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Distribution of small mammals along a deforestation gradient in southern Gansu, central China

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Small mammals were surveyed along a deforestation gradient in southern Gansu, China (2300–2600 m altitude), a high endemicity area for human alveolar echinococcosis. Rodent distribution was assessed using removal trapping in six habitat types from timbered forest to farmland and villages, by index transects, and by the collection of specimens by local people. Species captured were 2 shrews: *Anourosorex squamipes*, *Sorex sinalis*; 12 rodents: *Eozapus setchuanus*, *Microtus limnophilus*, *Cricetulus longicaudatus*, *Tscherskia triton*, *Apodemus agrarius*, *Apodemus draco*, *Apodemus peninsulae*, *Micromys minutus*, *Mus musculus*, *Rattus norvegicus*, *Niviventer confucianus*, *Myospalax fontanieri*; and 1 lagomorph *Ochotona thibetana*. On the basis of trap success four rodent assemblages were recognized. Species richness decreases after deforestation, especially in the intermediate stage (scrubland-grassland).

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Key words: *Microtus*, *Eozapus*, *Cricetulus*, *Tscherskia*, *Apodemus*, *Myospalax*, *Niviventer*, *Rattus*, *Anourosorex*, *Sorex*, deforestation, small mammal assemblage

Introduction

The world decline in forested areas has serious consequences for wildlife populations and regional and global diversity (Kittredge 1996). However, it is generally considered that in the northern hemisphere, forested regions have not changed greatly in area and human populations are increasing at a slow rate. This pattern does not apply to China where the population has doubled since the 1950s and people dramatically need wood and farmland. The effect of deforestation can be assessed from surveys performed along deforestation gradients, considered as faunal successions (Wetzel 1958, Connell and Slayter 1977, Forman and Godron 1986, Ferry and Frochot 1990, Blondel 1995, etc.). For small mammals as well as for other taxonomic groups, those patterns of variation can have consequences on biodiversity (Patterson *et al.* 1989, Rickart *et al.* 1991), forestry (Wood 1994), and disease transmission (Gratz 1994, Giraudoux *et al.* 1996). The need to conduct studies on succession of small mammal assemblages and on patterns of population dynamics can be enhanced when rodents impact public health. This is the case in southern Gansu where a large focus of alveolar echinococcosis has been described (Craig *et al.* 1992). This area is situated in central China at the confluence area of several Palearctic and Indo-Malayan faunal regions (Bobrov and Neronov 1995).

Most earlier studies on forest succession of small mammals have been carried out in north-east China (Heilongjiang, Jilin, Liaoning provinces) (Hsia and Li 1957, Hsia 1958, Shen and Li 1959, Hsia 1962, Hsia and Chu 1963, Li 1985, Shu *et al.* 1987, Yang *et al.* 1993), and little is known about the rest of the country. This includes the spur of the Qinghai-Tibet plateaus (including western Sichuan, western Gansu, and Qinghai provinces) where hundreds of thousands of hectares are currently deforested and converted into farmland. Lists of small mammals based on biogeographical divisions, altitudinal successions and vegetation were published in the 1980s (Chen *et al.* 1982, Zheng 1982, Wang 1983b, Feng *et al.* 1986, Zheng and Zhang 1990, Huang *et al.* 1995) but the basic ecology of most mammals remains poorly known.

Our goal in this study was to document the ecology of small mammal assemblages of southern Gansu and to provide a first evaluation of sampling procedures that allow rapid assessment of local faunas. Here, we describe the structure of small mammal assemblages along a deforestation gradient, and discuss the influence of sampling techniques.

Material and methods

The study site was located in an area where human alveolar echinococcosis is highly prevalent, in the south of Zhang County, Gansu. Zhang county is a mountainous region 140–200 km south of Lanzhou, the provincial capital. It covers 2100 km^2 and it is one of the ten poorest counties in China (Craig *et al.* 1992). The county is divided into 17 communes or districts, which includes several villages. The study was carried out in a 20 km^2 area in the vicinities of the villages of Shang He (Shang He commune, 34°27'N, 104°26'E), Shang Cao Tan (Shan Cao Tan commune, 34°35'N, 104°30'E), and Han Chuan, Huang He, Ben Ben Wan (Han Chuan commune, 34°33'N, 104°34'E). The elevation of the study area ranges from 2300 to 2500 m. The nearest meteorological station was in Zhang City (the county capital) 33 km away north of the study area and 1900 m altitude. Zhang city receives 375 mm rainfall annually, with a maximum of 112 mm in July and a minimum of 2-14 mm from November to March. The average temperatures are very low in winter (mean temperature is −6.7°C in January) and warm in summer (mean temperature of July and August is around 20°C). The mountaneous areas which range from 400–1000 m higher than Zhang city probably have higher rainfall and lower (3–6°C) mean temperature.

