Research Article

A Note on Rodent Migration following Gregarious Bamboo Flowering in North-Eastern Hill Region with Particular Reference to Mizoram (India) and Its Consequences

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Abstract

Bamboo is a versatile non-timber forest product (NTFP) with a wide range of domestic, commercial and industrial uses. Bamboos account for 12.8 percent approximately of the total forest cover in India. The North-Eastern Hill (NEH) region harbors more than 66 percent of the Indian bamboo genetic resources. Out of 125 bamboo sp. available in India, 8.4 taxa are found in NEH region. Mizoram occupies the largest forest area (30.8%) under different bamboo species, followed by Meghalaya with 26.0 percent.

The gregarious bamboo flowering of *Melocanna baccifera* or Mautam occurs periodically after every 48±1 years and causes ecological imbalance in NEH region comprising seven contiguous states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Tripura, Mizoram and Nagaland. Bamboo plants die after flowering and fruiting, leaving bare and exposed soil, which is disastrous in mountainous states. Secondly, rodents feed on the flowers and seeds of the dying bamboo, leading to a rapid growth in their numbers, which migrate toward agricultural fields, granaries and destroy standing crops and stored grains. The destruction of crops results in food scarcity and famine. The epidemiological imbalance also leads to increased risk of infection in man and animals or outbreak of rodent-borne diseases. The modes of transmission are through rat bite, insect vector bites, fleas and other ecto-parasites or contamination of food, water and air by rodent urine or excreta. Some of these diseases require immediate control measures to minimize the morbidity and mortality in local inhabitants.

From historical or scientific records, it is believed that masting of Mau bamboo-*M. baccifera* occurred across north-eastern India in 1815, 1863, 1911, and 1959. A *Melocanna* masting event occurred on schedule in Mizoram in 2006-09. The crops suffered massive damage, with yields at 30 year low.

It was reported that spontaneous increase in rodent population due to high nutritive value of bamboo fruits, reduction in cannibalism due to the availability of plenty of food during bamboo flowering and change in the ecological conditions resulting in 'r'-pattern of rodent breeding might be the probable reasons for the rodent outbreaks.

The rodent fauna of the Indian sub-continent is represented by 46 genera and 128 species. Out of 18 commensal rodents, *Rattus rattus* is the most predominant species. In NEH region, *Rattus* spp. forms about 45% of the total rodent population (specially, *R. nitidus*-24.51%) followed by *Mus* spp. (16.9% *M. musculus*) and *Bandicota bengalensis* (lesser bandicoot rat) about 31.5%. Rodents responsible for famine in the years of bamboo flowering are *R. rattus, R. nitidus, R. niviventer* and *R. r. brunnellsculus.*

Mizoram was under threat during bamboo flowering because Myanmar-a high risk area for transmission of plague, salmonellosis being endemic in Mizoram with frequent food

poisoning outbreaks, gastroenteritis being second leading health problem indicates unsafe food and drinking practices. Higher attitudes and practices of people towards rodents including consumption of their flesh, difficult terrains and inaccessible remote or interior villages with poor health facilities were the real threats for the transmission of rodent-borne diseases.

The state had prepared a series of Bamboo Flowering and Famine Combat Schemes (BAFFACOS) in 2005 for inter-sectoral coordination with various departments like agriculture, health, rural works and public works. A central team of rodent and rodent-borne disease experts from CAZRI, Jodhpur; NIPHM, Hyderabad and National Centre for Disease Control, Plague Surveillance Unit, Bangalore, visited Mizoram several times during 2006-2009 for making on the spot assessment, to demonstrate rodent pest management and surveillance, prevention and control of rodent-borne diseases in the region and to train the workers involved in surveillance and control works.

Keywords: Gregarious bamboo flowering, Rodent migration, Mautam, Thingtam, Rodent borne diseases, *Melocanna baccifera,* famine, Jhum cultivation, BAFFACOS.

Introduction

The North-Eastern Hill (NEH) region of India comprising seven contiguous states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Tripura, Mizoram and Nagaland accounts for 7.7% of area and 4.04% of country's population. All the seven regions have a lot in common. Most of them are located in the Himalayan region with hilly terrain, extremely fertile soil, tropical and sub-tropical forests, wide variety of flora and fauna, monsoon-type climate with humidity, short summers and severely cold and dry winters. All the seven states of NEH region in India support extensive bamboo forests dominated by species of bamboo with semelparous masting reproduction. NEH region has great diversity of bamboo resources. Bamboo plays a vital role in everyday life of the people in NEH region. The largest-scale events are associated with the flowering of *Melocanna baccifera*, an ecologically aggressive bamboo species that covers more than 26,000 km^2 of the northeast Indian states, and the adjoining areas of the Chin Hills of Myanmar and the Chittagong Hill Tracts of Bangladesh. Highly synchronized reproduction of *Melocanna baccifera* was observed to underpin a cycle of rodent outbreaks, famine and human deaths.

