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Amphibian assemblages in undisturbed and disturbed areas of Kudremukh National Park, central Western Ghats, India

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SUMMARY

Human activities have fragmented amphibian habitats and affected amphibian diversity and distribution, but the ecology is poorly known. A four-year study assessed the diversity and distribution of amphibians in undisturbed and disturbed sites of the Kudremukh National Park (KNP), India. Iron-ore mining and associated activities in the KNP have induced habitat fragmentation. The disturbed sites had ranges of habitat variables clearly distinguishable from undisturbed sites. Thirty-six species of anurans and six species of caecilians have been recorded in the KNP and the total amphibian species richness represents 20% of the whole Indian amphibian fauna. Among these, 20 species were distributed in both disturbed and undisturbed sites, while 22 were found only in undisturbed sites indicating they may be threatened by further habitat fragmentation. Species diversity and richness formed two distinct groups clearly associated with disturbed and undisturbed habitats, respectively.

Keywords: Amphibia, biological diversity, habitat fragmentation, environmental impact, mining, species richness

INTRODUCTION

Habitat plays a crucial role in moulding life histories. Generally, the life history of an organism depends upon the habitat (Begon *et al.* 1996) and the resource distribution has an important effect on ecology (Marsh *et al.* 2000). The habitats, distributions, abundances and ecologies of various larger animals have been reported during the process of conservation. For amphibians, such data are few and knowledge of the role of habitat in determining distributions is limited. However, there are great concerns about these animals in the face of anthropogenic activities (Lambert 1997; Marsh & Pearman 1997; Lehtinen *et al.* 1999; Kolozsvary & Swihart 1999; Lips & Donnelly 2002). Over the past two decades, there have been reports of substantial amphibian decline (Houlahan *et al.* 2000) attributed to various causes including habitat disturbance.

Many herpetologists opine that most historical and current amphibian declines are due to habitat destruction or alteration (Wyman 1990; Wake 1991; Bradford *et al.* 1993; Blaustein *et al.* 1994; Lannoo *et al.* 1994; Blaustein & Wake 1995; Hecnar & McClosky 1996; Sala *et al.* 2000; Young *et al.* 2001; Lips & Donnelly 2002). In most cases, physiological constraints have confined the amphibians to moist habitats, added to which their dispersal capacity and strong site fidelity have further restrained them (Sinsch 1990; Blaustein *et al.* 1994; Marsh & Pearman 1997). A relatively small degree of fragmentation could effectively isolate amphibian populations eliminating them from the areas that provide habitats for foraging and breeding (Marsh & Pearman 1997). Forest fragmentation threatens native populations by eliminating blocks of continuous habitat and is a direct negative influence of human activity (Marsh & Pearman 1997; Marsh 2001; Pough *et al*. 1998; Kolozsvary & Swihart 1999; Lehtinen *et al.* 1999; Williams & Hero 2001). Habitat fragmentation leads to loss of native habitat, limiting species' potential for dispersal, colonization, foraging ability and demographic structure and genetic make-up (Waldman & Tocher 1998). Fragmentation increases edge effects, resulting in microclimatic changes, increased incidences of fire, increased predation and competition from exotic species and modified food webs (Janzen 1983). Amphibian diversity and distribution change over gradients of several climatic, abiotic and ecological factors (Gascon 1991; Lee 1993; Plénet *et al.* 1998; Oliviera *et al.* 2000; Eterovick & Sazima 2000), and amphibian assemblages are sensitive to environmental variations (Blaustein *et al.* 1994; Pearman 1997; Daniels 1999). Amphibians are also considered good indicators of 'environmental health', especially in detecting damage to local environments (Hager 1998; Gibbs 1998).