Six habitat types were represented in the study area: (1) forest – steep and rocky slopes already widely cut. The main dominant species was *Pinus tabulaeformis* (10–15 m height), but it is now intensively cut by hand, carried first by people (sometimes for more than 10 km) and then, by ox-cart. This leaves a secondary forest of high and dense shrubs (*Betula albo-sinensis*, *Rosa rufolanatus*, *Sorbaria kirilowii*, *Viburnum mongolicum*, *Sambucus* sp., etc.) of 2–4 m height. Some rare patches (2–10 hectares) of *Picea sp.* and *Abies sp.* still remain in places (eg cliff and close vicinity of Guai Xi Shan temple); (2) shrubland – timber has been clear-cut and only small trees and bushes (1–3 m height) still remain due to coppicing. Farmers leave cattle there for browsing/grazing (cattle and cattle-yak crosses, goats, pigs, a few horses), and from place to place work the soil to prepare further ploughing; (3) scrubland/grassland – intensive grazing and wood cutting have produced expansive herbaceaous meadows with grasses (5–10 cm in height), *Polygonum viviparum*, *Stelleria chamaejasme*, *Alisma orientale*, *Sausserea* sp., *etc.* which become dominant interspersed with scrub patches (*Berberis* sp., *Hippophe rhamnoides sinensis*, *Salix purpurea*, *etc.*) 0.5–1.5 m in height. These grasslands are generally unploughable and left to cattle. They are sometimes partly replanted with *Larix principis-rupprechtii* in some areas; (4) river bank – grassland (graminacean cover with *Ranunculus sp.*, etc) with patches of *Salix purpurea, Hippophae rhamnoides,* along small streams; (5) farmland, more than 90% ploughed, field terrasses (*Vicia faba, Solanum tuberosum*, cereals, etc.) separated by banks (1–5 m, sloping down to the next field) with *Artemisia lavandulaefolia*, *A. gmelzinii*, *Cirsium setosum*, *Rubus xanthocarpus*, etc.; (6) villages (houses and gardens).

According to old local farmers, the forest was protected during Mao Zedongs time, and the deforestation process begun in the late 1970s and the early 1980s after the Cultural Revolution. The ploughed areas have been considerably extended during the last 20 years, encroaching onto very steep slopes, and farmers still attest to the existence of large forested patches with bears *Ursus* [*Selenarctos*] *thibetanus* (Cuvier, 1823), wolves *Canis lupus* (Linnaeus, 1758), and leopards *Panthera pardus* (Linnaeus, 1758) 15 years ago in places where only ploughed field and scrubland can now be seen. Tree stumps and roots of cut trees are often still present in unploughed areas, and they are regularly exploited by farmers for firewood when the deforestation front (shrublands) is too far from villages.

Preliminary trapping and sampling trials were performed in May 1994 and 1995 with a small number of traps (mainly with INRA traps), as part of a programme whose main target was the mass screening of human populations for alveolar echinococosis. Local people were also asked to catch and bring small mammals in for examination. Extensive sampling (77 trap lines) was carried out in July 1996. Animals were captured with sheet metal INRA live traps (5 × 5× 15 cm) (Aubry 1950), and small break-back traps (snapping bar 4.5 × 4.5 cm). Bait consisted of a mixture of flour, oil and water. Traps were checked every morning, rebaited and reset if necessary, for two or three nights (see results). Twenty five traps of each type were set in lines at intervals of 3 m. Break-back and INRA traplines were paired in each habitat types. Additional unpaired traplines, or isolated traps (in villages) were also set. The relative density of small mammals was expressed as percent trap success (number of animals trapped per 100 trap nights).

