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Population dynamics of rodents during bamboo flowering event in North East India

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ABSTRACT

The ecological aspects of rodents during bamboo flowering (BF) phase (*Mautam*) were studied in Meghalaya and Mizoram states of India during 2005-2008. Rodent population was almost stable during BF in Meghalaya. Likewise, it was also normal in Mizoram during 2005 to 2007. However, rodent outbreak was observed after gregarious flowering (GF) of *M. baccifera* during 2007-08 in Mizoram and it was more severe after complete fruit shedding. Rodent activities were found to be highest during July to October and their population was significantly higher in upland cultivated areas especially near animal farm-houses. Out of 12 species recorded, merely six species of rodents were observed in BF areas of Mizoram. Surprisingly, *Bandicota bengalensis* was recorded to be a pre-dominant species, though not observed in bamboo forests. Species wise, sex ratio of rodents varied from 1:0.81 to 1:1.12 in Mizoram. Furthermore, rodent population was recorded to be higher in GF areas and location wise it was more in Kolasib district of Mizoram. In general, sex ratio of rodents was quite equal in all districts of Mizoram; however it was basically female biased in sporadic flowering (SF) areas. Maturity status of rodents in Mizoram indicated their complete adulthood during flowering time; where testes and vaginas were largely scrotal and perforated type, respectively. Overall study concludes that, bamboo flowering alone didn't increase rodent population significantly; but other factors mainly weather and starting time of flowering could also be involved in this complex process.

Key words: Bamboo flowering, *Mautam*, North-East India, Population dynamics, Rodents, Species composition

Northeast India, a mega-biodiversity centre and a hotspot (Myer *et al.* 2000), possesses large number of bamboo species. Amongst, mautak or muli bamboo (*Melocanna baccifera*) and *Dendroctonus hamiltonii* are the major species. Gregarious flowering of bamboo is a mysterious phenomenon in nature and it is believed to enhance rat populations, as frequently reported from many countries (Douangboupha *et al.* 2003, Jaksic and Lima 2003, Rakotomanana 1966). Rodents are considered to be a most destructive vertebrate pest all over the surface of earth.

Thingtam and Mautam (flowerings of *Bambusa tulda* and *M. baccifera*, respectively) are the two important historical events periodically observed at the interval of 48 (±2) years in Mizoram. Both of these are considered to be a bad omen and later event is more severe. The recent Thingtam and Mautam were witnessed in 1976 and 1958, respectively (Anonymous 2006). Past reports revealed heavy losses in foodgrains due to rodent outbreaks during such events and sometimes 100% yield losses were found, leading to many deaths and migration of peoples. Besides rodents, other animals are also reported to increase during such events, e.g. cinnamon bugs, *Ochrophora montana* (Thakur and Firake 2012). In several cases, farmers didn't sow crops in the field and depended on other food materials (Aplin and Lalsiamliana 2010). Furthermore, rats voraciously feed on bamboo fruits; therefore, they have been destroying not only foodgrains and farm commodities but also reducing bamboo tree population in the forest.

It is assumed that the rodents eat bamboo seeds during mass flowering to increase their breeding potential and expand their population. It is also believed that the bamboo seeds contain potential estrogenic compounds that stimulate reproduction. The impact of rat floods is well documented with several historical documents indicating widespread famine and mass migration of people living in affected areas during such events (Douangboupha *et al.* 2003, Jaksic and Lima 2003, John and Nadgauda 2002, Nag 1999, Phillipi 1879). However so far, studies on long term dynamics of this bamboo flowering related rodent problems are insufficient and no report is till now available from any part of the world. Furthermore, connections between bamboo flowering and rodent outbreaks have not been scientifically proven and the causes of rat floods are simple assumption.