Well-protected national parks, nature reserves and sanctuaries have been established in many countries, but there are often significant human activities within these areas that damage biota locally. Such damage to ecosystems can be expected to be expressed in changes in the local distribution and diversity of amphibian species. Kudremukh National Park (KNP) in the central Western Ghats, India (Fig. 1), contains a mosaic of land habitat types and is rich in biological diversity, yet knowledge of the biodiversity is restricted to that of wet evergreen forests, the distribution of

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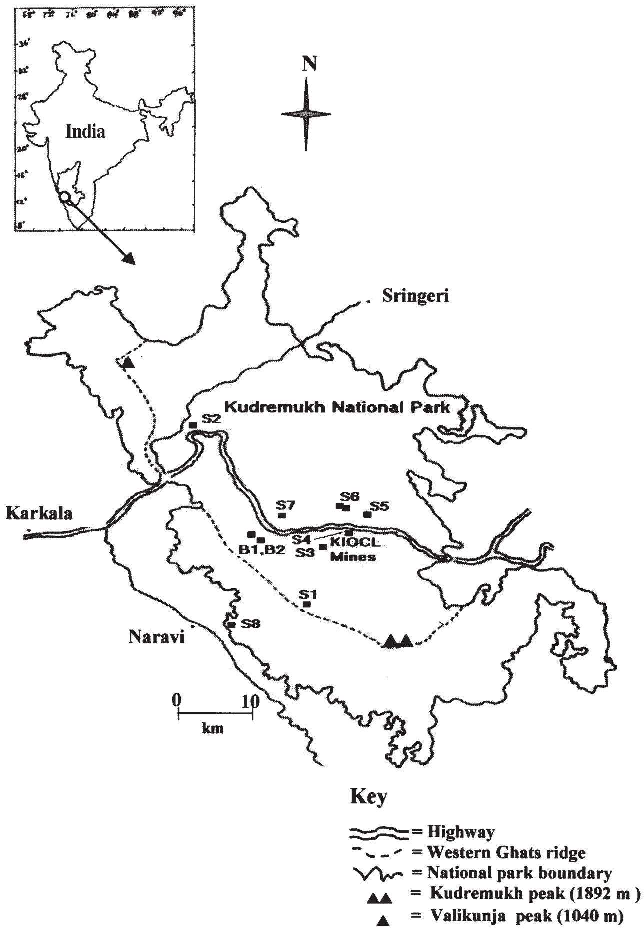

Figure 1 Map of Kudremukh National Park, India, showing the study sites numbered S1 to S8, and B1 and B2.

amphibians, birds and large mammals and an overview of biodiversity (Pascal 1988; Daniels 1992; Krishnamurthy 1999; Hussain *et al.* 1999; Krishnamurthy & Hussain 2000). Complex vegetation patterns and heterogeneity of habitat in KNP favours the occurrence of many forms of undescribed amphibian species (Krishnamurthy *et al.* 2001). In spite of clear disturbances to the National Park, there are limited ecological studies of the impact of anthropogenic activities on amphibians. The objective of the present work was to describe variations in amphibian diversity and composition associated with forest fragmentation and alteration induced by iron ore mining and human activities within the KNP. Knowledge of amphibian diversity along gradients of forest fragmentation is essential to understanding the influence of habitat quality and improves management of the forest for amphibian conservation.

MATERIAL AND METHODS

Study sites

The variety of ecosystems in the Western Ghats (WG) harbours diverse fauna and flora with a high degree of endemism in which amphibians are prominently represented. The Indian amphibian fauna comprises about 220 species (Alfred 2002); 58% (127 species) are recorded from the WG (Vasudevan *et al.* 2001). Among these 127 species, 93 are endemic to this area, constituting 73% and 43%, respectively, of the amphibian endemism known for WG and the whole of India. The WG is an unbroken relief of hill terrain dominating the west coast of peninsular India, categorized into three zones, namely that from Surat to Goa (northern WG), Goa to Palghat Gap (central WG) and south of Palghat Gap (southern WG) (Tewari 1995). The central WG cross Karnataka State and parts of Kerala State. In Karnataka State, the ratio of forest area to total geographical area in the WG is around 57%. From 1972 to 1989, five national parks and 19 sanctuaries were created under the Wildlife Protection Act of 1972 (Sridhar 2000). One such national park is the KNP (Fig. 1). The KNP (12°–16°N; altitude 300–1892 m above sea level) comprises forests of hilly terrain, in an area of 600 km^2, which includes Tungabhadra State Forest in the Chickmagalur Revenue District, Naravi Reserve Forest in the Dakshina Kannada District and Andar Reserve Forest in the Udupi District. The KNP has highland and lowland tropical evergreen forests, *shola*, grassland, savannah, and mosaics of mixed semi-evergreen forest and plantations in the peripheral area. In addition, vast mono-plantations of *Acacia* were established under an afforestation programme inside the Park. The KNP has no legal human settlements, except for a few tribal communities and the employees' township of the Kudremukh Iron Ore Company Limited (KIOCL). The iron-ore mining and associated township development inside the Park and the monoplantations have turned the Park into a mosaic of natural and fragmented/altered habitats.