Rodents were weighed and dissected for determination of sex, reproductive status, and parasitological examination. Heads (or the whole body for some specimens of every species) were preserved in 5% formalin solution. Skulls and skin were prepared in Montpellier and identification confirmed using the following references: Allen (1940), Corbet (1978), Musser (1981), Hoffmann (1987), Gromov and Erbajeva (1995), Musser *et al.* (1996). Nomenclature followed Wilson and Reeder (1993). Tissue samples of the genus *Microtus* were preserved for later karyotyping (Courant *et al.* 1998).

Landscape transects were performed in order to establish a general linkage between habitats and small mammal indices at wide scales. Data were collected using a linear transect method. Every commune was evaluated along lines which crossed the commune starting from villages and included representative features of each agricultural land. Along each transect, the presence-absence of rodent indices (holes, corridors, faeces, etc.) and the habitat types were noted within every ten paces (about 8–9 m). The rodent density index is the ratio of 10 pace intervals where one or more indices were recorded to the total number of intervals sampled (Delattre *et al.* 1990, Giraudoux *et al.* 1995, Delattre *et al.* 1996, Giraudoux *et al.* 1997).

Results

A total of 264 animals were collected, 199 of these were trapped, and 65 were brought by people. These included 16 taxa among which 15 species only were fully identified (Table 1).

Seventy-seven trap lines were set over the deforestation gradient (from forest to ploughed fields). Forty four traplines were checked 3 times (3300 trap nights). Thirty three traplines were checked only two times (1650 trap nights) for technical reasons (movement of the medical team from village to village in 1994–1995;

Table 1. Number (*n*), mean, maximum and minimum weights (in grams) of small mammals captured. Between parentheses: total number of animals actually trapped including those whose weighing or full identification was impossible (specimens brought in decomposed, or partly eaten in the trap). *Eothenomys / Clethrionomys*, *Apodemus/Mus*: in each case the two genus were impossible to differentiate on the basis of the specimens examined.

Species	Code	Males			Females			Sex unknown	
		n	weight (g)	min–max	*n*	weight (g)	min–max	*n*	weight (g)
Small mammals trapped by using INRA or break-back traps									
Sorex sinalis	Sosi	1	4						
Eozapus setchuanus	Eose	2	19	16–22	1	14			
Microtus limnophilus	Mili	15	29.9	11–50	10	25.7	9–36	1	11
Cricetulus longicaudatus	Crlo	17 (18)	21.6	10–49	20	19.7	13–32		
Tscherskia triton	Tstri	8	54.1	37–83	10	69.7	30–104		
Apodemus agrarius	Apag	33	26.5	7–42	32 (33)	23.1	6–40		
Apodemus draco	Apdr	3	25	22–29					
Apodemus peninsulae	Appe	15	28.7	9–44	7	22.4	17–30		
Mus musculus	Mumu	11	16.5	12–22	6 (7)	19	11–30		
Niviventer confucianus	Nico				1	25			
Ochotona thibetana	Octh				1	18			
Eothenomys/Clethrionomys	EoCl	(1)	23						
Apodemus/Mus	ApMu	(1)	20						
Small mammals brought by people									
Anourosorex squamipes								(1)	
Microtus limnophilus		7	31.1	11–42	4	25	12–31	1	37
Tscherskia triton		5	106	60–200	2	78	74–82		
Apodemus agrarius		1	36		1	11		1	27
Apodemus peninsulae					1	34			
Micromys minutus					1	7			
Rattus norvegicus		3	155	75–224	2	221	208–234		
Myospalax fontanieri		16	261	137–624	19	193	54–306		

vehicle breakdown in 1996) or could not be standardized (trap thefts). Sixty-five traps were set in houses and gardens in villages for a total of 95 trap nights.

Non parametric statistics were used for comparisons (Siegel and Castellan 1988).

Trapping efficiency

As a whole, trapping efficiency of the break-back traps was much better than that of the INRA traps (for three days: 5.5 animals per 100 trap nights, and 0.02 animals per 100 trap nights, respectively, Mann-Whitney U-test, p = 0.0001).