In spite of that, some aspects on biodiversity, damage pattern and activity of rodents have been reported from

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Gangetic plain of West Bengal, India (Santra and Manna 2008). Few studies also indicate damage trend of rodents in different regions (Prakash *et al.* 1986, Advani and Mathur 1982, Hoff *et al.* 1976, Chopra and Parshad 1986). Certain ecological aspects are also recently available on rodent dynamics especially during bamboo flowering situations (Aplin and Lalsiamliana 2010). Nevertheless, most important ecological studies are hitherto not available, showing basic idea on population dynamics of rodents during bamboo flowering events. There were many mysterious facts remained to be solved during past flowerings in the region. Therefore, this *Mautam* was eagerly awaited by scientific community, which was expected to occur during 2005 to 2008. In this view, current investigation aims to know the status of rodent population during bamboo flowering in Meghalaya and Mizoram states of India. Emphasis was mainly given on seasonal activities, species composition, population dynamics and reproductive attributes of rodents during outbreak situations.

MATERIALS AND METHODS

All the districts of Meghalaya and Mizoram states were surveyed during 2005 to 2008 to know the status of bamboo flowering, rodent populations and their behavior. Regular visits were done (during cropping seasons) in ten villages of each district and observations on different flowering conditions were noted. Initially, information on rodent activities was collected through focused group discussion (35-40 villagers comprising both male and females and government agencies wherever possible) in every village. All the villagers were informed two days prior to discussion through their chief (Headman) and target was successfully achieved with the help of local language translators.

Besides, population dynamics of rodents was studied by regular monitoring in different areas. Rat burrows were counted from selected locations of five different villages throughout the year and per cent active burrows were calculated. Different species of rodents were collected from all flowering areas of Meghalaya and Mizoram with the help of traps. In Mizoram, three main districts, viz. Mamit, Saiha and Kolasib were selected for monitoring of rodent population during outbreak period. One village each was selected in all 3 districts (except Kolasib where 3 villages were surveyed) with three sites, viz. gregarious, sporadic and no bamboo flowering site (normal condition) for fixing local traps '*Thangchep*'. Total 135 traps were fixed at each site, where about 45 traps were placed at each location; with one-trap lines consisted of 15 traps at 10 meter interval. The space between the traps was blocked by bamboo pegs and other wooden materials to confuse the rats. Observations were recorded for 3 consecutive nights after fixing the traps and the trap index (rodents/100 traps/24 hours) was calculated as per the standard methodology. Number of rodents trapped over a season in particular flowering condition were used for calculating % trapping in an area (rodents trapped/total no. of traps fixed in a season)

Body dimensions (length and weight) of all trapped rats were noted and new species were preserved and further identified from expert group of Zoological Survey of India (ZSI), Kolkota. Additionally, sex ratio of rodents was calculated and maturity status of all the collected samples was also checked. Genital organs of males and females were grouped into four categories, viz. scrotal testes, abdominal testes, perforated (open) vagina and imperforated vagina etc. Habitat of the rodents was also determined by removing stomach content of thirty randomly selected rats in each species from all areas; besides vegetation from all trapping sites was also preserved for analysis.

Each treatment was replicated three times in all the experiments. All the data were subjected to statistical analysis for calculation of mean and standard error. Statistical software SPSS 13.0 for windows (SPSS Inc. 2004) was used for overall statistical analysis. Differences between treatments were analyzed using ANOVA at a significance level of 0.05. Afterwards, Tukey HSD (Tukey's Honestly Significant Difference) test was used to find out the significant differences between mean values.

RESULTS AND DISCUSSION

Status of bamboo flowering and rodent outbreak in Meghalaya

First flowering was observed during January 2005 in the East Garo Hills district of Meghalaya (Table 1). Sporadic flowering (SF) of *M. baccifera* was also observed at several places. However, rodent population was found to be normal in these areas. Moreover, government agencies (District Forest Officer and District Agriculture Officer) and villagers also informed that SF of bamboos did not affect the rodent population in these areas. Likewise, rodents were not exploded even during gregarious flowering (GF). Surprisingly, white coloured animal *Jongma* (Garo language) was unseen during present time; which was observed by villagers during past flowering period.