I studied five distinct sites of disturbed and undisturbed nature within a 20-km radius of an active iron-ore mine located in KNP (Fig. 1). Undisturbed sites include: Kachige Hole (S1), Bhagavathi Forest (B1 and B2), Naravi Forest (S8) and Seerlu (S2); disturbed sites include: Ridge 1 Valley (S3), iron-ore mining area (S4), East shola – Sector IV (S5), Sectors II and III of the KIOCL residential area (S6) and Lakya dam and periphery (S7). Among these, S3 and S4 were located within the mining area, S5 and S6 were in the residential area, and S7 was located at the periphery of the dam constructed to dump the silt generated by the iron-ore processing. Within each of these sites, an area of 1 km^2 was identified for regular sampling. The study sites were delimited such that undisturbed and disturbed sites were located within a large province of a common climatic and physiographic region. Further, the delimination of each site was based on the earlier amphibian studies conducted in the region (Krishnamurthy & Katre 1993, 1997; Krishnamurthy 1996*a*, *b*, 1999; Krishnamurthy & Hussain 2000). These studies revealed the occurrence of maximum semi-aquatic habitat dwellers and a prominent migration of anurans to the water bodies during the breeding season. Hence, sites were selected in such a way that each of them should encompass

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Table 1 Ranges of habitat criteria used to distinguish the disturbed and undisturbed sites, and results of ANOVA test used to compare them.

Variable	*Undisturbed sites*	*Disturbed sites*	F	p
Canopy (%)	80–82	40–70	3.504	0.0309
Ground cover (%)	50–95	0–100	15.041	0.0001
Litter thickness (mm)	20–100	0–24	70813.115	0.0029
Litter weight ($g\,m^{-2}$)	>500	95–180	34.20	0.0072
Light intensity (Lux)	250–2900	1120–33600	4.540	0.0196
Density of trees (per 100 m^2)	5–14	10–22	21.741	0.0001
Density of shrubs (per 100 m^2)	20–35	0–1600	7.530	0.0046
Density of herbs (per 100 m^2)	50–65	0–65	11.980	0.0003

water sources and clearly support the character of undisturbed or disturbed habitats.

These sites were distinguished initially by visual observation, and later by considering the mean values of vegetation variables and the penetration of the light. These variables were canopy and ground cover, litter thickness and weight, light penetration and density of vegetation (Table 1). Light penetration at ground level was measured using an illuminometer (Kyoritsu model 5200). Ground cover was estimated by measuring the spread of vegetation within each quadrat. The canopy cover was measured using a forest densiometer. Later both ground and canopy covers were converted to the percentage of spread within each quadrat. The litter thickness was recorded using a millimetre scale and weighed using a spring balance (Eagle Kc/00330, precision 1 g). The densities of trees, shrubs and herbs were estimated by visual counts.

Methods

Amphibian species were recorded at intervals of 30 days between 1996 and 2000 using the 'all out search', in which thorough searches for amphibians were made in all seasons and possible habitats (litter, decaying logs, boulders, tree bark, ground cover, bushes and canopy). Boulders and decaying logs were upturned, litter and organic mulch were prodded, and the bushes and barks were thoroughly examined. Bushes and low canopies were searched thoroughly for arboreal forms, such species also being collected by following their calls using torchlight in the evening and at night. Removal of litter may be essential for obtaining accurate counts (Heatwole 2003) but, in the present study, the litter was not removed from the plot as litter weight, thickness and other vegetation variables were used to differentiate disturbed and undisturbed sites. Instead the greatest possible care was taken during each sampling to minimize under-counting of taxa or individuals. Amphibians were identified *in situ* using field keys devised by Daniel (1963*a*, *b*, 1975), Daniel and Sekhar (1989) and Daniels (1997*a*, *b*, *c*). Dubois (1992) thoroughly modified the nomenclature of Indian amphibians, but the taxonomic changes made by Dubois (1992) possess a number of weaknesses (Inger 1996). There are taxonomic uncertainties in the new names of amphibians of the WG (Daniels 1997*d*) but the changes are widely used among Indian herpetologists, hence the new names of the amphibian species are also provided here (Appendix I). Four man-hours were spent in sampling each quadrat (10 × 10 m) and an equal time was spent on each sampling throughout the study. The densities of amphibians were recorded and replicates of quadrats were used to obtain the mean number of amphibians per unit area. A minimum of 5% of the area of each study site was sampled using the randomly placed quadrats and species richness, and Shannon-Wiener and Simpson indices derived. The habitat evenness (Jaccard index, JI) for amphibian species richness was calculated.