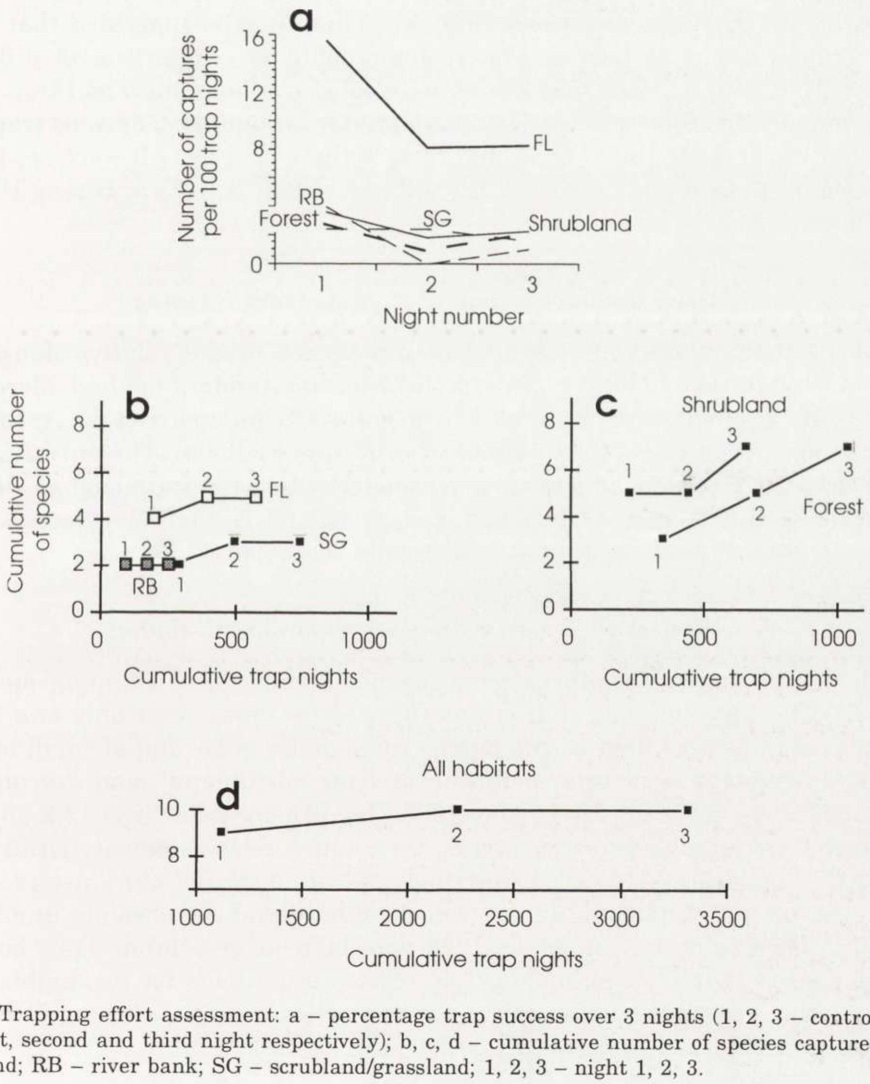

Fig. 1. Trapping effort assessment: a – percentage trap success over 3 nights (1, 2, 3 – controls after the first, second and third night respectively); b, c, d – cumulative number of species captured. FL – farmland; RB – river bank; SG – scrubland/grassland; 1, 2, 3 – night 1, 2, 3.

Furthermore, possible differential response to trap types between species was ruled out (χ^2 = 0.24, p = 0.97). Therefore, the paired lines have been pooled for further analysis.

Figure 1a shows there is a significant decrease in the number of captures per trap-night correlated with the number of nights (Friedman test = 7.05, p = 0.03). This means the sampling effort had a significant effect on the local density of small mammals. Figure 1b shows that the cumulative number of species reaches an asymptote after the second night in ploughed land, along river banks, and in scrubland/grassland. However it still increases after three nights in forest and shrubland (Fig. 1c). That means that the sampling pressure was not enough for those two habitats. However, no new species were added after the second night, considering all traplines as a whole (Fig. 1d). These results suggested that three nights trapping was at best the lower limit enabling comparison of different habitats. Therefore we used only the paired pooled traplines checked three times for the comparison of the relative densities (standard trapping): 22 pooled traplines (44 paired lines) set in July 1996 conformed to these criteria. All were set in the same area, in the general vicinity of the villages of Ben Ben Wan, Huang He and Han Chuan.

