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Impact of shifting cultivation on diurnal squirrels and primates in Mizoram, northeast India: A preliminary study

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The impact of human land-use practices on tropical forest ecosystems is a major area of research in conservation biology. In India, an important region containing extensive tropical evergreen and semi-evergreen vegetation is in the Eastern Himalaya and the hill states of northeast India[1,2]. Traditional slash and burn shifting cultivation or *jhum* practised by indigenous tribal peoples is the dominant form of human land-use in the hill tracts[3,4]. Some authors have labelled *jhum* cultivation as primitive and destructive of forests and biodiversity[5,6]. Recent studies, however, have suggested that it can be a sustainable form of land-use, compatible with specific conservation goals, if fallow periods are sufficiently long[7,8]. This study examines the impact of *jhum* cultivation on three arboreal squirrel and four primate species by comparing species densities in successional *jhum* fallows of known age with primary evergreen and semi-evergreen forests in Mizoram state, northeast India. The results emphasize the need to maintain mature forest and late-successional (≥ 25 yr) vegetation for conserving several arboreal mammal species.

THE study was conducted in Dampa tiger reserve in western Mizoram (c. 500 km^2, 23°20′–23°47′N and 92°15′–92°30′E). Hill ranges in the study area ranged between 250 m and 1,100 m above mean sea level (a.s.l.) in altitude. The natural vegetation consisted of tropical evergreen forests in the valleys and semi-evergreen forests on the higher slopes[9]. Anthropogenic successional vegetation occurs in the abandoned *jhum* fallows. These are initially colonized by grasses and weeds (1–2 yr) and later by bamboos (mostly (*Melocanna bambusoides*) and trees[4].

Six successional strata were identified for sampling and their ages were determined from interviews with local people and village elders. The strata and the years when they were cultivated and abandoned (within parentheses) were as follows: (i) 1 yr fallow (1994), (ii) 5 yr fallow (1989), (iii) 10 yr fallow (1985), (iv) 25 yr fallow (1969), (v) Disturbed primary and 100 yr forest (1895–1900) – the former represented a patch of disturbed primary forest adjacent to forest that had regenerated on an abandoned village site (the two sites were considered a single stratum for this study), and (vi) primary forest. In each of two sites representing a given stratum, a 500 m long line transect was marked from a random starting point along existing animal trails, or by clearing a small path. All sites were within the altitudinal range of 250–750 m above mean sea level. The two transects in a given stratum were separated by a linear distance of 1.5–6 km, except the two 25-year fallow transects, which were located 150–200 m apart in the only such patch of vegetation in the study area. A detailed description of the sites and transects is available elsewhere[9]. Each transect was walked twice a month from

December 1994 to April 1995 at a slow, uniform pace during the first three hours after sunrise, to complete the transect in 50 min. All detections of squirrels and primates within 50 m on either side of the transects were noted. Visibility was poorer in the tall, dense mature forest strata, and therefore the results can be considered as conservatively estimating the impact of *jhum* on the mammals. The two transects in a stratum were pooled to yield number of detections per km traversed (area sampled = 0.1 km^2). Vegetation was sampled at ten 100 m^2 circular plots located alternatively 10 m to the left and right of points spaced regularly 50 m apart on the transect. Tree (stems > 20 cm girth at breast height) density and woody plant species richness were enumerated on these plots. Bamboo culms were counted in 25 m^2 circular plots nested within the above plots. At 100 regularly-spaced points along each transect, canopy cover was ranked as follows: 0 when there was none overhead, 1 when the canopies of adjacent trees or bamboo culms barely met, 2 when the adjacent canopies overlapped with the sky still showing through, and 3 when the sky was no longer visible through the overhead leaves[10]. A canopy cover index was derived as the mean of 200 readings for each stratum.

