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NEW RECORDS OF RODENT SPECIES IN BANGLADESH: TAXONOMIC STUDIES FROM RODENT OUTBREAK AREAS IN THE CHITTAGONG HILL TRACTS

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Abstract: Rodents are regarded as crop pests, significant reservoirs and vectors for many zoonotic diseases around the world. Basic taxonomic information of rodents present in a locality can help understand which species are responsible as crop pest in that habitat. The phenomenon of the 50-year cycle of gregarious bamboo flowering and rodent outbreaks in the Chittagong Hill Tracts (CHT) of Bangladesh, rodents trapping were carried out in four habitats from March, 2009 to December, 2011 in Ruma upazila of Bandarban hill district. Variety of traps were used to capture small mammals. The captured species were measured and identified using taxonomical dichotomous keys and DNA bar-coding performed in Australia. A total of 14 different small mammalian species were captured of which nine belonging to the Muridae family, and one species each of Spalacidae, Sciuridae, Tupaiidae and Soricidae families. The dominant small mammal species captured were *Rattus rattus* (54.06%) followed by *Mus musculus* (26.39%), *Rattus nitidus* (10.98%), *Suncus murinus* (5.45%), *Mus terricolor* (1.09%), *Mus cookii nagarum* (0.97%), *Cannomys badius* (0.16%), *Leopoldamys edwardsi* (0.12%), *Berylmys bowersi* (0.12%), *Vernaya fulva* (0.08%), *Rattus andamanensis* (0.08%), *Tupaia glis* (0.04%) and *Callosciurus pygerythrus* (0.04%). *Rattus nitidus*, *Leopoldamys edwardsi, Vernaya fulva, Rattus andamanensis, Berylmys bowersi* and *Mus cookii nagarum* are new records of rodent species in Bangladesh. Ten individuals of *Mus* spp. (0.40%) were not identified to species level, requiring further genetic analysis to determine their species. The implications of these discoveries are discussed in terms of agricultural pests.

Key words: New rodent species, bamboo flowering, rodent outbreaks, taxonomy, Chittagong Hill Tracts

INTRODUCTION

Rodentia is the single largest Order of living Mammalia (about 42% of world mammalian biodiversity), encompassing 2,277 recognized species and 481 genera in 33 families (Wilson and Reeder 2005). Rodents are found everywhere in the world except Antarctica. Four major families of rodents (Hystricide, Rhizomyidae, Sciuridae/Petromyidae and Muridae) are found in Southeast Asia and the pacific region. And identification of rodent species is difficult because of very similar physical characteristics, especially members of the Family Muridae

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(Aplin *et al.* 2003). The Family Muridae includes more than 1,350 species (two-thirds of living rodents) which are found in Eurasia, Africa and Australia in particular (Aplin *et al.* 2003, Musser and Carleton 1993). It includes many of the world's most familiar rodents, such as house rats and mice and some are e the most destructive of all agricultural pests and vectors for many zoonotic diseases throughout the world (Meerburg *et al.* 200, Singleton *et al.* 2010a, Buckle and Smith 1994). It has been estimated that less than 10% of rodents are agricultural pests and others play a beneficial role in the ecosystem (Stenseth *et al*. 2003, Singleton *et al*. 2007). Species identification of rodent is important for rodent control activities to avoid the adverse effects on non-target species (Aplin *et al.* 2003).

The diversity of rodents is high in Bangladesh. Ahmed *et al.* (2009) listed 20 rodent species under four families from Bangladesh. These include Sciuridae (9 species), Muridae (8 species), Spalacidae (1 species) and Hystricidae (2 species). Khan, (2010) listed 22 rodent species in Bangladesh. Detailed taxonomical work on rodents are scanty in Bangladesh and very limited work has been carried out in Chittagong Hill Tracts (CHT). From 2006 to 2007 rodent outbreaks were reported in CHT resultant from 50-year cycle of *Melocanna baccifera* (local name is *Muli*/*Maotak*) flowering and mast seeding (Belmain *et al*. 2008, Hellen Keller International (2008a). Following the rodent outbreaks, a crop damage assessment was carried out by Ahaduzzaman and Sarker (2010) and found that *Rattus rattus* as dominant rodent species comprising 80% of the samples. *Rattus exulans, Bandicota bengalensis, Mus musculus,* and *Mus* spp. were also recorded from CHT. Rodent identification is urgent for effective control measures as well as conservation perspectives in CHT. This study explored rodent species in CHT associated with bamboo forests, community households, crop fields, outside households and forests to take necessary steps for control measures.

