance on the host abundance, the study area was segregated into four spots - Spot 1: Forest behind the Marine Science and Fisheries Institute; Spot 2: Botanical garden; Spot 3: Adjacent areas of Shahid Abdur Rab Hall; and Spot 4: Adjacent areas of Chittagong University campus. However, the guiding factors behind this spot selection or habitat segregation were the availability of food and fruit trees and closeness with the human habitation.

Samples were collected regularly every month by live trapping and/or shooting. Monthly at least one sample was collected from each spot and a total of 60 (39 males and 21 females) host specimens were collected during the study period. Live-trapped squirrels were euthanized following animal handling procedures approved by international guidelines (AVMA 2007). For helminths prospection, complete gut wall and lumen from oesophagus to rectum were dissected and carefully analyzed using stereo-microscope. To restrict morphological deterioration the parasites were fixed in hot AFA (Alcohol-formol-acetic) for cestodes and GA (Glycerine-alcohol) for nematodes and later half of these parasites were preserved in 70% alcohol and the rest in lactophenol for clearing and microscopic observations. Microdissections were performed wherever needed for detailed taxonomic studies. Microphotographs were taken by digital cameras (Sony, DSC-T90; Samsung ES99 and Optika Digital Microscopy, Optika 4083.B5) and drawings were prepared with the support of a camera lucida (Weswox, HLm-6 Black). The scheme of classification and taxonomic features were mainly followed after Yamaguti (1985c, 1961, 1959), with additional consultations from Anderson *et al*. (2009), Wardle and McLeod (1952), Chandler (1949), and various other online resources.

RESULTS AND DISCUSSION

Of the 60 (39 males and 21 females) host samples, 49 (33 males and 16 females) samples were found to be infected with 8 different helminth parasites - 1 cestode and the remaining 7 were nematodes (Table 1). No trematode and acanthocephalan parasites were encountered. The nematodes were found to be the prevalent parasite species and the family Trichostrongylidae and Oxyuridae appeared to be the dominant parasite group. The small intestine was the most favourable niche for the parasites which was validated by the recovery of 6 parasite species i.e. *H. diminuta*, *S. callosciurus*, *Monodontus* sp., *C. purvisi*, *Moguranema nipponicum* and *A. talpa* though *M. nipponicum* also recovered from the stomach but were more abundant in the

Table 1. Identified gastrointestinal helminth parasites of *Callosciurus pygerythrus*

Scientific name of the parasite	Order	Family	Site of infection
Cestoda			
Hymenolepis diminuta	Cyclophyllidea	Hymenolepididae	Small Intestine
Nematoda			
Strongyloides callosciurus	Rhabdiasidea	Strongyloididae	Small intestine
Trichuris ovis	Trichuridea	Trichuridae	Large intestine
Monodontus sp.	Strongylida	Ancylostomatidae	Small Intestine
Cyclodontostomum purvisi	Strongylida	Ancylostomatidae	Small Intestine
Moguranema nipponicum	Strongylida	Trichostrongylidae	Stomach and small Intestine
Ascarops talpa	Spirurida	Spiruridae	Small Intestine
Syphacia obvelata	Oxyurida	Oxyuridae	Large intestine

small intestine. Based on available literatures consulted in the present study, 5 out of 8 identified species, namely - *S. callosciurus*, *T. ovis*; *Monodontus* sp., *M. nipponicum* and *A. talpa* are considered as new records for Bangladesh and obviously the host animal is the new host record for all these parasites.