Relative densities estimated from standard trapping

Table 2 shows there were significant differences in the relative density of species among the five habitat types sampled with the standard method. Moreover, a significant gradient from shrubland to ploughed fields occurred for *Apodemus agrarius* (Spearman correlation coefficient = 0.77, p = 0.0004). The only *T. triton* captured in shrublands was less than ten meters away from a ploughed field in Huang He. A higher density in forest and shrubland is suggested for *Eozapus setchuanus*, but differences are not statistically significant.

Complementary results from non-standardized trapping

Eighty animals were captured by using non-standardized trapping methods (Table 3). The high number of *Microtus limnophilus* came from only two INRA traplines set in a rocky area with a patchy cover of dry grass and of small bushes (actually a habitat type intermediate between "shrubland" and "scrubland/ /grassland") close to Shang He in May 1994. The density index was 13.2 animals per 100 INRA trap nights for two nights, a very high relative density locally (see Table 2 for comparisons). At the same time, 2 *M. limnophilus* were also recorded from a line set in a field bank nearby. On the other hand the absolute number of *Cricetulus longicaudatus* caught in 1996 was high in grasslands (14), but the average density index (1.8 animals per 100 INRA trap nights for two nights) was similar to that recorded with standard traplines. Surprisingly a young *Ochotona thibetana* was recorded in Shang He village (break-back trap).

Table 2. Density index (expressed as the number of captures per 100 nights trap) of mammals captured by using standard paired lines. Code, code of each paired line; see species abreviations in Table 1. KW – Kruskal-Wallis test; MW – Mann-Whitney *U*-test corrected for ties: comparisons were made between habitats where population density were higher (bold numbers) and other habitats (italic numbers and species absent).

Habitats	Code	Species											
		Apdr	Nico	CIEo	Eose	Appe	Sosi	Mili	Crlo	Apag	Tstr	Mumu	AmMu
Forest	01JA				**0.7**								
	02JB					**0.7**				*1.4*			
	03JC												
	30KB					**1.4**							
	31KC	**2.0**				**2.7**						*0.7*	
	32KD			0.7		**2.0**							
	33KE	**0.7**	0.7										
Shrubland	26JX				**0.7**								
	27JY				**0.5**	**1.9**			**0.5**	**0.9**	*0.5*		
	28JZ					**0.7**	0.7	**0.7**	**0.7**	**0.7**			
	29KA									**1.3**			
Scrubland/ grassland	04JD								**2.7**				
	08JH									**2.1**			
	09JI									**0.7**			
	10JJ					*0.7*				**1.3**			
	11JK									**3.4**			
River bank	22JW							**1.3**		**0.7**			
	23JV							**1.3**					
Farmland	05JE								**3.6**	**3.6**	**4.3**	**2.2**	0.7
	06JF									**5.5**	**0.7**	**2.8**	
	07JG					*0.7*			**0.7**	**4.8**	**3.4**	**0.7**	
	25JU								**4.8**	**4.1**	**0.7**		
Test		MW			MW	MW		MW	KW	KW	MW	MW	
Probability		0.05			0.1	0.07		0.003	0.05	0.009	0.0001	0.001	

Table 3. Number of small mammals captured by using non standardized trapping.

Species	Forest	Scrubland grassland	River bank	Farmland	Village
Microtus limnophilus		13	6	2	
Cricetulus longicaudatus		16	1	2	
Tscherskia triton		2		1	1
Apodemus agrarius		1		4	2
Apodemus peninsulae	3	6	5	5	
Mus musculus				2	7
Ochotona thibetana					1

Specimens brought in by people

Most were *Myospalax fontanieri* (Table 1), since peasants actively control their populations with local traps due to serious damage to cultivated plots. The relatively high number of *Microtus limnophilus* is also noteworthy since people did not control their populations and nor use special traps to catch them. All the specimens of this species were collected in Shang He, where relatively high densities were detected locally from non-standardized methods.