MATERIAL AND METHODS

The study was conducted at Neweden, Munlai, Basatlang and Mualpi villages under Ruma upazila of Bandarban hill district (Fig. 1) and field data were collected from June, 2009 to December, 2011. These villages were selected for rodent trapping based on availability of 50-year cycle of *Melocanna baccifera* flowering forests and one of the most rodent infestation areas in CHT (Belmain *et al.* 2008).

Rotational trapping in four habitats: Rotational habitat trapping were carried out in two villages of Munlai and Neweden. The rotational habitat trapping commenced on March 18, 2009 and continued up to December 31, 2009. Trapping was carried out in four different habitats in each village: (i) Bamboo

forests, (ii) *Jhum* / crop fields, (iii) inside houses and (iv) outside around villages using 15 kill traps, two single-capture cage traps, two multi-capture live-traps, six large Sherman traps and 15 medium Sherman traps, giving a total of 40 traps per transect. Trapping was replicated two times (each village) in each

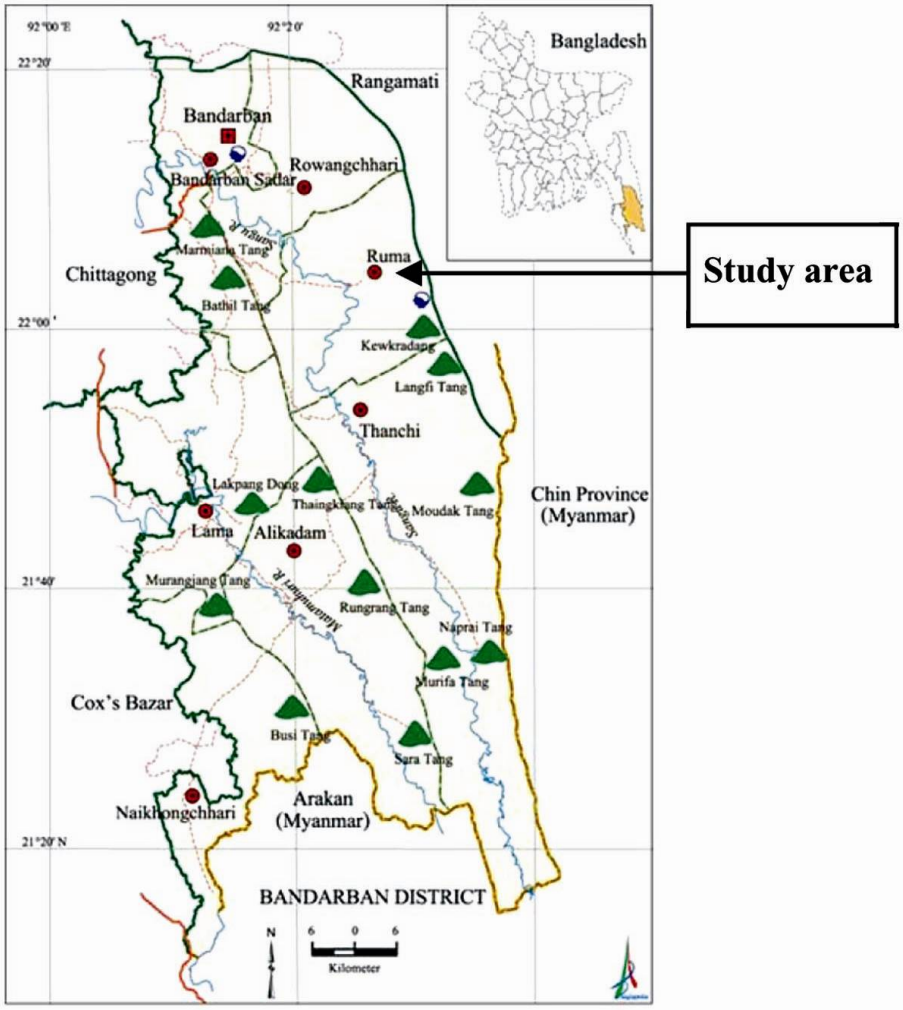

Fig. 1. Map showing the study area (Ruma upazila under Bandarban hill district) indicated with an arrow.
Source: Banglapedia, 2003. Online accessed at http://en.banglapedia.org/images/e/e6/BandarbanDistrict.jpg