Cestoda: Hymenolepis diminuta Rudolphi 1819. (Cyclophyllidea: Hymenolepididae: Hymenolepidinae). The genus *Hymenolepis* is thought to be included in a complex of cryptic species because some species of this genus possess unarmed rostellum while others have no rostellum (Haukisalmi *et al*. 2010). However, after numerous revisions, *Hymenolepis* currently includes hymenolepidid cestodes with an unarmed scolex which parasitize rodents (12-13 species), bats (about 4 species) and hedgehogs (López-Neyra 1942a,b, Gulyaev and Melnkova 2005). Therefore, the unarmed scolex (Fig. 1) and much broader proglottids of the present cestode confirmed its identity as *Hymenolepis* (Chandler 1955, Wardle and McLeod 1952) and absence of filaments in the onchosphere (Fig. 2) distinguished this species from other species of this genus. It is now established that the life cycle of *H. diminuta* involves rodents as the definitive host and beetles or other arthropods as the intermediate hosts (Andreassen *et al.* 1999, Makki *et al.* 2011). Not only that, for this parasite, a diverse assemblage of rodent definitive hosts (i.e. Sciuridae, Gliridae, Dipodidae, Cricetidae, Muridae and Gerbillinae) has been reported by many parasitologist all over the world and some of these rodents are - *Bandicota indica*, *B. savilei*; *Berylmys berdmorei*, *Berylmys bowersi*, *Leopoldamys edwardsi*, *Maxomys surifer*; *Mus cookie*; *Niviventer fulvescens*; *Rattus exulans*; *R. losea* and *R. tanezumi* (Ryzhikov *et al.* 1978). In Bangladesh, this species first reported from *Rattus rattus*, *Bandicota benghalensis*, *Scalopus scapanus*, and human (Huq 1969, Areekul and Radomyos 1970, Sinniah 1979, Chenchittikul *et al.* 1983). However, the present host is the new record for this cestode.

Nematoda: Strongyloides callosciurus Sato, H. 2007. (Rhabdiasidea: Strongyloididae) *Strongyloides* has only parthenogenetic females in the parasitic phase and Sato *et al.* (2007) mentioned that they should be characterized mainly by the morphology of parasitic females (Figs 6 and 7) and exhibit both homogonic and heterogonic development in their life cycle (Schad 1989, Viney 1994, Dorris *et al.* 2002). Approximately 50 species are recognized to parasitize different amphibians, reptiles, birds and mammals (Speare 1989). Little (1966a) and Speare (1989) found three characteristics in parasitic female useful for the identification of species – (a) the form of the stroma, (b) the form of the ovaries; and (c) the stage passed in the feces (Fig. 6). However, from all species of this genus only two *viz., S. robustus* and *S. callosciurus* showed morphological resemblance with the present samples but *S. callosciurus* had the highest similarity with the present specimen both morphometrically and host preference (Table 2). This is the first record of this parasite from Bangladesh and the host as new host record too.

Table 2. Comparison between two closely related species of *Strongyloides* with the present species (Measurements in mm unless mentioned otherwise).

Characters	*S. robustus* Sato *et al.* 2007	*S. callosciurus* Sato *et al.* 2007	Present species (Based on 5 female samples)
Body length	5.5 - 6.5 (6)	6.25	5.54 - 10.2
Body width at the distal end of oesophagus	0.052 - 0.058 (0.056)	0.048	0.037 - 0.039
Length of oesophagus	1.14 - 1.4 (1.29)	0.939	0.923 - 0.98
Vulva from anterior end	3.3 - 3.9 (3.6)	4.05	3.82 - 4.13
Length of tail	0.090 - 0.116 (0.1)	0.070	0.0781- 0.0786
Greater diameter of egg	0.045 - 0.072 (0.058)	0.054 - 0.066 (0.056)	0.040 - 0.0462
Lesser diameter of egg	0.033 - 0.042 (0.036)	0.027 - 0.038 (0.032)	0.025 - 0.027
Host	*Sciurus* spp. *Tamiasciurus* spp. *Glaucomys* spp. *Spermophilus* spp. and *Tamias* spp.	Asian squirrel	Irrawaddy squirrel