Four species each of diurnal squirrels and primates occurred in the study area. The four squirrel species, in increasing order of body size, were the Himalayan striped squirrel (*Callosciurus macclellandi*), hoarybellied squirrel (*C. pygerythrus*), Pallas's squirrel (*C. erythraeus*), and Malayan giant squirrel (*Ratufa bicolor*). The four primate species were Assamese macaque (*Macaca assamensis*), capped langur (*Presbytis pileatus*), Phayre's leaf-monkey (*P. phayrei*), and hoolock gibbon (*Hylobates hoolock*). A total of 98 sightings was made on transects, 77 of squirrels and 21 of primate groups. The abundances of three squirrel species in the different successional stages are given in Figure 1. The fourth species, the Himalayan striped squirrel, was detected only once along the transect in the 100 yr forest stratum, where it was frequently observed during casual observations. Abundance of two species, the Malayan giant squirrel and Pallas's squirrel differed significantly among the six strata (Kruskal-Wallis $\chi^2 = 24.80$ and 24.21, respectively, $P < 0.001$). This result was primarily because of the complete absence of these species from the 1, 5, and 10 yr fallows. When analysed separately, no significant differences in the abundance of these species were found among the three late-successional strata (25 yr, 100 yr, and primary forest). The hoarybellied squirrel did not show any significant difference in abundance across the strata (K-W $\chi^2 = 7.56$, $P = 0.18$).

The distribution pattern of squirrels in different habitats represented by the successional strata was related to forage availability and the dietary requirements of the squirrels. Species that occurred only in the late-successional stages, the Malayan giant squirrel and Pallas's squirrel, are primarily tree canopy-dwelling species that feed mostly on tree fruits, seeds, and leaves[11,12]