habitat with four consecutive trap nights per month. In case of bamboo forests and crop fields, traps were placed every 20 m apart from each other. All traps were carefully tied with a rope and connected to a red colour marked bamboo stake to identify the traps easily. Two kill traps were distributed per household

for inside houses trapping and positioned along walls where there were signs of rodent activity, e.g. near rice store, kitchen, bedroom and ceiling areas of the houses. Household traps were rotated each month to new households. Flour, cooked rice and dried fish/shrimp were used as bait at the rotational habitats. However, banana, coconut and bamboo seeds were also used as bait in the bamboo forests and crop fields. During each trapping session, traps were checked daily. Captured species were collected from the trapping habitats (community household, outside of the community household, bamboo forests, crop field) each day.

Trapping at community households: Intensive community rodent trappings were carried out in the villages of Munlai, Neweden and Basatlang from June 08, 2009 to January 31, 2011 to understand rodent population abundance in the houses and the effects of long-term intensive trapping. Trapping was done inside houses and run by community peoples. Data were recorded five consecutive trap nights in a week. A total of 152 kill traps were used for capturing the rodents of which 52 traps in Munlai, 50 traps in Neweden and 50 traps in Basatlang village. Traps rotated around the community houses.

Trapping in the flowered Melocanna baccifera (Continuous bamboo) forests: Trapping in the *Melocanna* bamboo forests were started in July 09, 2009 and continued up to December 13, 2009 in the village of Basatlang, Munlai and Neweden. Three trap lines were used in three different forests each with 30 traps and traps placed 20 m apart from each other. Each trap was carefully tied with rope to the bamboo stand so that rodent could not move the traps. Everyday traps were set up in the evening (before dark) and checked in the morning. Trap lines mixed of large and small Sherman (10) and kill traps (20).

Trapping at trap barriers systems (TBS) at Jhum/crop fields: Three *Jhum*/crop fields were randomly selected based on availability of adjacent *Melocanna baccifera* bamboo forests in the village of Basatlang, Munlai, and Neweden and established physical trap barrier system (TBS) with plastic fences all around the crop fields. The main purpose of the physical barriers were to assess effectiveness of barriers from the rodent attack. A total of 66 multi-capture live cages were used at the physical barrier crop fields of which 28 in Neweden, 20 in Munlai and 18 traps in Basatlang and data collection were done from July 03, 2009 to December 31, 2009. Live cages (traps) were carefully positioned every 10 m apart and all were facing outwards. Traps were checked daily in each crop field and captured species were recorded.

Trapping at newly Melocanna baccifera bamboo flowering forests: Trapping in newly bamboo flowering forests were carried out in the village of Mualpi, Munlai and Neweden from December 15, 2009 to December 31, 2010 to observe rodent

population breeding in newly bamboo flowering forests. Three trap lines were set up and 250 kill traps were carefully positioned in those forests where 50 in Maupli-, 100 in Munlai and 100 in Neweden villages. However, the number of traps were reduced to 125 numbers from the month of September 2010 of which 25 traps in Mualpi, 50 in Munlai, and 50 in Neweden due to excessive rainfall and landslides in that bamboo forests. Flour, banana and coconut were used as bait in the habitats. A bamboo stand was selected as starting point for trapping to identify the trap line before setting the trap lines. The bamboo stand was marked with red colour paint to identify easily the trap line.

Trapping in the forests: Trapping in the forests were carried out in the village of Mualpi and Munlai from February 01, 2011 to December 31, 2011. The selected forests were natural forests, mixed with *Melocanna* bamboo forests. Two trap lines were set up in those forests. Fifty snap traps were set up in each forest in the month of February, 2011. After that, the numbers of traps were increased to 200 in March, 2011 of which 100 in Mualpi and 100 in Munlai. Further, traps numbers were increased 250 to cover the whole forests of which 125 snap traps in Mualpi and 125 in Munlai.