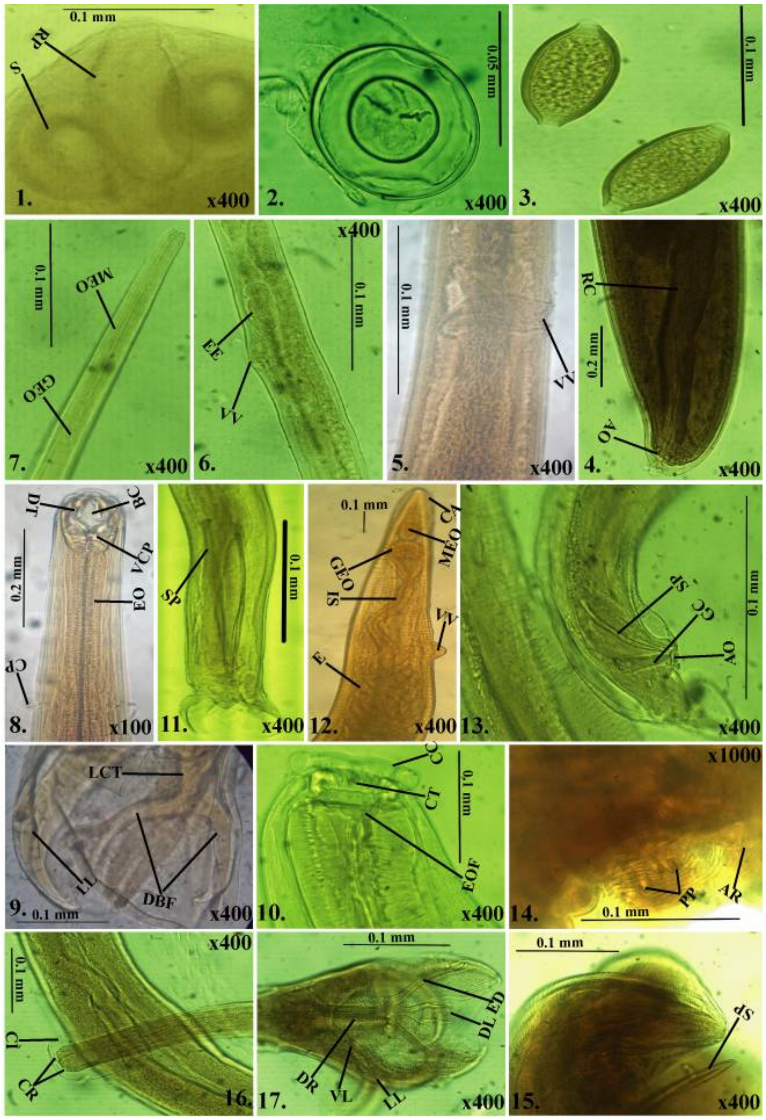
Trichuris ovis Abild 1795. (Trichuridea: Trichuridae: Trichurinae). The presence or absence of the spicular tube, the length of the spicule and cloacal tube, the shape of the proximal and distal cloacal tube along with the classical morphometric characteristics have been used as features with high discriminatory value for species differentiation (Schwartz 1926), while the body length, vagina length and egg size could also be used as variables to discriminate and classify entire female and the analysis might yield a 100% accurate classification (Gomes *et al.* 1992, Spakulova 1994, Suriano and Navone 1994, Rossin and Malizia 2005, Robles *et al.* 2006). Yamaguti (1985c) enlisted 71 species from the genus *Trichuris*. Based on the egg shape and size [0.087 (0.08-0.1) × 0.046 (0.04-0.075) mm] (Figs 3-5) and the length of the oesophagus [28.120 (24.5-32) mm], the present species was identified as *T. ovis*. Like other nematode parasites of this present study, it is also the new record for Bangladesh and the present host is new host record for this parasite.

Monodontus sp. Mollin 1861. (Strongylidea: Ancyclostomatidae: Bunostominae) *Monodontella* (Yorke and Maplonestone 1926) has been regarded a synonym of *Monodontus* by different authors (Lichtenfels 1980, Kalia and Gupta 1983). A pair of ventral cutting plate (Fig. 8), infundibular buccal capsule (Fig.

8), subventral lancets (Fig. 8), large common trunk (Fig. 9), bifurcated dorsal ray (Fig. 9) and symmetrical spicule with opposed uteri are the characters to place the present sample under the genus *Monodontus*. Up to now, eight species of the genus *Monodontus* has been described (Kalia and Gupta 1983) though Yamaguti (1985c) enlisted 10 species under this genus. However, surprisingly, the species of this genus can be placed into two distinct groups, *M. giraffae* and the remaining species of this genus. No clear evidence has been proposed by any taxonomist behind this grouping. But from the comparative study between *M. giraffae* and other species show a clear distinction in between them (Table 3). From the comparison it was seen that the present *Monodontus* samples showed numerous resemblances with *M. lousianensis*, but lack of sufficient sample no conclusion could be made. However, no parasitological works from Bangladesh reported the presence of this parasite from any host. So, this genus might be the new record for Bangladesh from this host.