$$JI = a/(a + b + c)$$

where a is the number of species occurring in both habitats, b is the number of species unique to the first habitat and c is the number of species unique to the second habitat (Prasannarai & Sridhar 2001). Adult microhabitat, seasonality of occurrence and distribution of each species are detailed. Vegetation and climatic factors were correlated with habitat quality and amphibian assemblages. The amphibians of WG occur in terrestrial, aquatic, semi-aquatic and arboreal habitats, and each of these form a group of specialists (Mahanta *et al*. 1996). Based on the habitat criteria and past experience of occurrences of each species, the amphibians were segregated into distinct habitat generalists (groups). Species richness and corresponding density (as a percentage) of each habitat generalist were recorded. SPSS (version 10.0) was used to process and analyse the data.

RESULTS

Species richness

There were 42 species of amphibians in KNP representing 20% of the Indian amphibian fauna, comprising 36 anuran and six caecilian species, dominated by members of Ranidae (21 species) and Rhacophoridae (eight species). Bufonidae and Ichthyophidae were represented by four species each, Microhylidae by three species and Caecilidae and Uraeotyphlidae by one species each (Appendix I). Among the 42 species, 30 species (71%) are endemic to the WG (Anon. 2001).

Habitat based distribution of amphibian species

Based on ANOVA, there were five sites in the undisturbed or partially modified category and five sites in the disturbed category (Table 1). The disturbed sites were originally

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primary forest habitats located adjacent to iron-ore mining and altered by mining, dam construction, afforestation in hillocks of shola forest and grasslands, and development of the KIOCL township. The mining and ore-processing activities in these areas have affected both terrestrial and aquatic habitats. The terrestrial habitats were affected by denudation and removal of the top layer of soil, which has ultimately silted in the water bodies.

Amphibians in the KNP occurred in all the habitats (Appendix I). The amphibians were distributed into two groups with 20 species occurring in both disturbed and undisturbed sites, and a group of 22 species present only in undisturbed sites. In the undisturbed sites, the amphibian richness correlated with some of the habitat variables (canopy cover, $r = 0.77$, $p = 0.005$; light intensity, $r = -0.73$, $p = 0.011$; air temperature, $r = -0.82$, $p = 0.02$; water temperature $r = -0.69$, $p = 0.039$ and soil temperature $r = -0.75$, $p = 0.008$). Some of these variables (such as air, water and soil temperature) were dependent on the habitat criteria used to determine the strata (for example the maximum canopy cover reducing air and soil temperature).

Among the habitat generalists, the aquatic species (AqHG) were categorized as open (two species) or closed (six species) aquatic species. The semi-aquatic habitat dwellers (SaqHG) were categorized into ground vegetation cover (four species), litter (six species) or seepage (six species) microhabitats. The terrestrial habitat dwellers (THG) were allocated to open (three species) or closed (seven species) conditions, while the arboreal habitat dwellers (AoHG) could be split into bush dwellers (eight species) and high canopy dwellers (two species). Species distributions showed considerable differences between undisturbed and disturbed habitats. Among the eight AoHG, seven (87.5%) species were found in disturbed habitats, while 37.5% (three out of eight) of AqHG and 50% (five out of 10) of THG were found in disturbed sites. Among the SaqHG, only five species out of 16 were recorded in disturbed sites.