Measurements of collected species and identification: Collected samples were identified by examining physical characteristics followed by Aplin *et al.* (2003) and preserved in 70% ethanol for further taxonomic analysis. Measured each species head and body length (mm) in straight line along the animals' vertebral column from the tip of the nose to the distal end of the anus (with the animal lying on its back) with the help of ruler scale. The tail length of the species was measured along a straight line from the middle of the anus to the tip of the tail and. Only undamaged tails were measured and recorded, with damaged tails noted in data sheet. The hind-foot length was measured from the heel to the tip of the central (longest) toe, without including the claw. Ear length was measured from the bottom of the notch of the ear to the furthest point along the rim). Care was taken while measuring ears, noting whether the margin of the ear was damaged or not. All the measurements were carried out with a steel ruler. After taking physical measurements, each collected species was weighed (g) with a Pesola spring balance (https://www.pesola.com/e/). Pesola balances were checked regularly before use to ensure correct calibration. Finally, the age and sex of the captured species were determined following Aplin *et al.* (2003) procedures. Female species also have teats associated with subcutaneous mammary glands. These are arranged down either side of the body. The teats are prominent and easy to locate in sexually mature females, especially in those that have had young. However, they can be very difficult to locate in juveniles and the presence or absence of teats should not be used as a means of

determining the sex of an individual. For classification purposes, pairs of teats or mammae are counted in three groups; pectoral, postaxillary and inguinal. For example, the number of teats would be given as 1+2+2 (Aplin *et al*. 2003).

Further taxonomic studies of the collected samples (281) were shipped to the South Australian Museum and University of Adelaide in Australia. DNA bar-coding was also performed at the University of Adelaide in Australia to confirm the taxonomically of the captured species, particularly *Rattus rattus* and also studied cranial features.

Measurement of cranial features: Skull preparations were carried out at the South Australian Museum. The adult *Rattus rattus, Rattus nitidus, Leopoldamys edwardsi, Rattus andamanensis,* and *Cannomys badius* were sorted and done for skull preparation. However, *Mus* species and juveniles were not performed for skull preparation. The rodent head was removed from the body with the help of scissor and head placed in a jar with a label. Then head was soaked in water for three to four days. Meat was extracted from the head with the help of forceps and scissor and then brain was broken. Head was soaked again in water for five days and skull was cleaned with toothbrush. After that skull was soaked in detergent liquid and water for one day and kept for drying. Dried skull was labelled with tag and kept in a plastic bag. Vernier scale was used for skull measurement and taken of each species skull photograph. The measurement parts a rodent skull was: (1) Bulla length (mm)-bulbous projection of the ear bone), (2) condylobasal length (mm) - length of the skull, measured from the front of the incisors to the most posterior part of the skull all the occipital condyles, occipital crest, (3) incisive foramen length (mm)-hole or opening in a bone through which nerves and blood vessels may pass), (4) interorbital width (mm)-distance between the upper edge of the orbit, measured across the top of the skull), (5) upper molar row length (mm) and (6) zygomatic width (mm)-curved bones forming an arch along the side of the skull below the orbit to a point near the external opening of the ear canal, sometimes referred to as the cheekbone (Roest 1991).

RESULTS AND DISCUSSION

Fourteen different species were found in the trapping habitats (Table 1). The most dominant small mammals' species was *Rattus rattus* (54.06%) and the least was *Tupaia glis* (0.04%) and *Callosciurus pygerythrus* (0.04%) (Table 1). Out of the 14 small mammals, 12 were rodent species (Table 2) and two shrew (Family Soricidae) species. Six of 12 rodent species are new records for Bangladesh. The new species are *Mus cookii nagarum, Leopoldamys edwardsi,*

Rattus nitidus, Rattus andamanensis, Berylmys bowersi and *Vernaya fulva. R. rattus* and *M. musculus* were found in all trapping habitats.