Status of bamboo flowering and rodent outbreak in Mizoram

Sporadic to mass flowerings of *M. baccifera* and *D. hamiltonii* were found during 2005-06 in almost all the districts of the state (Table 2), but related rodent outbreaks were not seen in any of these areas. Nevertheless, rodent outbreak was observed all over the state after gregarious flowering (GF) of *M. baccifera* during 2007-08; where Mamit, Serchhip and Kolasib were the most affected districts. Interestingly, Champhai district had the least bamboo flowering area but rodent upsurge was observed in eastern part of district (Dulte, Kawlkuh, Tualte, Tualpui and Khawzawl villages). Furthermore, rodent population was normal during flowering of *M. baccifera,* but increased considerably after fruit shedding. Dropped fruits were recorded to be either chewed or eaten up to kernel level by rodents

Rodent outbreaks after bamboo flowering is widely

Table 1 Status of bamboo flowering in Meghalaya (2005-2008)

Month and year	District	Areas	Flowering type	Bamboo species
January 2005	East Garo Hills	Tura, Asanangiri, Rombagre, Oragidok, Silbagre, Rongram, Rongkhon and Chitoktak	Sporadic	*D. hamiltoni*
January 2005	West Garo Hills	Tikrikilla, Machokgre, raksamgre, Wathegre, Jangnapara, Gondagre, Gondachibalgre, Jongma and Bulchudungre villages	Sporadic	*M. baccifera*
January to May 2005	East Khasi Hills, Jaintia Hills and West Khasi Hills		Sporadic	*D. hamiltoni*
January 2005	East Khasi Hills	Nongtrai and Nonglait villages and Mawsanram block	Sporadic	*M. baccifera*
January 2005	Ri Bhoi District	Nongpoh	Sporadic	*M. baccifera* and *D. hamiltonii*
January 2005	Jaintia Hills	Amlarem	Sporadic	*M. baccifera* and *D. hamiltonii*
2006	Ri-Bhoi	Byrnihat and Nongpoh areas	Sporadic	*M. baccifera*
2006	Ri-Bhoi	Byrnihat and Nongpoh areas	Gregarious	*D. hamiltoni*
2006	East Khasi Hills	Upper Shillong, Nongumlong, Mawklot, Nonglyer, Nongkseh and Lummawbah and Balat and Ranikor	Sporadic	*D. hamiltoni*
September-October 2007	West Khasi Hills, East Garo Hills, South Garo Hills and East Garo Hills	Many places	Sporadic to Gregarious	*M. baccifera*
September-October 2007	West Garo Hills East Garo Hills South Garo Hills	Rongram, Gamegree and Dalu devlopment blocks of Tura sub division, Betasing of Ampati Sub Division, Resubalpara Sub Division, Samnda, Songsak and Rongjeng devlopment blocks, and Rongera, Gasuapara and Baghmara Blocks	Gregarious	*M. baccifera*

Table 2 Status of bamboo flowering in Mizoram (2005-2008)

Month and year	District	Areas	Flowering type	Bamboo species
January 2005	Mamit	Most of the areas	Gregarious	*D. hamiltonii*
May 2005	Mamit	Smaller area near Teirei river	Gregarious	*M. baccifera*
February-May 2005	Serchhip	Most of the areas	Sporadic	*M. baccifera* and *D. hamiltonii*
May-June 2005	Serchhip	Thenzwal and Zote S	Sporadic	*M. baccifera* and *D. hamiltonii*
2005-2006	Mamit, Saiha, Kolasib, Aizawl, Serchhip and Lunglei	Large patches	Sporadic to Gregarious	*D. hamiltonii*
2005-2006	Mamit, Saiha, Kolasib, Aizawl, Serchhip and Lunglei	Large patches	Sporadic	*M. baccifera*
2007-08	Almost all districts	Fifty villages	Gregarious	*M. baccifera*