From the time immemorial many beliefs are associated with bamboo flowering. In general, bamboo flowering is considered to be a bad omen as described in Mahabharata 5000 years ago. Bamboo flowers gregariously at a periodic interval and during bamboo flowering rodent outbreaks usually occur in NEH region, which decimates paddy and other crops fields thereby causing famine. Gregarious bamboo flowering is well known for causing famine in Mizoram and Arunachal Pradesh. This event was recorded for the first time in 1862 and the next bamboo famine which devastated the entire Mizo chiefdoms was recorded in1881-82 (Military Report on the Chin-Lushai Country, 1881). It was estimated that 15,000 Mizos perished and many people fled to the neighboring plain areas of Cachar and Manipur.[1-7]

In Mizoram too where 31% of the total forest area is covered by bamboo, the rodent outbreaks due to bamboo (*M. baccifera*) flowering caused tremendous destruction of food crops resulting in famine.[7-9] Flowering of *M. baccifera,* which is locally known as 'Mautam', occurs periodically after every 48±1 years. Every 48 years, the Mautam bamboo blooms and its seeds lead to an explosion in rodent population in the jungle, which destroy food supplies of the entire villages after rats move on to farm fields and devour crops and destroy the stored grains in granaries.

A *Melocanna* masting event occurred on schedule in Mizoram in 2006-2009. The crops suffered massive damage, with yields at 30 years low. Details of two previous *Melocanna* masting events, in 1910-12 and in 1958-60, are available from colonial sources; both events were followed by rodent outbreaks leading to extensive crop destruction and famine, with significant human mortality.[7,10,11]

Regular rodent outbreaks associated with bamboo flowering also occur in Laos, Japan, Madagascar, South America and other countries. Throughout Asia, farming people believe that the episodic of mass flowering of bamboo ("masting") causes rodent outbreaks and famine, and similar beliefs are also espoused among subsistence farmers in South America. Many rural people in Asia claim to have seen it, quite often more than once in their lifetime.[12-16]

Published reports by WHO stated that human plague cases were reported from Myanmar[17] and thus enzootic foci of plague in Myanmar is a great threat for human plague outbreak in Myanmar and the neighboring states of Mizoram and Manipur in India. Chin State is located in western Myanmar, surrounded by the Chittagong Hill Tracts, and Mizoram. In Myanmar, sporadic rodent epizootics and suspected bubonic plague cases were present almost every year in Sagaing Div., Shan state,

Manadalaya div. and Yangaon div. Natural foci of plague in Myanmar present definite, continual but unpredictable potentials for plague outbreaks.

Like their neighboring countries, the people of Chin in Myanmar depend on upland rice cultivation for their daily calories. Unfortunately, they also share the problem of rising rat populations after bamboo flowering. Impacts of rodent outbreaks throughout Chin state in 2007-08 were believed to be the most serious in 50 years. It is reported that rodent outbreaks occurred in 30 villages in Paletwa, north of Chin State, in 2007. Caused by the *Rattus rattus* species, outbreaks erupted two months after bamboo flowering. In September 2009, rodent outbreaks occurred in Palatwa Township, Chin state, and Kyauktaw Township, northern Rakhine state (Arakan). Rodent damage to upland rice started in August 2009 following massive bamboo flowering, similar to the 2007 and 2008.[18,19]

Study Areas: Mizoram

Mizoram is in the eastern-most corner of India bordering Cachar district of Assam and Manipur state in the north, Tripura in the north west, Myanmar in the east and south and Bangladesh in the west. The state shares a 722 km border with the neighboring countries of Bangladesh and Myanmar. It extends from 21°56'N to 24°31'N, and 92°16'E to 93°26'E. The tropic of cancer runs through the state nearly at its middle. The state has a mild climate, relatively cool in summer 20 to 29°C (68 to 84°F) and winter temperatures range from 7 to 22°C (45 to 72°F). The region is influenced by monsoons, raining heavily from May to September with little rain in the dry (cold) season. The climate pattern is moist tropical to moist sub-tropical, with average state rainfall 254 cm (100 in) per annum.