Cyclodontostomum purvisi Adams 1933. (Strongylida: Ancylostomatidae: Ancylostomatinae) From morphology and geographical point of view, *C. purvisi* appears to be most nearly related to *Agriostomum*, which occurs in ruminants in Southeast Asia and South Africa. The presence of anteriorly tilled cephalic end (Fig. 10), cephalic collar (Fig. 10), 8 pairs of strongly curved teeth (Fig. 10), esophageal funnel (Fig. 10) and larger dorsal lobe (Fig. 11) directed the present species under the genus. Yamaguti (1985c) reported only one species i.e. *C. purvisi* under this genus and the present species showed considerable resemblance with the description found in other literature except the host type (Table 4). However, previously this parasite was recorded from a number of rat host, including the genera *Rattus*, *Bandicota*, *Berylmys*, *Leopoldamys*, *Maxomys*, *Niveventer*, and *Sundamys* (Hasegawa and Safruddin 1994). In Bangladesh, Huq (1969) reported *C. purvisi* from *Rattus rattus, Bandicota bengalensis* and *Scalopus scapanus* from Mymensingh district. So, the present host is the new host record for this parasite from Bangladesh.

Moguranema nipponicum Yamaguti 1941. (Strongylidae: Trichostrongylidae: Graphidiinae) Durette-Desset (1977) placed this genus in Molineinae, in Molineidae, but later she (1983) removed this species to Haemonchinae, in Trichostrongylidae. This trichostrongylid nematode species has resemblance with a few other genera under this family, namely *Pararhabdonema*, *Nochtia*, *Histiostrongylus*, *Allintoshius*, *Viannaia*, *Trichotravassosia*. However, the presence of corona radiata (Fig. 16) in the present species, perhaps, separated the identified genus from rest of the other genera since no literatures were found reporting the presence of corona radiata in the later genera, though Yamaguti (1941) did not confirm the presence of this structure in the type species but



Figs 1-17. Microphotographs representing taxonomic features of the identified parasite species of *Callosciurus pygerythrus*. 1. *H. diminuta* scolex; 2. *H. diminuta* onchosphere; 3. *Trichuris ovis* egg; 4. *T. ovis* female anal opening; 5. *T. ovis* vulval opening; 6. *Strongyloides callosciurus* vulval and embryonated egg; 7. *S. callosciurus* anterior region; 8. *Monodontus* sp. anterior end; 9. *Monodontus* sp. bursa; 10. *Cyclodontostomum purvisi* anterior region; 11. *C. purvisi* posterior region; 12. *Syphacia obvelata* anterior region; 13. *S. obvelata* posterior region; 14. *A. talpa* male posterior region; 15. *A. talpa* spicule; 16. *Moguranema nipponicum* anterior region; 17. *M. nipponicum* bursa. Abbreviations: AO: Anal opening; AR: Area rugosa; BC: Buccal capsule; CA: Cervical alae; CC: Cephalic collar; CI: Cuticular inflation; CP: Cervical papillae; CR: Corona radiata; CT: Curved teeth; DBF: Dorsal bifurcation; DL: Dorsal lobe; DR: Dorsal ray; DT: Dorsal teeth; E: Egg; ED: Externolateral; EE: Embryonated egg; EOF: Esophageao funnel; GC: Gubernaculum; GEO: Glandular esophagus; IS: Intestine; LCT: Large common trunk; LL: Lateral lobe; MEO: Muscular esophagus; OE: Oesophagus; PP: Pedunculated papillae; RC: Rectum; RP: Rostellar pouch; S: Sucker; SP: Spicule; VCP: Ventral cutting plate; VL: Ventral lobe; VV: Vulva.