Table 2 details the mean densities of individuals and numbers of species recorded in each habitat category. The undisturbed sites harboured more species with high densities. The differences in species richness and density of habitat generalists between disturbed and undisturbed sites were significant (density: AqHG $F = 10.52$, $p < 0.025$; AoHG $F = 5.23$, $p < 0.05$; SaqHG $F = 6.91$, $p < 0.05$; THG $F = 2.5$, $p > 0.05$; species richness: AqHG $F = 11.27$, $p = 0.01$; SaqHG $F = 58.78$, $p < 0.01$; AoHG $F = 0.018$, $p > 0.05$; THG $F = 0.021$, $p > 0.05$). Thus, there were prominent differences in distribution between disturbed and undisturbed sites and influence of habitat on the local changes in the amphibian assemblage.

Irrespective of habitat categories, the diversity indices alone reveal the maximum species richness and high relative density among the undisturbed sites (Table 3). The data also showed clear differences in species richness and density between disturbed and undisturbed sites. This was further confirmed by the JI of species association between the undisturbed and disturbed sites (total evenness; JI = 0.47). Pair-wise tests revealed a high degree of species association among undisturbed sites (Table 4). The undisturbed site S1 had a high degree of association with disturbed site S5 (Table 4). Among disturbed sites, low values of JI indicated low diversity and commonness of species (Table 4). In the disturbed sites, although 20 species were recorded, the density of individual species was low. Figure 2 depicts the

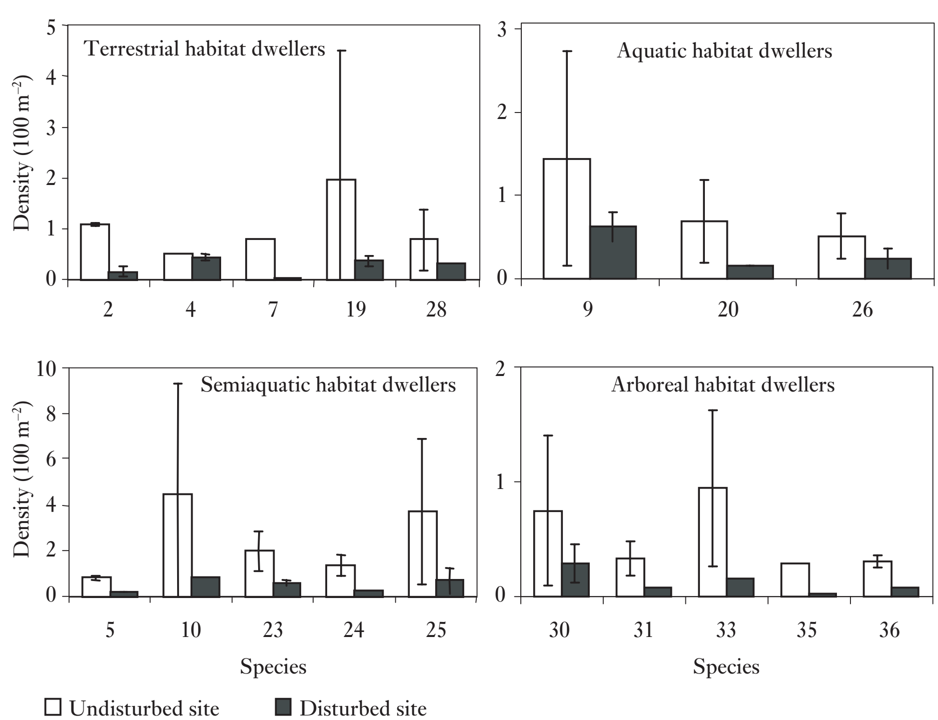

Figure 2 Distribution (mean ± SE) of those species present in both disturbed and undisturbed sites of Kudremukh National Park. The species numbers are explained in Appendix I.

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Table 2 Species richness (S) and mean density (D, number per m^2) of arboreal (AoHG), aquatic (AqHG), semi-aquatic (SaqHG) and terrestrial habitat (THG) species in different sampling sites.