Mizoram covers an area of approximately 21,087 sq. km. The state has third-highest total forest cover (90.68 percent) with 1,594,000 hectares (3,940,000 acres). Bamboo grows wildly in Mizoram and harvesting 40% of India's annual bamboo crops. Mizoram has a population of 1,091,014 with highly literate agrarian economy, but suffers from slash-and-burn jhum or shifting cultivation and poor crop yields. In recent years, the jhum farming practices are steadily being replaced with a significant horticulture and bamboo products industry.

Bamboo Flora and Gregarious Bamboo Flowering in Mizoram Region

India has the largest area under bamboo in the world, estimated around 11.36 million hectares and second only to China in bamboo production (4.6 million tons) per year. Bamboos account for 12.8 percent approximately of the total forest cover in India. India has 136 species of bamboo across 22 genera. The NEH region harbors more than 66 percent of the Indian Bamboo genetic resources. Fifty-eight species of bamboo belonging to 10 genera are distributed in the northeastern states alone. Mizoram occupies the largest forest area (30.8%) under different bamboo species, followed by Meghalaya with 26.0 percent. In hilly terrain of Mizoram, there are twenty major varieties of bamboo covering nine genera of which *M. baccifera* contributes about 95% of the growing stock of bamboo. *Melocanna* bamboo forests cover huge areas of northeastern India and surrounding areas of Bangladesh, Myanmar, and Nepal, with a total area in India alone probably in excess of 26,615 sq. km. Other important species are *Dendrocalamus hamiltonii, D. longispathus, Bambusa tulda, B. khasiana, Calamus sp.* and *Arundinaria callosa* of which only seven species flower in different times. The local names of these species are Mautam, Rawthing, Rawangal, Rawni and Rawthla. Two major bamboo species flowering coincide with outbreak of rodents are Mautam and 'Thingtam'. Out of these, mautam is reported to be much more severe than thingtam. The period between two mautams is calculated to be 48 years. First official record of mautam was in 1862. And similar rodent outbreak was reported after 49 years in 1911. The gap between mautam and thingtam is 18 and 30 years approximately. Gregarious bamboo flowering in NEH region during different periods is shown in Table 1. Similar outbreaks due to mautam, induced by the flowering of bamboo during 1958-59 recorded tremendous losses in Mizoram.

In the Asian context, one bamboo masting event surpasses all others in its scale and claimed impacts-this is mautam. The masting and subsequent mass mortality (tam means death) of a particular widespread bamboo *M. baccifera* is called Mau by the regional people. From historical records, it is believed that masting of Mau bamboo occurred across north-eastern India in 1815, 1863, 1911, and 1959, suggesting an approximately 50-year flowering cycle.[1,10,11,13,14]

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Table 1.Gregarious Bamboo Flowering in North Eastern States of India