Table 1. Small mammals captured from four localities in different habitats of Ruma upazila under Bandarban district of Chittagong Hill Tracts in Bangladesh between 18 March, 2009 and 31 December, 2011 (n = 2,486)

Name of species	% of species	Habitats									
		BF	JF	OAV	IH	NBF	CH	CBF	F	TBS	Total
Berylmys bowersi	0.12	-	-	-	2	-	1	-	-	-	3
Callosciurus pygerythrus	0.04	-	-	-	-	1	-	-	-	-	1
Cannomys badius	0.16	-	-	-	-	-	-	-	-	4	4
Leopoldamys edwardsi	0.12	-	-	-	-	1	2	-	-	-	3
Mus cookii nagarum	0.97	1	6	1	7	-	7	-	2	-	24
Mus musculus	26.39	10	17	4	116	14	443	2	36	14	656
Mus spp.	0.40	-	1	1	1	6	1	-	-	-	10
Mus terricolor	1.09	1	-	-	5	5	12	-	4	-	27
Rattus andamanensis	0.08	-	-	-	-	2	-	-	-	-	2
Rattus nitidus	10.98	3	-	-	12	57	168	-	29	4	273
Rattus rattus	54.06	9	6	10	28	222	868	11	138	52	1344
Suncus murinus	5.47	1	2	2	4	1	120	1	5	0	136
Tupaia glis	0.04	-	-	-	-	1	-	-	-	-	1
Vernaya fulva	0.08	-	1	-	-	-	1	-	-	-	2
Total	100	25	33	18	175	310	1623	14	214	74	2486

BF = Bamboo forests, JF = *Jhum* fields, OAV = Outside around villages, IH = Inside households, NBF = Newly bamboo flowering forests, CH = Community households, CBF = Continuous bamboo forests, F = Forests and TBS = Trap barrier systems/crop barrier field.

Morphological features of taxonomically confirmed new rodent species

Berlymys bowersi (Anderson 1879): A large size rat (Table 3) with white incisor enamel and brownish-grey dorsal fur, which is sharply demarcated from a pure-white belly. The ears (pinnae) are moderately large and thinly furred. The tail is usually slightly longer than the head + body. Hind foot is white above with a grey strip (Aplin *et al.* 2003).

Mammae: 1 + 1 + 2

Mus cookii nagarum (Ryley 1914): A medium size mouse (Table 4) with soft, few hairs through the fur. Fur colour on back is grey-brown to orange brown. Fur colour on under surface is white. The belly fur is cream with dark-grey

Table 2. Identified rodent species from Ruma upazila of Bandarban district

Family name	Scientific name	English name	Local name	IUCN status
Muridae	*Rattus rattus*	Common house rat, black rat	Idur, Gechu -idur	Least Concern (LC) (Amori *et al*. 2008)
	Rattus nitidus	Himalayan rat		Least Concern (LC) (Aplin *et al*. 2008f)
	Rattus andamanensis	Indochinese forest rat		Least Concern (LC) (Aplin *et al*. 2008b)
	Mus musculus	House mouse	Nengti indur, Shola indur	Least Concern (LC) (Musser *et al.* 2008)
	Mus cookii nagarum	Cook's mouse, Ryley's		Least Concern (LC) (Aplin *et al*. 2008e)
	Mus terricolor	Earth-colored mouse		Least Concern (LC) (Aplin, 2008a)
	Berylmys bowersi	White-toothed rats		Least Concern (LC) (Aplin *et al*. 2008c)
	Leopoldamys edwardsi	Edward's rat, Edwards's Long-tailed giant rat.		Least Concern (LC) (Aplin *et al*. 2008d)
	Vernaya fulva	red climbing mouse, Vernay's climbing mouse		Least Concern (LC) (Lunde *et al*. 2008)
Spalacidae	*Cannomys badius*	lesser bamboo rat	Bash idur	Least Concern (LC) (Aplin *et al*. 2008g)
Sciuridae	*Callosciurus pygerythrus*	Hoary-bellied Squirrel, Irrawaddy Squirrel	Badami Katbirali, kathbirali, Kota	Least Concern (LC) (Shrestha *et a*l. 2008)

Table 3. Physical measurements of *B. bowersi* (n = 3)

Adult measurements	Mean	Sd	SEM	Range
Head + body (mm)	148.33	22.55	13.02	125 - 170
Tail length (mm)	203.00	23.64	13.65	181 - 228
Foot length (mm)	33.67	0.58	0.33	33 - 34
Ear length (mm)	23.67	1.53	0.88	22 - 25
Weight (gm)	162.33	24.83	14.33	142 - 190

Sd = Standard deviation, SEM = Standard error of the mean.