observed phenomenon throughout the world including Argentina, Peru, Brazil, Chile, Madagascar, Laos, Japan, Myanmar, India and Bangladesh (Douangboupha *et al.* 2003, Jaksic and Lima 2003). Earlier scientific community was doubtful about this type of rodent outbreaks; although it was fuelled by several historical reports. The popular belief is that gregarious flowering of bamboo produces large quantities of seeds and it contains potential estrogenic compounds that stimulate reproduction of rodents, leading to their outbreaks. However, several reports also signified normal rodent population during such events (Jaksic and Lima 2003); indicating role of something else**.** Therefore, abundant availability of bamboo seeds during such events is not alone contribute for explosion of rat population; but some other factors may also be involved in this complex process. Climatic parameter perhaps rainfall and time of commencement of flowering are two important factors might have considerable effect on rodent population (Jaksic and Lima 2003, Aplin and Lalsiamliana 2010).

In present study, rodent population was normal during bamboo flowering in Meghalaya. Likewise, it was also normal in Mizoram during 2005 to 2007. However, outbreak was observed after gregarious flowering of *M. baccifera* during 2007-08 and it was more severe after complete fruit shedding. Similarly, in a well-documented case in Parana State, Giovannoni *et al.* (1946) found that flowering of

bamboo, *Merostachys* sp started in September and October of 1945 and mast-seeding in March and April of 1946, with rodents irrupting in July 1946. In our study, even if, Mamit, Serchhip and Kolasib were the major bamboo flowering districts and Mamit district had a remarkable importance regarding last *Mautam* (1957-1959); rodent outbreak was also observed in Champhai district of Mizoram. Maximum area of this district is under lowland rice; where rodents caused severe damage in paddy field during September-October. Due to the anticipated increase in rodent population, a number of farmers even did not sow/transplant the paddy and other crops in their fields. Higher migration of rodents towards NF areas particularly during cropping season perhaps enhanced their population in Champhai district.

Bamboo flowering and rodent activities in Meghalaya and Mizoram

Bamboo flowering was started during October-November and fruit formation took place from January-April. Fruit dropping was found during rainy season, where they germinated within a fortnight's time and afterwards, the mother plant soon dried up and died. Overall findings revealed more rodent activities from March to October; where active burrows were highest during July (61.29%) and October (69%) in Mizoram and Meghalaya, respectively. On the contrary, it was observed to be decreased from November onwards and lowest during January- February (Fig 1). Location wise, rodent activities were significantly higher ($F=24.83$, $P<0.01$) in upland cultivated areas near animal farms (59.21%), followed by upland cultivated areas (56.35%), lowland cultivated areas (47.23%) and jhum land (46%); while it was lowest in uncultivated areas (39.45 and 40.10% in upland and lowland, respectively).

Burrow index provides enough idea about seasonal activities of rodents in the region. In current study, rodent activities were lowest during January-February, being peaked during July to October. According to recent report of Santra and Manna (2008), two peaks in the breeding frequency of rodents were observed in West Bengal (India), one during monsoon (July to September) and the other during late winter or spring (March to April). Higher population during these periods might be due to increased breeding and surplus availability of food in crop field. Rodents belong to genus *Rattus* are the major inhabitants in this region and thus past reports on these species as well demonstrated their seasonal population trend not only in Mizoram, India (Aplin and Lalsiamliana 2010) but at similar agro-ecosystems of Laos too (Aplin *et al*. 2007, Douangboupha *et al.* 2009). Furthermore, rodent activity was higher in cultivated upland areas than uncultivated and lowland.

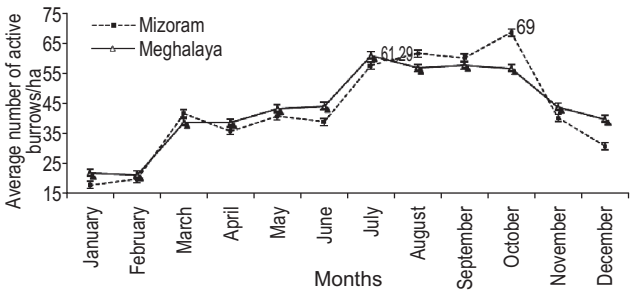

Fig 1 Burrow index in different months in Mizoram and Meghalaya (2005-2008)