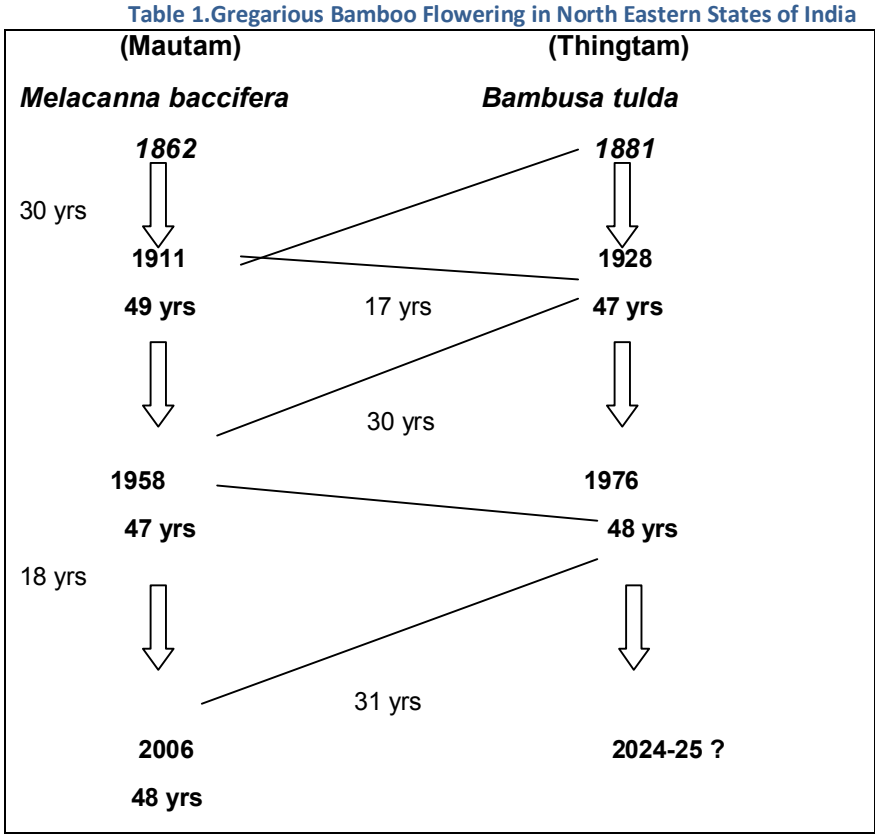

Figure 1.Bamboo Flowering in Mizoram

Correlation between Bamboo Flowering and Rodent Explosion

Rodent outbreaks associated with gregarious bamboo flowering is well documented. According to the folk belief, the rodents feed on the large quantities of highly nutritious seeds of the dying bamboo trees, which, in turn, are believed to trigger a rapid increase in the birth rate of the rodents leading to the population explosion of the rodents. Following depletion of bamboo seeds, the huge populations of rodents 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.

The factors, which induced the rodent outbreaks, are not clearly concluded. However, high nutritive value of bamboo fruits helps rodents in prolific breeding. *Melocanna baccifera* has a lifespan of approximately 48 years, reproduces with a high degree of synchrony, and is a prodigious producer of fruits-up to 83.6 tons per hectare. The fruits of *M. baccifera* are rather unusual, being large, ovoid or globose with a long extended beak, between 6 and 12 cm long and up to 8 cm wide and weigh up to 275 g. A single plant produces up to 30-40 kg of tasteless fruits before death. Flowering and death of each plant usually takes a maximum of one year. Large quantities of nutritious bamboo fruits stimulates the early onset of breeding in *Rattus sp.* and other bamboo forest-dwelling rodents, thus causing a population increase several months earlier than during nonmasting years.[2-4,6,7,20-23]

In the Asian context, the one field study of rodent populations during a bamboo flowering event failed to produce evidence of large increases in rodent numbers or of extensive population movements of the kind often mentioned in the "anecdotal" accounts. Similarly, a study of historical records of rodent outbreaks in Laos failed to yield a compelling case for bamboo flowering as a cause of the outbreaks in Laos. In the South American context, previous analyses of these phenomena relied entirely on second-hand sources and it was only very recently that an ecological study of a bamboo flowering-associated ratada was completed.

The nutritional value of bamboo fruits includes typically high starch and protein contents. Chemical analysis of *Melocanna* fruit in the Forest Research Institute, Dehradun, yielded values of 50.3% starch, 11.6% protein, 3.0% ash, and 0.2% fats.[24-26]

Some of the scientists believe that the flowers and seeds increase the estrogen level in the rodents which enhances the reproduction rate and their number increases in an epidemic proportion, thus sudden availability of nutritious food increases the potentiality of local rodent population.

Pathak and Kumar[6] and Rao[27] reported that spontaneous increase in rodent population due to high nutritive value of bamboo fruits, reduction in cannibalism due to the availability of plenty of food during bamboo flowering and change in the ecological conditions resulting in 'r'-pattern of rodent breeding might be the probable reasons for the rodent outbreaks.[6,27]

The increase in amount of food available was probably the most common proximal cause of increase in rodent population. The rats and mice reproduce in numbers due to sudden and constant supply of bamboo fruits for a period of 5 years. When the source of food is finished, the rodents migrate toward crop fields, plantations and human habitations and consume everything and thus spread the rodent-borne diseases.

Figure 2.Fruits of *Melocanna baccifera* and Bamboo fruit eaten by rodents

Jhum Cultivation in NEH Region: A Risk Factor for Rodent Explosion

Shifting cultivation is the primitive form of soil utilization, usually of tropical rain forests and bush areas of central Africa, central America and southeast Asia. It is locally termed as Ladcmg in Indonesia, Caingin in Philippines, Milpa in Central America and Mexico, Ray in Vietnam, Conuco in Venezuela, Roca in Brazil, Masole in the Congo and Central Africa. It is also practiced in the highlands of Manchuria, Korea, Bangladesh like Chittagong, Bandarban, Rangamati regions and southwest China. In India, it is known as Jhum in NEH region, Podu, Dabi, Koman or Bringa in Orissa, Kumari in Western Ghats, Watra in southeast Rajasthan, Penda, Bewar or Dahia and Deppa or Kumari in the Bastar district of Chattisgarh. Jhum cultivation is a local name for slash and burn agriculture practiced in the north-

eastern Hill states of India. In NEH region out of the total reporting area of 33 million hectares, about 3 million hectares are under cultivation and out of this 2.6 million hectares are under jhum cultivation. Nagaland and Mizoram have the largest area under shifting cultivation, i.e., 6.08 and 6.04 lakh hectares respectively. Jhum cultivation is most practiced on the slopes of hills in thickly forested area. This involves clearing of piece of forest land by felling trees and burning the dried forest wood into ashes. The growers cut the treetops of surrounding forest areas to allow sunlight to reach the land. They use the area for growing crops of agricultural importance such as upland rice, maize, millets, pulses, cotton, sesamum, vegetables or fruits. Having used for some years the growers shift to other fertile areas because the land loses its natural fertility. Jhumias return to the same plot after thirty to forty years of non-use for slash and burn cultivation.