The mean weight of *Tscherskia triton* caught by locals was higher than that of the animals trapped (one-tailed t-test = –2.3, df = 22, p = 0.015), suggesting that the traps were too small to catch the biggest specimens (maximum weight of trapped animals = 104 g; of animals brought by people = 200 g).

Rodent index transects

A total of 3390 intervals of ten paces were sampled (about 30 km). Figure 2 shows there were significant differences in rodent indices according to habitats. *Myospalax* indices were higher in ploughed fields and field bank (pooled) than in any other habitats (χ^2 with Yate's correction for continuity = 50.84, p = 0.0001). This corroborates information obtained from farmers about the distribution of *Myospalax*. There were no significant differences in indices of small sized (< 100 g) rodents between shrubland, grassland and river bank. On the other hand the comparison of those habitats with ploughed fields showed highly significant differences (χ^2 with Yate's correction for continuity = 8.9, 43.9, 12, p = 0.03, 0.0001, 0.0005 respectively), as well as with field banks (χ^2 with Yate's correction for continuity = 68.8, 78.4, 32.4, respectively p = 0.0001). Those index data cannot be easily interpreted, since indices are not species-characteristic, and since small sized rodents of several species live in every habitat. However, indices clearly

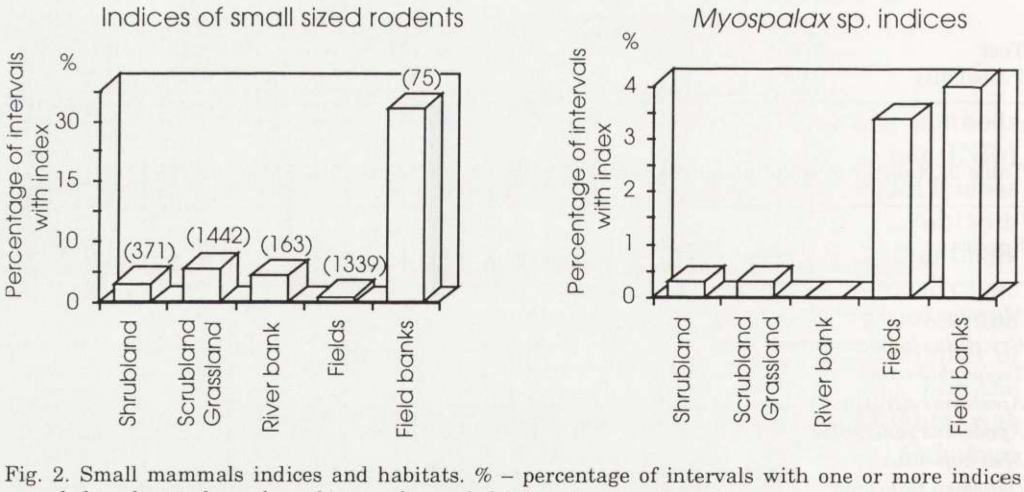

Fig. 2. Small mammals indices and habitats. % – percentage of intervals with one or more indices recorded to the total number of interval sampled (given in parentheses).

show that rodent colonies/holes (mainly *Cricetulus, Apodemus agrarius* and *Mus musculus*, see above) occur much more often in field banks, rather than in the fields themselves (χ^2 with Yate's correction for continuity = 273.2, p = 0.0001).

Discussion

Sampling representativity

The size of the traps did not generally allow capture of animals exceeding 70 g. Bigger species that could not be trapped using INRA traps or small break-back traps included squirrels, strictly subterranean species, etc. However they would have been brought or mentioned by local people if abundant. The efficiency of INRA traps was lower than that of break-back traps used here: however, the latter often crushed the skull which can prevent species identification. Thus a varied trapping regimen should be maintained for further studies. At least, the present paper deals with the distribution of small sized mammals (< 70 g) with surface activity, and of bigger species considered as agricultural pests by farmers.

Rodent assemblages in south Gansu

This study is the first to link rodent assemblages to different stages of a deforestation gradient in central China. Allen's review on mammals of China (Allen 1938, 1940) includes many old records from Kansu (the former name of Gansu province, whose limits were not exactly the same). More recent reviews put species in a biogeographical framework and provide general information on their distribution and habitats (Nowak 1991, Wilson and Reeder 1993, Huang *et al.* 1995). However, they give little information on specific habitats, rodent assemblages and ecological succession.