Table 3. Comparison between present species with two groups of species under the genus *Monodontus* (measurements in mm unless mentioned otherwise)

Characters	*M. giraffae* (Ming *et al.* 2010)		*M. louisianensis* (Chitwood and Jordan 1965)		Present species	
	Male (10 samples)	Female (10 samples)	Male	Female	Male (4 sample)	Female (5 sample)
Total body length	13.70 - 15.50	17.79 - 19.97	8 - 9.7	12.6 - 16	7.8 - 9.7	9.78 - 11.47
Maximum body width	0.380 - 0.440	0.5 - 0.77	-	0.31 - 0.38	0.31 - 0.33	0.3 - 0.36
Length of buccal capsule	0.200	0.2	0.09	0.15 - 0.16	0.13 - 0.15	0.18 - 0.223
Width of buccal capsule	0.080	0.07	0.083	0.103 - 0.11	0.10 - 0.12	0.1 - 0.11
Length of oesophagus	1.15 - 1.45	1.4 - 1.65	0.94	1.3	0.88 - 0.90	0.80 - 0.84
Maximum width of oesophagus	0.16 - 0.24	0.21 - 0.30	0.15	0.18	0.165 - 0.173	0.160 - 0.20
Minimum width of oesophagus	-	-	0.10	0.07	0.085 - 0.093	0.70 - 0.80
Nerve ring from anterior end	0.50 - 0.67	0.55 - 0.65	0.39	0.45	0.340 - 0.390	0.475 - 0.515
Excretory pore from anterior end	0.65 - 0.75	0.75 - 0.82	0.40	0.50	0.380 - 0.400	0.640 - 0.650
Vulva from posterior end	-	9.22 - 11.39	-	5.6	-	3.41
Greater diameter of egg	-	0.049 - 0.069	-	0.06 - 0.063	-	50 - 59
Lesser diameter of egg	-	0.028 - 0.044	-	0.035 - 0.04	-	0.030 - 0.038

Table 4. Comparative measurements of *Cyclodontostomum purvisi* from different hosts and Localities (measurements in mm unless mentioned otherwise) (only the male)

Characters	Host and localities		
	Maxomys whiteheadi, East Kalimantan, Indonesia (Hasegawa and Syafruddin 1994)	*Eropeplus canus*, *Paruromys dominator*, *Rattus hoffmani* South Sulawesi, Indonesia (Hasegawa and Syafruddin 1994)	*Callosciurus pygerythrus* Chittagong, Bangladesh (Male, 1 sample)
Length	6.9 - 9.7	4.4 - 8.8	4.44
Width	0.260 - 0.332	0.292 - 0.384	0.21
Cephalic collar diameter	0.116 - 0.154	0.115 - 0.148	0.11
Oesophagus length	0.506 - 0.608	0.475 - 0.584	0.460
Width of oesophagus	0.156 - 0.189	0.16 - 0.2	0.137
Nerve ring	0.261 - 0.339	0.259 - 0.312	0.24
Excretory pore	0.388 - 0.49	0.304 - 0.42	0.51
Length of spicule	0.537 - 0.711	0.528 - 0.712	0.66
Length of gubernaculum	0.051	0.051	0.051

Yokohota *et al.* (1988) disclosed this structure in their redescription. The present species has transverse striations, though Yamaguti (1941) did not mention this structure, which is very prominent in its cephalic cuticular inflation (Fig. 16) but not so in rest of the body and there is no transverse striation in the bursa like that of the *Pararhabdonema*, *Nochtia* and *Allinotoshius*. Longitudinal ridge or striation, running from the end of cuticular inflation to throughout the body, was not a character of *Moguranema* while it was a common character to the other mentioned genera. Symmetrical bursa with poorly differentiating dorsal lobe (Fig. 17) and thick arcuate externodorsal (Fig. 17) finalized the position of the present species under this genus. Till now, only one species has been reported under this genus i.e. *Moguranema nipponicum* and the description of the present species showed most similarity with the description of *Moguranema nipponicum* given by Yamaguti (1941) and Yokohota *et al.* (1988). Previously, this species has been recorded only from a number of shrew mole and Japanese mole *viz., Dymecodon pilirostris*, *Urotrichus talpoides*, *Talpa mizura*, *Mogera wogura*, *M. koeae* and *M. tokudae* (Yokohota *et al.* 1988). However, Meyers and Kuntz (1964) reported this species from Formosan mole (*Talpa micrura isularis*), Taiwan. This is the first record of this species from squirrel and also from Bangladesh.