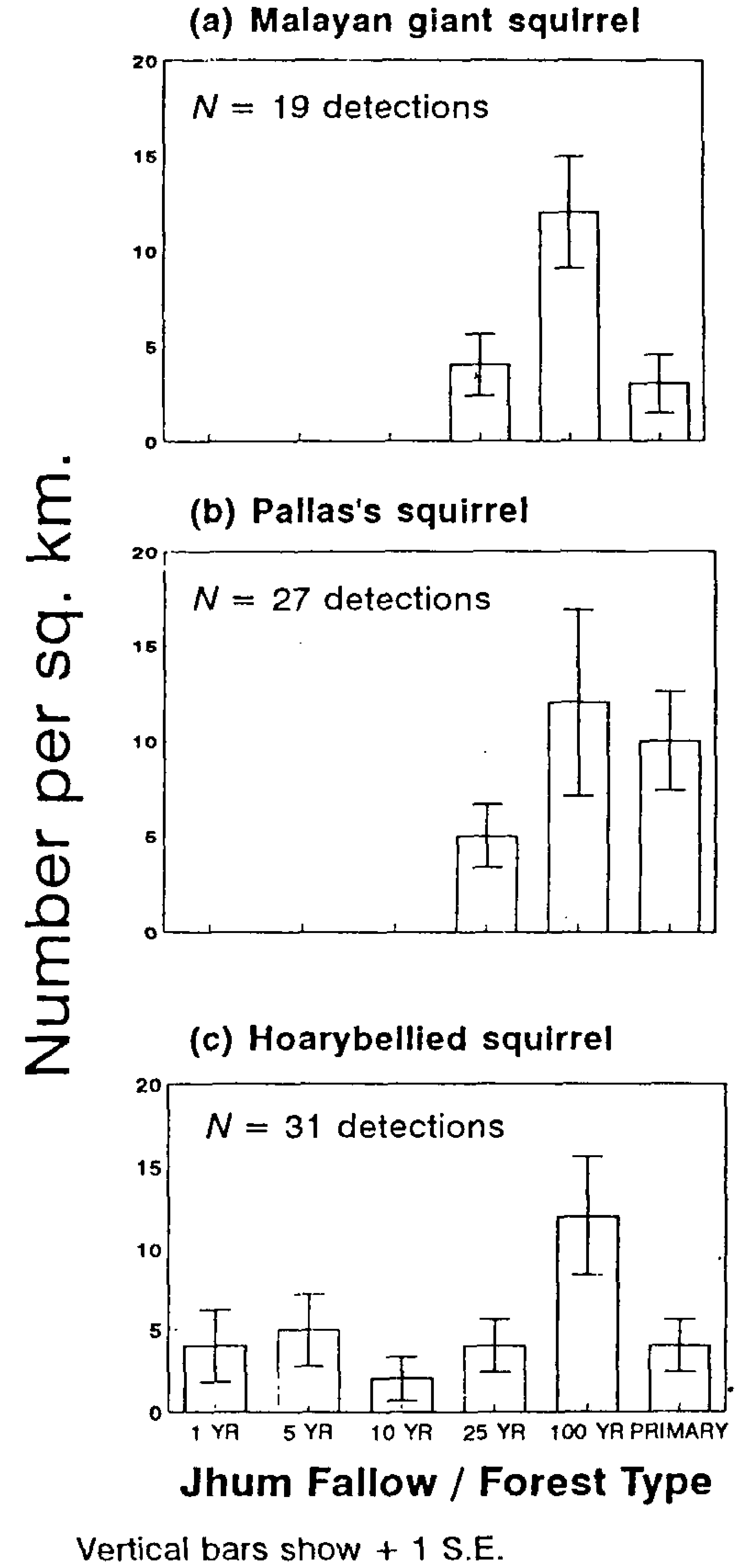

Figure 1. Density of three squirrel species in the six successional strata as determined using strip transects.

Table 1. Vegetation changes during succession after shifting cultivation: Comparison of the six strata

Variable: Stratum	Tree density No./100 m^2	Bamboo density Culms/25 m^2	Tree species richness No./100 m^2	Canopy cover index
1 yr fallow	0.10^{a}	10.40^{a}	0.10^{a}	0.01^{a}
	(0.07)	(1.32)	(0.07)	(0.00)
5 yr fallow	2.80^{b}	25.55^{b}	1.40^{b}	1.02^{b}
	(0.59)	(4.63)	(0.26)	(0.06)
10 yr fallow	2.45^{b}	40.11^{c}	1.20^{a,b}	1.90^{c}
	(0.51)	(5.64)	(0.17)	(0.05)
25 yr fallow	3.50^{b}	45.95^{c}	2.75^{c}	2.22^{d}
	(0.78)	(5.75)	(0.56)	(0.05)
Dist. primary and 100 yr fallow	8.25^{c} (0.53)	3.85^{a} (2.47)	6.45^{d} (0.34)	2.35^{d} (0.05)
Primary forest	11.50^{d}	0.00^{a}	7.90^{e}	2.34^{d}
	(1.01)	(0.00)	(0.76)	(0.05)
N	20	20	20	200
ANOVA F	42.89	24.02	53.86	421.4
(*P*)	(<0.001)	(< 0.001)	(< 0.001)	(< 0.001)

Tabled values are means (1 S.E.). Variable means sharing the same alphabet in a column do not differ significantly (Duncan's multiple range tests, $P < 0.05$). *N* – number of sample points in each successional category (sample points from the two sites in each stratum were pooled for one-way analysis of variance – ANOVA).

Table 2. Number of detections of primate troops in the six successional strata

Species	Successional strata 1 yr	5 yr	10 yr	25 yr	100 yr	Primary
Assamese macaque	–	–	–	1	4	2
Capped langur	–	–	1	–	3	1
Phayre's leaf-monkey	–	–	4	1	2	–
Hoolock gibbon	–	–	–	–	–	2
Total	–	–	5	2	9	5
km walked	10	10	10	10	10	10

Tree density and species richness were high in these areas, i.e., fallows aged 25 yr or more. The 1 yr fallow was bereft of tree and canopy cover but for a few dead trees (Table 1). In contrast, the 25 yr fallow had a higher tree density, several tall trees (approximately > 20 m in height), and a continuous tree-and-bamboo canopy cover (Table 1). Trees of food value to the Malayan giant squirrel (such as *Dillenia indica*) and the Pallas's squirrel (such as *Dysoxylum binectariferum*) were also more abundant in the later successional stages (≥ 25 yr, TRSR, pers. obs.). The Malayan giant squirrel has been noted to be dependent on tall, undisturbed primary forests[13]. The 10 and 25 yr fallows in this study were adjacent to primary forest and the observations indicate that the species utilizes late-successional forest vegetation (25 yr) in addition to mature forest. A few nests of the Malayan giant squirrel were noticed on tall trees in mature forest. The absence of suitable nest sites in fallows aged ≤ 10 yr may be another reason for the species' absence in these areas.