Species composition of rodents in Meghalaya and Mizoram

About twelve species of rodents (including one squirrel) were collected from the region; where two species, viz. *Berylyms bowersii* (Anderson) and *Rattus sikkimensis* (Hinton) were exclusively recorded from Mizoram (Table 3). Amongst, *B. bengalensis* was observed to be a pre-dominant rat in both Meghalaya (37.51%) and Mizoram (29%) followed by *R. rattus*. Surprisingly, only six species (*R. rattus*, *Berylyms mackenziei*, *B. bowersii, Cannomys badius*, *Niviventer fluvescens* and *R. sikkimensis*) were observed in bamboo flowering areas (Table 4). Moreover, sex ratio of rodents varied from 1:0.81 to 1:1.12; indicating almost equal proportion of both sexes in all the species of Mizoram (Table. 4).

Amongst 12 rodent species recorded in present study, only 6 species were noticed in bamboo flowering areas with equal sex ratio in almost all species. Surprisingly, *B. bengalensis* however contributed large proportion among all, which was not observed in bamboo flowering areas. Nevertheless house rat, *R. rattus* was subsequent major

Table 3 Rodent species composition in Mizoram and Meghalaya

Common name	Species	Composition (%)	
		Meghalaya	Mizoram
Lesser Indian mole rat	*Bandicota bengalenis* (Gray)	37.51	29.00
Common house rat	*Rattus rattus* (Linnaeus)	33.52	23.51
Norway rat	*Rattus norvegicus* (Berkenhout)	00.69	04.48
Himalayan rat	*Rattus nitidus* (Hodgson)	11.09	10.35
Sikkim rat	*Rattus sikkimensis* (Hinton)		03.51
Mackenzie's rat	*Berlylmys mackenziei* (Thomas)	01.84	01.87
Bay bamboo rat	*Cannomys badius* (Hodgson)	00.57	03.56
Himalayan chestnut rat	*Niniventer fluvescens* (Thomas)	01.73	11.15
Unknown rat	*Rattus* spp. (Unknown species)		00.52
House mouse	*Mus musculus* (Waterhouse)	12.78	10.27
Bower's rat	*Berylyms bowersii* (Anderson)		01.65
Irrawady squirrel	*Callosciurus pygerithrus* (Geoffroy)		

Table 4 Habitat and sex ratio of rodent species in Mizoram

Species	Habitat	Sex ratio (M:F)
Rattus rattus	Houses, godowns, crop fields near bamboo flowering areas	1 : 0.84
Rattus nitidus	Houses, godowns, crop fields	1 : 1.12
Rattus norvegicis	Houses, godowns	1 : 1.12
Berylyms mackenziei	Jhum, rice fields, forests, bamboo flowering areas	1 : 0.81
Niniventer fluvescens	Crop fields, forest areas, plantation crops, bamboo flowering areas	1 : 0.97
Bandicota bengalensis	Godowns, rice fields including *jhums*, houses	1 : 1.05
Rattus spp. (Unknown)	Houses	1 : 1.00
Cannomys badius	Crop fields, forests, bamboo flowering areas	1 : 1.00
Mus musculus	Houses	1 : 0.92
Berylmys bowersii	Forest areas, plantation crops, bamboo flowering areas	1 : 0.97
Rattus sikkimensis	Forest area, plantation crops, bamboo flowering areas	1 : 0.90
Callosciurus pygerithrus	Forest areas, plantation crops, bamboo flowering areas	1 : 1.00

species also recorded in bamboo flowering areas. *B. bengalensis* is generally found in or near godowns, rice fields including *jhum* land and houses etc. Furthermore, higher population of this species perhaps due to their small size, higher birth rate and fertility and availability of surplus food in the locality. These factors provide favorable conditions for population increase and choice of food is also accountable to their absence in flowering areas. Stomach content removed from trapped rats in current study also indicated absence of bamboo fruits in stomach of *B. bengalensis.*