Table 4. Physical measurements of *Mus c. nagarum* (n = 22)

Adult measurements	Mean	Sd	SEM	Range
Head + body (mm)	78.86	9.48	2.07	56-93
Tail length (mm)	85.14	13.32	2.91	50-96
Foot length (mm)	16.18	1.92	0.42	9-18
Ear length (mm)	12.32	2.36	0.51	7-16
Weight (g)	18.68	3.62	0.79	9-23

Sd = Standard deviation, SEM = Standard error of the mean.

bases. The tail is slightly shorter or slightly longer than the head + body (Aplin *et al.* 2003). The pes (hind foot) is large and hairy. Incisors are orange.

Mammary formula: 1+2+2

Leopoldamys edwardsi (Thomas, 1882): *L. edwardsi* is large-sized rat with a longer tail. The tail is longer than head and body. Fur colour on back is short, reddish brown to orange with sharp boundary to belly colour. Fur colour on under surface is white or cream. The upper surface of feet is white. Incisors are orange; ears are also grey in colour (Aplin *et al.* 2008d). Physical measurements of collected *L. edwardsi* specimens and their skulls have been presented in Tables 5 and 6.

Mammae: 1 + 1 + 2

Table 5. Physical measurement of *L. edwardsi* (n = 3)

Adult measurements	Mean	Sd	SEM	Range
Head + body (mm)	216.67	11.02	6.36	204-224
Tail length(mm)	269.67	65.58	37.86	194-310
Foot length (mm)	43.67	5.77	3.33	37-47
Ear length (mm)	25.00	3.61	2.08	21-28
Weight (g)	252.33	60.88	35.15	202-320

SD = Standard deviation, SEM = Standard error of the mean.

Table 6. Skull measurements of *L. edwardsi*

Measurements	Mean	Sd	SEM	Range	n
Bulla length (mm)	5.88	0.14	0.10	5.78-5.98	2
Condylo basal length (mm)	51.47	2.54	1.79	49.67-53.26	2
Incisive foramen length (mm)	8.70	1.06	0.61	7.48-8.39	3
Inter orbital width (mm)	8.08	0.44	0.25	7.58-8.39	3
Upper molar row length (mm)	9.24	0.14	0.08	9.16-9.40	3
Zygomatic width (mm)	23.70	2.09	1.21	22.19-26.09	3

Sd = Standard deviation, SEM = Standard error of the mean, n = Number of sample.

Rattus nitidus (Hodgson, 1845): A medium-size rat with soft, woolly fur that is brown dorsally. Belly fur is grey-based. The ears are large and lightly furred. The tail is approximately equal in length to the head+body. Incisors are orange (Aplin *et al.* 2003). The pes is relatively long and narrow, and clothed in pure white hairs. The manus and lower forelimb are also pure white. Measurements of collected *R. nitidus* samples have been given in Tables 7 and 8.

Mammae: 1+2+3

Rattus andamanensis (Blyth, 1860): A medium sized rats with a tail usually longer than body, all dark. Fur is soft or with scattered spines and many hairs project through the fur on the back. Back fur colour is brown to orange-brown. Fur colour on under surface is white or cream to roots. Feet are broad, white above or with a narrow brown. Ears are usually larger than and incisors are orange (Aplin *et al.* 2008b). Measurements of collected *R. andamanensis* specimens have been presented in Tables 9 and 10.

Mammary formula: 1+2+3

Table 7. Physical measurements of collected *R. nitidus*

Adult measurements	Mean	Sd	SEM	Range	n
Head + body (mm)	150.26	23.13	1.98	105-220	137
Tail length (mm)	159.41	24.69	2.13	106-220	135
Foot length (mm)	32.14	2.66	0.23	24-39	137
Ear length (mm)	20.88	2.50	0.22	16-28	136
Weight (g)	100.69	40.65	3.49	50-225	137

SD = Standard deviation, SEM = Standard error of the mean, n = Number of sample.

Table 8. Skull measurements of *R. nitidus*

Measurements	Mean	Sd	SEM	Range	n
Bulla length (mm)	7.11	0.26	0.09	6.75 - 7.40	8
Condylo basal length (mm)	43.44	1.97	0.70	41.67 - 47.11	8
Incisive foramen length (mm)	8.19	0.09	0.04	8.05 - 8.30	6
Inter orbital width (mm)	6.93	0.55	0.19	6.01 - 7.59	8
Upper molar row length (mm)	7.10	0.17	0.06	6.94 - 7.37	8
Zygomatic width (mm)	22.27	0.94	0.33	21.05 - 23.42	8

SD = Standard deviation, SEM = Standard error of the mean, n = Number of sample.