The hoarybellied squirrel, in contrast to the above species, appeared to be omnivorous and foraged on the ground, mid-canopy, and top-canopy layers of the forest (TRSR, pers. obs.). It was common even in home gardens, disturbed roadsides, and in areas close to villages and newly-abandoned *jhums*. Thus, this species is apparently not affected as much as the other two by *jhuming* and human disturbance. The Malayan giant and Pallas's squirrels occur primarily in late-successional and mature forest (≥ 25 yr), a fact reinforced during extensive casual observations over the six-month study period. Barring some areas, such as well-wooded, steep ravines within *jhum* fallows, these species are unlikely to persist in a landscape where the *jhum* cycle or fallow period is 5–10 yr or less, particularly where late-successional and mature forest vegetation is lacking.

Among the primates, the hoolock gibbon was detected exclusively in mature forest (100 yr and primary) on an almost daily basis in different areas during the study. It was, however, detected only twice along transects in primary forest (Table 2). The gibbon is almost exclusively arboreal and predominantly a frugivore[14,15]. Known food species of hoolock gibbons such as *Artocarpus chaplasha*, *Ficus* sp., *Parkia roxburghii* and *Schima wallichi*[14,15], were more abundant in the 100 yr and primary forest areas (TRSR, unpublished data). Structural attributes of the forest vegetation may also be important for this brachiating, arboreal species. The capped langur, a folivorous species, has been reported to occur mainly in late-secondary (> 15 yr) and mature forests in the neighbouring state of Tripura[16]. The few transect observations made here and earlier, more extensive surveys suggest that late-secondary and mature forest may be the main habitat for capped langurs and Assamese macaques in Mizoram (ref. 17 and Table 2). The sole sighting of capped langur in the 10 yr fallow was at the edge of the disturbed primary forest where the group ranged. This occurred when the langurs came to feed on fresh flush of leaves of *Gmelina arborea* trees planted by the Forest Department.

In contrast to the above primate species, the Phayre's leaf-monkey was never seen in primary forest (even outside of transect observations). Troops of this species are known to occur at higher densities in secondary forests that are about 10–15 yr old[7,16,18]. These forests (like the 10 yr fallow in this study) characteristically contain bamboos (*M. bambusoides*) and pioneer trees such as *Macaranga* sp., *Callicarpa arborea*, and climbers such as *Mikania scandens*, on which over 30% of the total feeding time of the Phayre's leaf-monkey is reported[16]. This again suggests the importance of food resources in habitat utilization by these primates.

Detailed information on habitat utilization patterns of mammals in *jhumed* and undisturbed areas in northeast India is required before the impact of *jhum* on different species is fully understood. Results from this preliminary study suggest that continued persistence of several arboreal mammal species, such as the Malayan giant and Pallas's squirrels, hoolock gibbon, and capped langur, will require the maintenance of mature forest and late-successional (≥ 25 yr) vegetation. Other species such as the hoarybellied squirrel and the Phayre's leaf monkey may be less affected by habitat alteration due to *jhum* cultivation, but, even for the latter, very short fallow periods (< 10 yr) are likely to be deleterious[7]. In most parts of northeast India, fallow periods have declined to 5–10 yr, and in some places may be as short as 3–5 yr[4]. Measures such as protection of mature forest, regeneration of *jhum* fallows, and forest restoration (including planting of food tree species) are therefore required to conserve these species.

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Erratum

Sympathetic neurotransmission: A new biological role for ATP?

R. Manchanda

[*Curr. Sci.*, 1996, **70**, 275–285]

1. p. 278, column 1, 4th para.
   Published text: We may now *see* against ...
   Corrected text: We may now *set* against ...

2. p. 278, column 2, 2nd line from bottom of page:
   Published text: unaffected *by* Na-mediated ...
   Corrected text: unaffected *the* Na-mediated ...

3. a) Legend to Figure 4, last line;
   b) p. 280, Column 1, 3rd line;
   c) Legend to Figure 6, 2nd line from bottom:

In all cases *min* should read *ms* (milliseconds).