With regard to regional studies in Gansu, three deal with biogeographical distributions (Wang 1983a, Zheng and Zhang 1990) or with the description of damage and burrow systems of some species (Chen *et al.* 1982). *Apodemus sylvaticus* has been given recorded in southern Gansu (Zheng and Zhang 1990) and southern Shaanxi (Zheng 1982) but actually that mouse cannot be *A. sylvaticus* and is likely *A. peninsulae* or *A. draco* (Ellerman 1961). The closest regional and local studies including assemblages of forest small mammals have been carried out in the Liupan mountains (Ningxia) 250 km northeast (Annoy 1989), in the Qinlin and Dabashan moutains (Shaanxi), 350 km east (Zheng 1982, Wang and Fan 1983), and in the Wolon Natural Reserve (Sichuan) 350 km south (Wu *et al.* 1992). Unfortunately, few details are given on the trapping techniques, the scales at which they have been implemented, and the sampling strategy, so that quantitative comparisons are difficult between these studies. All the species trapped in our study were also recorded in at least one of the neighbouring provinces, except *Apodemus peninsulae*.

Eozapus setchuanus is known to occur in southeastern Qinghai, southern Gansu and western Sichuan (Smith *et al.* 1990). It has also been recorded from the Liupan mountains, southern Ningxia (Annoy 1989). Nowak (1991) indicates that the preferred habitat of *Eozapus* is beside streams and cool forest at high elevations, and this species is designated as endangered because of the destruction of forest habitats (according to Nowak, only about a dozen specimens has been collected). This species is however regularly recorded from Chinese studies carried out in the forests of its distribution range. The present study shows it can be also found in dense shrubland after deforestation where it appears to be not so rare. The capture of a young *Ochotona thibetana* in the village of Shang He was also unexpected (Smith *et al.* 1990) because this village was about 10 km away from forest, and surrounded with ploughed fields and scrubland.

Figure 3 sums up the distribution trends of the dominant rodent species according to the deforestation gradient. As a whole, four rodent assemblages were distinguished: (1) a forest assemblage which extends to dense shrubland characterized by *Apodemus draco, Eozapus setchuanus* and *A. peninsulae*. *Apodemus draco* seems to be more strictly limited to forest than the two others, whereas *A. peninsulae* can extend its range to the fields in the vicinity of villages. *Niviventer confucianus* is to be related to this assemblage as it has also been mostly found in forest in earlier studies (Zheng 1982, Wang 1983b). Two commensal rodent species, *Apodemus agrarius* and *Mus musculus*, may also occur in the forest assemblage; (2) a scrub assemblage characterized by *Cricetulus longicaudatus* and

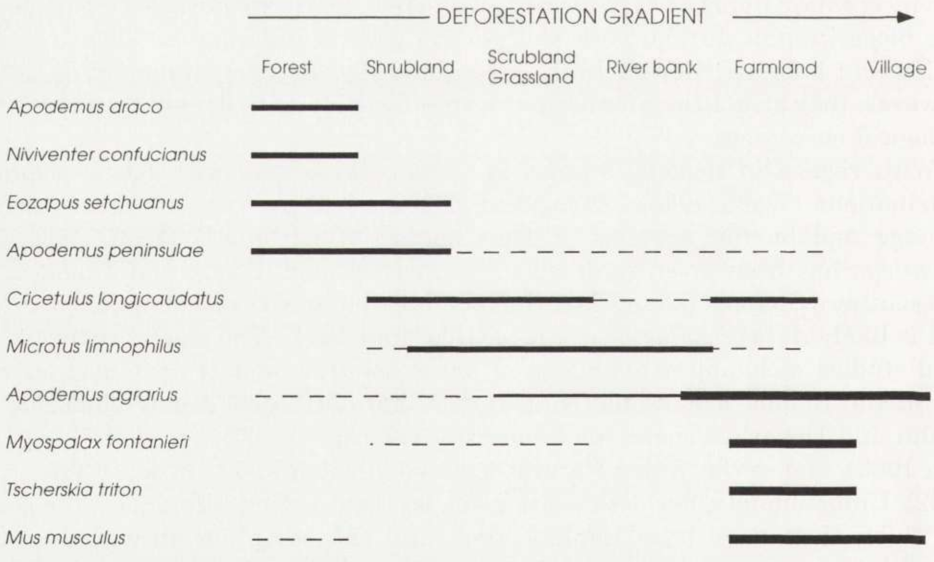

Fig. 3. Distribution of the dominant species along the deforestation gradient. Thick line, highest densities, dotted line, low density or occasional occurence. The sampling methods do not allow for density comparisons between species.