Table 5. Comparative measurements of the three species of the genus *Ascarops* and the present species (measurements in mm unless mentioned otherwise) (Only the male)

Characters	*A. kutassi* Huber *et al.* 1983	*A. tuvensis* Huber *et al.* 1983	*A. talpa* Huber *et al.* 1983	Present species (3 samples)
Ratio between left and right spicules	1 : 4	1 : 3.8	1 : 5.5	1 : 5.31
Length of area rugosa	1.25	Not mentioned but very minute	0.17	0.181

Ascarops talpa Huber *et al.* 1983. (Spirurida: Spiruridae) Asymmetrical spicules (Fig. 15), area rugosa (Fig. 14), lateral flanges, cervical papillae, 4 pairs of preanal pedunculated papillae (Fig. 14) are the main distinguishing characters of the genus *Ascarops*. According to Yamaguti (1985c), this genus has 5 species whereas Huber *et al.* (1983) reported 7 species under this genus. The key characteristics to differentiate the species of this genus are – the ration of left to right spicules and the length of the area rugosa (Yamaguti 1985c). Based on the differentiating characters, the present *Ascarops* species showed maximum similarity with *A. talpa* though two other species *viz., A. kutassi* and *A. tubensis* also showed similarity in many morphometric characters other than the mentioned two characters (Table 5). Van Beneden (1973) for the first time recorded the genus *Ascarops* from an insectivore. Goldberg *et al.* (1997) reported a number of vertebrates paratenic hosts of this parasite, particularly those that habitually feed upon insects: rodents, shrews, armadillos, birds and lizards. However, this is the first record of the occurrence of this parasite from the present host and also from Bangladesh.

Syphacia obvelata Rudolphi 1802. (Oxyurida: Oxyuridae: Syphaciinae) The presence of cervical alae (Fig. 12), prebulbar swelling (Fig. 12) and a distinct posterior bulb containing a valvular apparatus (Fig. 12), a large pendunculate postanal papillae, single spicule (Fig.13) and anteriorly positioned conspicuous vulva (Fig. 12) placed the present sample into this genus *Syphacia*. The present specimen, however, fully agree with the diagnosis of the genus *Syphacia* mentioned in Yamaguti (1959). Yamaguti enlisted 23 species under this genus of which *S. muris* and *S. obvelata* were from rats, which have almost similar morphological details though the present specimen showed maximum resemblance with *S. obvelata* described by Riley (1920). However, the main differences between *S. muris* and *S. obvelata* was the head, shape and size of spicule and gubernaculum, pronounced post-cloacal papillae, length of tail and number of the location of the mamelons (Table 6) (Farrar *et al.* 1994, Parel *et al.* 2008). In Bangladesh Khanum and Arefin (2003) reported *S. obvelata* from laboratory mice, *Mus musculus.* Bhowmick (2010) and Huq *et al.* (1985) reported the presence of this parasite in a review report and also commented on its economic importance as causative agent for about 150 to 200 diseases to laboratory animals and humans (zoonosis).

Table 6. Comparison between *Syphacia muris*, *S. obvelata* and the present species (measurements in mm unless mentioned otherwise)

Characters		*S. muris* Pinto *et al.* 2001	*S. obvelata* Riley 1920	Present species	
				Male (Based on 5 samples)	Female (Based on 5 samples)
Body length		2.5 - 2.8	3.5-5.7	1.45 - 2.29	3.65 - 4.10
Body width		0.17 - 0.2	0.3	0.15 - 0.21	0.14 - 0.3
Length of oesophagus		0.15	0.3	0.24 - 0.342	0.33 - 0.38
Diameter of bulb		0.050 - 0.080	0.1	0.060 - 0.070	0.090 - 0.1
Vulva from anterior end		0.72 - 0.75	0.5	-	0.65 - 0.77
Egg	Greater diameter	0.060 - 0.072	0.125	-	0.11 - 0.13
	Lesser diameter	0.028 - 0.032	0.040	-	0.030 - 0.040
Spicule		0.048	0.08	0.045 - 0.070	-
Gubernaculum		0.028	0.035	0.045 - 0.055	-