Table 9. Physical measurements of *Rattus andmanensis* (n = 2)

Adult measurements	Mean	SD	SEM	Range
Head + body (mm)	123.50	47.38	33.50	90 - 157
Tail length (mm)	143.00	49.50	35.00	108 - 178
Foot length (mm)	28.50	6.36	4.50	24 - 33
Ear length (mm)	18.00	2.83	2.00	16 - 20
Weight (g)	50.00	42.43	30.00	20 - 80

Sd = Standard deviation, SEM = Standard error of the mean.

Vernaya fulva (G. M. Allen, 1927): It is a small mouse (Table 11) with an exponentially long tail. Fur is soft and fluffy. Ears are brown. Dorsal surfaces of feet are covered with rich orange-brown hairs. Incisors are ophistodont, pigmented yellow-orange, and ungrooved along their anterior face (Lunde 2007).

Table 10. Skull measurement of *Rattus andamanensis* (n = 1)

Measurements	Mean
Bulla length (mm)	7.63
Condylo basal length (mm)	42.13
Incisive foramen length (mm)	7.10
Inter orbital width (mm)	5.94
Upper molar row length (mm)	7.70
Zygomatic width (mm)	20.90

Table 11. Physical measurements of *V. fulva* (n = 2)

Adult measurements	Mean	SD	SEM	Range
Head + body (mm)	65.50	13.44	9.50	56-75
Tail length (mm)	93.50	4.95	3.50	90-97
Foot length (mm)	15.50	0.71	0.50	15-16
Ear length (mm)	12.50	0.71	0.50	12-13
Weight (g)	12.50	3.54	2.50	10-15

SD = Standard Deviation, SEM = Standard error of the mean.

The diversity of rodents in the Chittagong Hill Tracts (CHT) of Bangladesh is high. This study confirmed six undocumented rodent species from Bandarban (one of the three hill districts) of CHT. The new rodent species for Bangladesh are *Mus cookii nagarum, Leopoldamys edwardsi, Rattus nitidus, Rattus andamanansis, Berylmys bowersi* and *Vernaya fulva*. Rodent taxonomy is very much important for effective control measures as well as conservation perspectives (Aplin *et al.* 2003). For example, *Rattus rattus* is a serious pest species in the agricultural and households (Brown *et al.* 2017, Singleton and Petch 1994). This study also confirmed that *Rattus rattus* is the dominant rodent species in the study area and followed by *Mus musculus* and *Rattus nitidus*. Similar geographic condition in India such as Mizoram, Assam and Nagaland where *R. rattus* was found to be the main species (Aplin *et al.* 2010). Htwe *et al.* (2010) and Douangboupha *et al.* (2010) also reported during the rodent outbreaks periods that *R. rattus* was the main pest species in the Chin State of Myanmar as well as Lao PDR. *R. nitidus* can be separated on its feet narrower than in *R. rattus*, white or brown above. *R. andamanensis* can be separated from

R. rattus by measuring the ears. Ears are usually larger than the similar size of *R. rattus. Leopoldamys edwardsi* can be distinguished by its body length which is > 250 mm, tail length 300 - 350 mm and feet length > 50 mm. *Mus musculus* species can be differentiated from *Mus cookii nagarum* from its feet. Feet of *M. cookii nagarum* is very narrow and white above. *Berylmys bowersi* can be identified by its white incisors and two teats on lower body. *Vernaya fulva* can be identified easily from other *Mus* species by its long tail and dorsal fur, which is brownish orange. According to International Union for Conservation of Nature (IUCN) Red List Categories (Lunde *et al.* 2008) *Vernaya fulva* belongs to the Least Concern ver. 3.1. However, little information is documented around the world regarding on *V. fulva* population abundance and trend. Measuring the rodent skull found that the skull length of *Leopoldamys edwardsi* is higher than others. However, the average bulla length (5.88 mm) of *L. edwardsi* is smaller than *R. rattus* (8.31 mm). *R. nitidus* skull can be distinguished with the *R. rattus* skull on the condylo basal length and bulla length. Ten samples of *Mus* species could not be identified up to species level, so that further taxonomic research is necessarily required.

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