Microtus limnophilus whose range extends from semi-open shrubland to river and field banks. Actually the distribution of *Microtus limnophilus* seems determined by a reasonably dense grass cover and the presence of small bushes under which they can find shelter. It is absent in overgrazed grassland and its presence in field banks was related to high densities in the adjacent scrubland. This habitat is to be compared to Thomas' description in Gansu (Allen 1940) for *Ratticeps flaviventris*, likely confused with *M. limnophilus*: grass meadow by a stream; dry shrubby bank on mountain side; more or less forested countries; mossy ground around rotten fir tree roots; rocky mossy mountain top; (3) a farmland assemblage characterized by *Apodemus agrarius*, *Tscherskia triton*, *Myospalax fontanieri*, and *Mus musculus* (4) a village assemblage characterized by commensal rodents as *Mus musculus*, *A. agrarius*, and *Rattus norvegicus*. *Apodemus agrarius* seems to be the most ubiquitous species even though its density is higher in farmland around villages.

Accounting for biogeographical vicariance of species, this pattern parallels the results obtained for deforestation gradients in northeastern China (Hsia and Li 1957, Shen and Li 1959, Shu *et al.* 1987, Yang *et al.* 1993). A density decrease of *Apodemus peninsulae*, *Apodemus latronum* (Thomas, 1911), *Clethrionomys rufocanus* (Sundevall, 1846) and *C. rutilus* (Pallas, 1779) was recorded along successions from primeval coniferous-broadleaf mixed forest to meadows and farmland. *Apodemus agrarius* showed a reverse tendency. *Microtus fortis* (Büchner, 1889) and *Microtus maximowiczii* (Schrenk, 1859) (outbreaks mentioned) were limited to grassland. In the first years after logging, *Clethrionomys rufocanus* density increased in the cut-over land, likely still covered with dense bushes; moreover, this species and *Apodemus latronum* showed larger seasonal variations in density in such habitats than in forest. This relatively higher stability of forest rodent populations has been also recorded in Europe (Giraudoux *et al.* 1994). Surprisingly, some records of *Tscherskia triton* in secondary forest were mentioned by Shu *et al.* (1987) and Yang *et al.* (1993).

This survey of rodent assemblages is far from being complete and calls for complementary investigations. Many *Ochotona* sp. indices (feces) were recorded in rocky and scrubby slopes at the bottom of cliffs close to the villages of Ben Ma Dia (34°32'13"N, 104°30'56"E) and of Huang He. Those habitats however represent a very small percentage of the study area. Moreover, important pluriannual changes in population density may occur with potentially cyclic species (eg arvicolids) and could modify the community structure described here (Giraudoux *et al.* 1994).

As far as assessed from these preliminary data, species richness (total 16) varies according to the gradient of deforestation: 11 in timbered forest and shrubland, 5 in scrubland/grassland and in grassland along river banks, and 7 in farmland. The intermediate stages of succession exhibit depauperate assemblages, while more diverse assemblages occur in forest, shrubland and farmland. *Microtus limnophilus* and *Cricetulus longicaudatus* are the key species of this depauperate assemblage and they are considered rodent pests in the grasslands of southern Gansu, as is *Ochotona thibetana* (Chen *et al.* 1982). It is obvious that deforestation leads to the loss of forest species, and thus to a decrease of the regional biodiversity. It has been shown that forest and agriculture landscape patterns in Europe have an effect on population dynamics and outbreaks of grassland arvicolids (Delattre *et al.* 1992, Giraudoux *et al.* 1997). Thus, it could be important to explore how deforestation in China may lead to the extension of depauperate habitats favourable to rodent pests, possibly creating higher risks for rodent outbreaks in pastoral lands and increasing public health risks.

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