By and large, rodent community of this region resembles closely that of the uplands of Myanmar and Laos (Aplin *et al.* 2007), with only minor differences in species composition. Recent report of Aplin and Lalsiamliana (2010) from Mizoram also illustrated similar rodent composition though excluded *B. bengalensis*; which is recorded as a major species in present investigation. Since this species generally not residing in or near bamboo flowering areas; therefore it is perhaps not mentioned in their work. Nevertheless, *B. bengalensis* have been observed near bamboo forest in Bangladesh (Ahaduzzaman and Sarker 2010) and it is also a pre-dominant species in Manipur, India (Roy *et al.* 1987). Furthermore, another major species in region, *R. rattus,* has also been frequently observed in several places during bamboo masting (Aplin and Lalsiamliana 2010, Ahaduzzaman and Sarker 2010).

Trapping and trap index of rodents in Mizoram during outbreak situation

Per cent trapping over a season and trap index of rodents indicated significantly higher number of rats in GF areas followed by SF; while it was lowest in non-flowering (NF) areas of all districts (Fig 2 and 3). Furthermore, their numbers were considerably higher in Runglei area of Kolasib followed by Saiha district (Fig 2).

During outbreak, rat population was relatively higher in GF areas followed by SF and lowest in areas devoid of bamboo flowering. Location wise, population was comparatively higher in Runglei area of Kolasib district (Mizoram). Reduced cannibalism in rodents as a consequence of abundant food supply possibly increased their population during mass flowering. Relatively higher rat population in Runglei area of Kolasib district conceivably attributed to its seasonal cropping pattern and more bamboo flowering area; where rodents got abundant food supply for longer time than other places

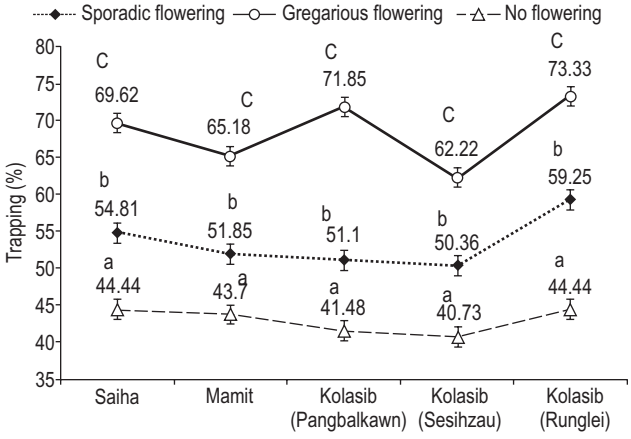

Fig 2 Per cent rat trapping over a season in different flowering situations during outbreak. Bars having same arena with different letters indicate statistically significant differences (P=0.05, Tukey HSD test)

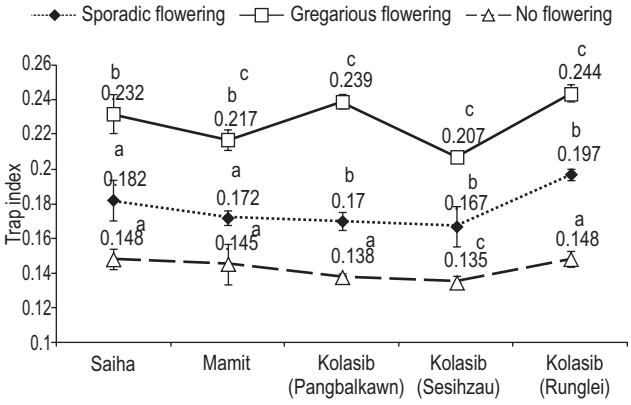

Fig 3 Trap index of rats in different flowering situations during outbreak. Bars having same arena with different letters indicate statistically significant differences (P=0.05, Tukey HSD test)

Rodent activities, sex ratio (male: females) and maturity status during outbreak period in different flowering conditions of Mizoram

Significant differences were noticed in active burrows (F=328.91, 923.73, 542.46 and P<0.001 each) at GF, SF and NF areas, respectively. It was higher at Sesihzau (Kolasib) in almost all flowering conditions; while lowest at Mamit district. Sex ratio in different flowering situations revealed significantly higher (F=22.50, P=0.002) females in SF areas (1: 1.11). Besides, female proportion (1: 0.96) was almost same in GF and NF areas. Considerably higher numbers of testes (F=32.14, P=0.001) were scrotal in SF and NF areas; while it was largely abdominal in GF areas (48.5%). Unlike, vagina of females were mainly perforated (F=12.83, P=0.007) in GF, whereas imperforated in SF (41.8%) and NF (38.5%) areas (Fig 4).