Jhum cultivation offers low yields of crops. Before 1947, agriculture in Mizoram predominantly used to be Jhum cultivation. A 2012 report estimates the proportion of shifting cultivation area in Mizoram to be about 30 percent-predominant part of which was for rice production (56 to 63 percent). Shifting cultivation is gradually reducing the forest wealth and damaging the ecology beyond redemption in Northeast India. In 1984, Govt. of Mizoram launched a program called New Land Use Policy (NLUP) with an objective to put an end to the practice of jhuming by providing alternative land-based permanent occupation and stable income to the families practicing jhuming.[28] Rodent damage to *jhum* crops increases through the cropping season as more young rodents emerge to feed on the maturing crops. Harvest puts an end to this period of rapid growth in field-rat populations.

Rodent Fauna of NEH Region

The rodent fauna of the Indian sub-continent is represented by 46 genera and 128 species. Out of 18 commensal rodents, *Rattus rattus* is the most predominant species. In NEH region, *Rattus* spp. forms about 45% of the total rodent population (specially, *R. nitidus*-24.51%) followed by *Mus* spp. (16.9% *M. musculus*) and *Bandicota bengalensis* (lesser bandicoot rat) about 31.5%. *Rattus niviventer* (white-bellied rat), *Cannomys badius* (bamboo rat), *R. bowersi, R. khyensis, R. tistae, R. r·bullocki* (Manipur rat), *Rattus norvegicus*, *M. booduga* (field mouse) and *B. indica* (larger bandicoot rat) are also distributed in the region. Rats responsible for famine in the years of bamboo flowering are *R. rattus, R. nitidlis, R. niviventer* and *R. r. brunnellsculus* (Table 2).

Rodent species, which are widespread in both irrigated and dry farming systems in the country, are the Indian gerbil, *Tatera indica*, the soft-furred field rat, *Rattus meltada*, and the house mouse, *Mus musculus*. *Tatera indica, R. meltada, Mus musculus* and *Rattus rattus* are the efficient reservoirs or carriers of human plague in India. However, both *T. indica* and *R. meltada* have not been reported from north-eastern hill region. The rodent fauna of Mizoram was documented taxonomically from early and recent collections (Table 2). The dominant commensal and peri-domestic rodent species is the black rat-*Rattus rattus*. Two critical features that seem to underpin the success of this species are its relatively high reproductive potential, its apparent capacity to breed whenever food is available in sufficient quantity and quality, and its propensity to shift its diet depending on availability. Other species found mainly in ruderal situations and fields across Mizoram are the Himalayan rat (*Rattus nitidus* (Hodgson 1845), *Callosciurus pygerithrus (*Geoffroy, 1831)*, Rattus rattus tistae and Bandicota bengalensis*. Rodents found exclusively in field and forest habitats include several species of white-toothed rats (sub-genus *Berlymnys of Rattus* spp.), spiny rats (*Rattus niviventer* (Hodgson)), several species of mice (*Mus cervicolor* Hodgson and *Mus famulus cookie* (Ryley, 1914)) and bamboo mice (*Chiropodomys gliroides* (Blyth, 1856)). Bamboo rats-*Cannomys badius badius* (Hodgson) are also found in fields and forests.[29-32]

Table 2.Rodent Fauna of North-Eastern Hill Region, India

Rodent Species	North Eastern States						
	Mizoram	Tripura	Manipur	Assam	Meghalaya	Arunachal Pradesh	Nagaland
Bandicota bengalensis (Gray,1835)	++	+++	+++	+++	+++	++	+++
Bandicota indica nemorivaga (Hodgson,1836)	-	-	-	++	++	-	-
Mus booduga(Gray,1837)	+	+	-	-	-	+	-
Mus musculus Linnaeus	+++	+++	+++	+++	+++	+++	+++
Rattus rattus (Linnaeus)	+++	+++	++	+++	+++	+++	+++
Rattus rattus tistae	++	++	++	++	++	++	-