Table 7. Host specificity spectrum and life cycle pattern of the identified parasites of *Callosciurus pygerythrus*

Name of the parasites	Previously recorded hosts	Previous records in Bangladesh	Host specificity	Life cycle	Remarks
H. diminuta	Rodents of the family Sciuridae, Gliridae, Dipodidae, Cricetidae, Muridae and Gerbillinae	Rats and human (Areekul and Radomyos 1970, Sinnah1979)	Broad host specificity but restricted only to rodents	Two hosts- Man/rat as definitive and beetle as intermediate (CDC 2009)	Host record of this parasite in Bangladesh
Strongyloides callosciurus	Reptiles, birds, amphibians, mammals. Pallas squirrel in Japan (Speare 1989)	-	Much broader host specificity	Complex free-living and parasitic with autoinfection and multiplication (Olsen *et al.* 2009)	Both the host and the parasite are the new record for Bangladesh
Trichuris ovis	Cattle, pig, goat, sheep and camel (Brayton 1911)	-	Much Broader host specificity but only in herbivores	Direct (Brayton 1911)	Both the host and the parasite are the new record for Bangladesh
Monodontus sp.	Herbivores like giraffe, camel, deer, rodents and suids (Chitwood and Jordan 1965, Ming *et al.* 2010)	-	In herbivore host but specificity not narrow	Not sure but may be direct life cycle (Ming et al. 2010)	Both the host and the parasite are the new record for Bangladesh
Cyclodontos-tomum purvisi	Rats and moles (Hasegawa and Syafruddin 1994)	Rats and moles (Huq 1969)	Broad host specificity but restricted only to rodents	Direct but there may have possibility of having insect involvement (Varughese 1973)	Host record of this parasite in Bangladesh
Moguranema nipponicum	Recorded from shrew mole and Japanese mole, Formosan mole (Yokohota *et al.* 1988)	-	Broad host specificity but restricted only to rodents	No document	Both the host and the parasite are the new record for Bangladesh
Ascarops talpa	Insectivores (rodents, shrews, armadillos, birds and lizards) (Goldberg *et al.* 1997)	-	Much broader host specificity	Two hosts – Man/rat as definitive and beetle as intermediate host**	Both the host and the parasite are the new record for Bangladesh
Syphacea obvelata	Both laboratory and natural rats and mice and also in human (Smales 2001)	laboratory mice and human (Khanum and Arefin 2003, Huq *et al.*1985)	Much broader host specificity	Direct life cycle either by retro-infection or by contaminated water and food (Prince1950)	Host record of this parasite in Bangladesh

** In case of *Ascarops strongylina* it was found that the life cycle is indirect and dung beetle engulf the larval or adult stage during meal and when pig ingest it with water or feed then the parasite transfer into their definitive host (http://parasites.ftz.czu.cz/parasites/parasite.php?idParasite=52). As the present host is also an insectivore (Datta and Nandini 2015), so same method might also be applicable for the present host.

CONCLUSION

All the identified parasites showed broad host specificity, however, more specifically, *Strongyloides callosciurus* and *Ascarops talpa* had much broader host specificity including all vertebrate hosts, while the others were restricted only in various rodent families (Table 7). Therefore, the present parasites might be acquired from either intermediate hosts or from other hosts for which the rodents may have been accused most. The intestine, especially the small intestine, was the most favorable niche for the identified parasites. The dominancy of nematode parasites, perhaps, due to the involvement of arthropod insects into host diet (Thorington *et al.* 2006, Datta and Nandini 2015, IUCN Bangladesh 2015) which might have served as intermediate host and the affiliation of beetle in the life cycle of *Cyclodontostomum purvisi* and *Ascarps talpa* has already been proved (Table 7). The absence of trematodes may be attributed to the fact that for completion of life cycle of these parasites, implication of aquatic molluscan intermediate host is advocated, though the present host has terrestrial habitation. However, such confinement could not be proposed for acanthocephalan as previously many acanthocephalans have reported from terrestrial rodents. *H. diminuta* and *S. obvelata* may have zoonotic role to human and other vertebrates or vice versa, as their role as zoonotic agent has already been established by others.

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