Burrow index significantly varied in different flowering situations; but no characteristic trend was found in diverse locations of Mizoram. Nonetheless, it was higher in Kolasib district than others. It might be due to the fact that rodent species caught other than Kolasib districts were mainly of genus *Rattus*; which are mainly arboreal and seldom make burrows (Hooker and Innes 1995), living in the forest and cause damage to the crops only in the night time by regular movements (Anonymous 2006)**.** Furthermore, erratic trend in burrow index may also be attributable to the species composition of rats in that area. Number of burrowing-type rats in the particular region decides percentage of active burrows in that locality.

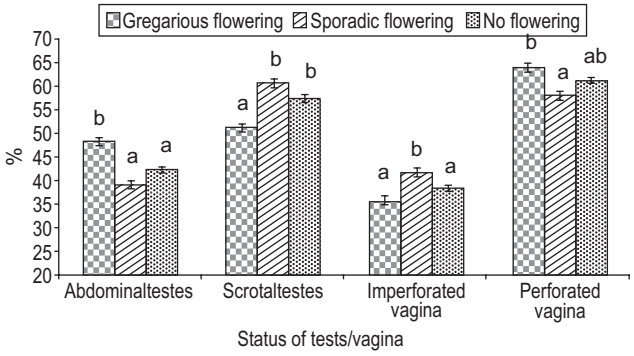

Fig 4 Maturity status of rodents in different flowering conditions during outbreak. Bars having same arena with different letters indicate statistically significant differences (P=0.05, Tukey HSD test)

Sex ratio and maturity status of rodents during outbreak period in Mizoram

Significant differences were not found in sex ratio of rodents in different districts of Mizoram. Nevertheless, females were moderately higher in almost all locations except Mamit district. Similarly, maturity status of rodents was virtually equal in all locations. Testes and vagina of rodents were found to be scrotal (50.04 to 59.22%) and perforated (59.82 to 65.6%), respectively.

Maturity status of rat is the excellent index to know their movement and breeding status. The testes of mature males are in the scrotum which hides the anus and is bald at the rear; while in mature females, vagina is open (perforated) and have large nipples with very little hair around each one (Cunninghum and Moors 1983). During outbreak in Mizoram, testes and vagina of large proportion of rats were scrotal and perforated, respectively. Fascinatingly, status of testes was mainly scrotal in rats caught from SF areas; while vagina of females was largely perforated in rats from GF areas. Overall results are suggesting that rat development was higher in SF and GF areas during outbreak period and most notable fact that breeding was also increased in such places. Higher rodent catches in SF and GF areas during outbreak also confirms this fact. In general, sex ratio of rodents was quite equal in all districts of Mizoram; however significantly higher number of females was observed in SF areas, demonstrating significance of even partial availability of bamboo seeds on rodent population and notably on increasing female birth. However, rodent population only exploded during GF of 2007-08 in Mizoram and remaining time it was normal even during GF in both the states. Therefore, it is sure that, bamboo flowering alone does not contribute for population explosion of rodents; but some other factors may also be involved, as previously explained.

Overall study concludes that, around 12 rodent species are common in Mizoram and their activities are considerably higher during July to October. Furthermore, bamboo flowering alone doesn't increase rodent population significantly; but other factors mainly weather and starting time of flowering may also involve in this complex process. Nevertheless, it needs to be scientifically assessed to give exact conclusion; for that we have to wait for next *Mautam* which is expected to occur nearly between the years 2053 to 2056.

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