(Hinton,1918)							
Rattus rattus khyensis Hinton	+	+	+	+	+	-	-
Rattus norvegicus (Berkenhout)	++	+	-	++	++	-	-
Rattus. r. brunneusculus (Hodgson 1845),	+	+	+	+	+	-	+
Rattus nitidus (Hodgson 1845)	+++	++	+++	+++	+++	+++	++
Rattus rattus bullock Roonwal,1948	-	-	+	-	-	-	+
Rattus niviventer (Hodgson)	++	+	+	++	++	+	+
Rattus fulvescens (Gray)	-	-	+	+	+	-	+
Rattus manipulus (Thomas)	-	-	+	-	-	-	-
Rattus bowersi (Anderson)	+	-	+	+	+	-	+
Hadromys humei (Thomas)	-	-	+	+	-	-	-
Mus cervicolor Hodgson	+	+	+	+	+	+	+
Mus cervicolor imphalensis (Roonwal)	-	-	+	-	-	-	+
Mus famulus cookie (Ryley,1914)	+	+	+	+	+	-	+
Cannomys badiusbadius (Hodgson)	+	-	+	+	+	+	++
Vandeleuria oleracia dumeticola (Hodgson)	-	-	+	+	+	+	+
Callosciurus pygerithrus (Geoffroy,1831)	++	++	-	+	+	-	-
Golunda ellioti Gray	-	-	-	+	-	-	-
Chiropodomys gliroides (Blyth,1856)	+	+	-	+	+	-	-

+++Major rodent species; ++Minor rodent species; +Rarely found

Major Reasons for the Possible Outbreak of Rodent-Borne Diseases during Bamboo Flowering in Mizoram

Major reasons for the possible outbreak of rodent-borne diseases during bamboo flowering were poor general health infrastructures, rudimentary disease surveillance activities, difficulty in utilizing existing general and specific communicable disease surveillance systems due to strict funding guidelines and limited resources, non-documentation of past health experiences, shortage of staffs due to numerous vacant posts and increase in number of districts from 3 to 8 without corresponding increase in number of crucial health posts, absence of specific posts for personnel qualified (epidemiology and entomology) and trained in surveillance of diseases, poor diagnostic facilities for rodent borne diseases, coordination with other departments and poor communication facilities in difficult terrains.

Possible Transmission of Rodent Borne Zoonotic Diseases during Bamboo Flowering

Rodent can transmit 56 zoonotic diseases in man and animals in India and neighboring countries, which are responsible for around 2.5 billion cases of human illness and 2.7 million human deaths a year. It was Identified the 13 zoonoses most important to poor livestock keepers because of their impacts on human health, livestock sector, amenability to agriculture-based control, and other criteria.

Rodents' presence in a geographic region may play a key role in perpetuating infectious organisms that pose a health threat to people in the area. Mizoram was under threat during bamboo flowering because of Myanmar-a high risk area for the transmission of plague; Salmonellosis being endemic in Mizoram with frequent food poisoning outbreaks; gastroenteritis being second-leading health problem indicates unsafe food and drinking practices; documented contamination of spring

water; attitudes and practices of people toward rodents including trapping, bare hand handling and consumption of their flesh; difficult terrains and presence of remote or interior villages with poor health facilities; general ignorance and hence less priority given to associated health hazards of bamboo flowering; disruption of supplies to the state; poor implementation due to denial of project components and deviation from technicality (BAFFACOS).

Rodent migration after gregarious bamboo flowering can trigger a consequence far more serious than crop destruction-an increase in the frequency of transmission of rodent-borne pathogens to human and animals. Apart from destruction of crops, the epidemiological imbalance also leads in increased risk of infection or outbreak of rodent-borne diseases such as viral, bacterial, rickettsial and parasitic. In South America, bamboo flowering and subsequent mast seeding trigger rodent outbreaks associated with zoonotic diseases.

The modes of transmission of these diseases are through bites of rodents, fleas and other ecto-parasites or contamination of food, water and air by rodent urine or excreta. The risk of infection by these diseases is very high since people in Mizoram, Arunachal Pradesh and Manipur come in close contact with rodents including handling or consumption of their flesh. Some of the rodent-borne diseases are epidemic prone requiring immediate control like plague and some are hundred percent fatal like rabies.

Rodents may serve as reservoirs of disease agent (e.g., Lyme disease spirochete, *Borrelia burgdorferi* and plague-*Yersinia pestis*) that are picked up by arthropod vectors and transmitted to humans through bites. In these cases, direct contact with rodents or their excreta pose no health risk. Hanta virus, which is found to be present in the saliva, urine and feces of the infected rodents spread to humans via inhalation of aerosolized excreta, ingestion of excreta, or by direct contact with the rodent itself. Rodents may directly transmit the pathogen to man through bites (Rat bite fever).[33-37]

Table 3.Some of the Important Rodent Borne Diseases Communicable to Man and Animals in India and Neighboring Countries

Diseases	Etiological agent	Reservoir/ Carrier	Vector sp.	Usual method of transmission
Scrub Typhus	*Rickettsia tsutsugamushi*	*Rattus* sp.	Mite: *Leptotrombidium*	Vector bite
Typhus fever, Murine	*Rickettsia typhi (mooseri)*	*Rattus norvegicus R. rattus, R. exulans*	*Xenopsylla cheopis*	Flea bite
Rickettsial pox	*Rickettsia akari*	*Mus musculus*	*Liponyssoides sanguineus*	Mite bite
Rat bite fever	*Spirillumminus, Streptobacillus moniliformis*	*Rattus rattus*	-	Rat Bite & Scratches
Leptospirosis (Weil's Disease)	*Leptospira icterohaemorrhagiae, Leptospira interrogans*	*Rattus rattus, Bandicota bengalensis,Rattus norvegicus*	-	Urine contamination
Plague	*Yersinia pestis*	*Tatera indica, Bandicota bengalensis,Rattus rattus, Mus musculus*	*Xenopsylla cheopis, Xenopsylla brasiliensis*	Flea bite
Psudotuberculosis	*Yersinia pseudotuberculosis*	*Rattus rattus, Mus musculus, R. norvegicus*	-	Fecal matter or contaminated food/ water
Relapsing fever	*Spirochaetes. genus Borrelia*	Gerbils	*Body Lice-Pediculus humanus humanus*, soft bodied ticks genus *Ornithodoros*	Lice or tick bite
Salmonella infections	*Salmonella enteritidis*	*Mus musculus, Rattus rattus, R. norvegicus*	-	Urine contamination, rat droppings

	Salmonella livingstone	*Rattus norvegicus, Mus musculus*	-	Urine contamination, rat droppings
Lyme Disease	*Borrelia burgdorferi, B. burgdorferi sensustricto, B. afzelii*	*Mus musculus, other rodents*	Ixodid ticks	Tick bite
Bartonella illness	*Bartonella elizabethae, B. grahamii, B. vinsoni*	*Mus musculus* and *other rodents*	Ticks, *Leptopsylla segnis,* Rat flea-*Xenopsylla cheopis, Nosopsyllus fasciatus*	Tick/ flea bite
Babesiosis	*Babesia microti, Babesia* KO1, *B. divergens, B. ovata, B. major*	*Meriones sp. and other rodents*	*Ticks-Rhipicephalus sp. Ixodessp. Haemaphysalis sp.*	Tick bite
Cutaneous leishmaniasis	*Leishmania major*	*Desert gerbil-Meriones hurrianae*	*Sand Fly-Phlebotomus salehi*	Sand fly bite
Giardiasis	*Giardia muris*	*Rodents*	-	Contaminated food, soil, or water,
Angiostrongylosis	*Angiostrongylus cantonensis*	*Rattus norvegicus* and *Rattus rattus*	Land snail and fresh water snail	Eating of raw snails and fish
Toxoplasmosis	*Toxoplasma gondii*	*Rattus rattus, Mus musculus, R. norvegicus*	-	Ingestion of oocysts (e.g., not washing hands after gardening or eating unwashed fruits or vegetables from a garden); Drinking water contaminated with the *Toxoplasma* parasite
Rat-mite dermatitis		*Rattus norvegicus, Rattus rattus, Mus musculus, Meriones sp.*	*Mite-Ornithonyssus bacoti*	Mite bite
Kyasunar Forest Disease (distributed only in Karnataka and Kerala state, India)	*KFD Virus (Gen. flavivirus)*	Small Rodents	*Ticks:Haemaphysalis spinigera, Ornithoros Chiropterphila*	Tick bites
Crimean-Congo hemorrhagic fever	CCHF virus of genus *Nairovirus* (family Bunyaviridae)	Rodents	*Rhipicephalus sanguineus,Hyalomma* tick, *Boophilus, Dermacentor*, and *Ixodes*	Tick bite, Man to man transmission
Hepatitis E	Hepatitis E virus	*Bandicota bengalensis,Rattus rattus brunneusculus*	-	Contamination of food and water

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Cow Pox	DNA virus-*Orthopoxvirus* genus	Rodents	-	Direct contact with reservoir
Rabies	Genus-Lyssavirus	*Bandicota* sp.	-	Rodent bite
Hanta Virus	RNA viruses (family Bunyaviridae,genus Hantavirus), *Thottapalayam* virus(TPMV)	*R. norvegicus,Apodemus peninsulae,Rattus rattus, Bandicota indica, Apodemus agrarius*	-	Through contact with rodent urine, saliva, or feces
Boutonneuse Fever	*Rickettsia conori Rickettsia sibirica Rickettsia australis*	*Rattus spp.*	*Rhipicephalus sanguineus*	Bite of infected ticks
Angiostrogyliasis A nematode disease of the CNS	*Angiostrongylus cantonensis*	*Rattus norvegicus, R. rattus*, *R. exulans, Bandicota indica* and *Melomys littoralis*.	Mollusks-genus *Pila*	consumption of raw mollusks
Capillariasis	*Capillaria hepatica*	*Rattus rattus* and other rodents	_	Ingestion of embryoted eggs in soil

Bamboo Flowering and Famine Combat Scheme (BAFFACOS) in Mizoram

Flowering of bamboo is always followed by famine and epidemic outbreaks as experienced in Mizoram during 1862, 1881, 1911 and 1959. Diagnostic facilities for the majority of the rodent-borne diseases were not available in Mizoram.

Reagents, field test kits and medicines for treatment were also in need to be procured. Appropriate preventive actions, immediate investigation, diagnosis and management, capacity building and awareness generation, etc., were the key strategies to the successful control of these diseases.

Scarcity of water has compelled the majority of people in Mizoram to depend largely on stored water and open spring water sources and thus has a very high risk of contamination by rodents.

However, for various reasons, a national level action plan for Bamboo Flowering and Famine Combat Scheme (BAFFACOS) was not developed in the past. The state had prepared a series of Bamboo Flowering and Famine Combat Schemes (BAFFACOS) in 2005 to involve various departments like agriculture, health, rural works and public works.

A series of inter-sectoral workshops were also conducted to train officials to work in an emergency mode if famine broke out. During the recent episode (2006-09) an amount of Rs. 566.55 crore was earmarked for implementation of the scheme covering 5 (five) years period and all work components envisaged in the scheme were implemented in the identified locations with high socio-economic indicators indicating the unsafe eating and drinking practices.[36-38]

Efforts to Control Rodent Migration and Transmission of Rodent-Borne Diseases during Recent Bamboo Flowering in Mizoram

Based on ICAR, Govt. of India forewarning, a central team of rodent and rodent borne disease experts from CAZRI, Jodhpur; NIPHM, Hyderabad and National Centre for Disease Control, Plague Surveillance Unit, Bangalore, visited Mizoram several times during 2006-2009 for making on the spot assessment, to demonstrate rodent pest management and surveillance, prevention and control of rodent-borne diseases in the region. Public health workers, clinicians and other health workers in different zones of Mizoram were trained on surveillance, diagnosis of the diseases and their control. The team recommended precise survey of the bamboo flowering area, surveillance of rodent incidence in jhoom cultivation areas, creating awareness amongst residents on rodent problem and their control and outbreaks of rodent borne diseases and their control.[27,39,40]

Discussion

Rodent outbreaks will continue to occur during or after the bamboo flowering; therefore, there is an urgent need to apply rodent management strategies that have been tested in NEH region and found effective by the scientists of national rodent management network in

India. Capacity building on rodent management in the extension system also needs stronger emphasis.

Rodent, flea and other ecto-parasite control is a long-term measure. Killing of rodents during outbreaks or epidemics of rodent-borne diseases is not advised since it will result in ecto-parasites leaving the dead rodent bodies infecting human beings or animals directly or through other animals. These indicate the need for close inter-sectoral coordination with other departments.

Effective rodent and vector control measures include environmental sanitation in and around the houses and in the community, trapping of rodents using multiple catch traps (Wonder traps) or local traps, killing of rodents and ecto-parasites using rodenticides/ insect ides and fumigation of rodent burrows. Regular surveillance of rodents for the presence of infection is essential. Appropriate control plans should be drawn for the next 'Mautam' or 'Thingtam' by establishment of well-equipped laboratories, recruitment of appropriate staff and their training, facilities for catching rodents, close coordination with agriculture department (active in rodent control but without any health-related surveillance), community participation and health education.

Inter-sectoral coordination, which includes rodent control, may be undertaken by agriculture department while examination of dead rodents or ecto-parasites and flea surveillance and control by entomology cell of Health Department. Passive surveillance of dogs which are the sentinel animal for plague may be undertaken by animal husbandry department, water surveillance for contamination by PHE and microbiology div. of health department, food safety measures specially for rodent contamination by health and food and civil supplies departments, public education by health department and department of information and public relations. Reporting of rat falls and cases of rodent-borne diseases can be done by existing health department surveillance network as well as by community members.

Conflict of Interest: None

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