Sites	*AoHG*		*AqHG*		*SaqHG*		*THG*	
	D	*S*	*D*	*S*	*D*	*S*	*D*	*S*
Undisturbed								
B1	2.05	5	4.91	5	9.39	7	1.91	2
B2	0	0	1.34	2	4.05	5	0.11	1
S1	3.75	4	5.30	3	17.19	7	8.95	5
S2	3.34	1	2.20	2	29.75	6	0.92	1
S8	1.51	4	1.95	5	6.19	8	4.27	7
Disturbed								
S3	0.70	2	0.66	1	1.00	2	0	0
S4	0	0	0.16	0	0.58	2	0.51	2
S5	0.76	5	1.08	1	1.90	3	0.67	2
S6	0	0	0.16	2	0.83	2	0.96	4
S7	0.51	3	0	0	0.75	1	1.33	4

Table 3 Diversity indices for amphibians in the study sites.

Sites	*Species richness*	*Density*	*Simpson index*	*Shannon-Wiener index (H')*
Undisturbed				
B1	19	15.00	12.64	2.7
B2	8	4.52	4.66	1.74
S1	19	28.40	9.38	2.57
S2	10	29.72	4.65	1.79
S8	24	11.45	17.48	3.0
Disturbed				
S3	6	1.94	4.47	1.63
S4	5	1.10	4.37	1.54
S5	12	3.62	7.25	2.17
S6	7	1.60	4.7	1.67
S7	8	2.15	5.63	1.88

Table 4 Jaccard Index (JI) of amphibian species association between sites.

	Undisturbed sites					*Disturbed sites*			
	S1	*B1*	*S8*	*S2*	*B2*	*S5*	*S6*	*S7*	*S3*
B1	0.56								
S8	0.59	0.6							
S2	0.21	0.23	0.17						
B2	0.21	0.11	0.18	0.2					
S5	0.52	0.41	0.41	0.23	0.11				
S6	0.29	0.16	0.22	0.1	0.14	0.27			
S7	0.22	0.11	0.21	0.15	0.13	0.25	0.36		
S3	0.18	0.12	0.1	0.24	0.15	0.125	0	0.17	
S4	0.25	0.17	0.19	0.05	0.17	0.21	0.5	0.3	0.1

density (mean ± SE) of individuals of species present both in disturbed and undisturbed sites. Among the frogs of THG, two species of open terrestrial microhabitat (*Bufo melanostictus* and *Ramanella montana*) and three of closed terrestrial habitats (*Bufo beddomii*, *Rana curtipes* and *Tomopterna rufescens*) occurred in both habitats. Out of these, *B. melanostictus* had a high density (64.34% of total) in disturbed habitat. Among the AqHG, two frogs of open aquatic microhabitat (*Rana cyanophlyctis* and *R. tigerina*) and one of closed aquatic microhabitat (*Micrixalus saxicola*) were recorded in disturbed sites, with less than 25% of their total density recorded in undisturbed sites. *Rana cyanophlyctis* and *R. tigerina* of open aquatic microhabitat were common in agricultural fields and were more abundant in undistributed sites. In disturbed sites, two SaqHG, *Microhyla ornata* and *R. limnocharis* (microhabitat with ground vegetation cover), were recorded with 12 and 23% of their density in undisturbed sites, while frogs occurring in seepages (*Nyctibatrachus aliciae* and *R. semipalmata*) and litter (*R. temporalis*) were recorded at low density (<10% of their density in undisturbed sites). Out of the eight species of AoHG, excluding *Philautus beddomii,* all other species were recorded in disturbed sites. Among these, *P. charius* was predominant, with 25% of total density recorded for

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disturbed sites. The remaining species occurred with less than 10% total density in undisturbed sites. *Philautus nasutus* and *P. glandulosus* were recorded from both disturbed and undisturbed sites; in undisturbed sites these species were at low density.

DISCUSSION

The diverse herpetofauna of WG is evidenced by the 127 amphibian species constituting 59% of Indian amphibian fauna. The area is also known for its endemism; 73% of the amphibians are endemic. The high species richness and endemism of KNP are comparable to those of any other rainforest of north-eastern India and the tropical region (Vasudevan *et al*. 2001). In the Ashambu hills of the Kalakkad-Mundanthurai Tiger Reserve in the southern WG, 32 species of amphibians have been reported from the forest floor (Vasudevan *et al*. 2001). Twenty-one species occur in the coffee estate of the Coorg District bordering Nagarahole National Park, WG (Bennett 2000). The species richness (42 species) was high in the present study and 22 species were distributed exclusively in undisturbed native forest. The differences between the amphibian richness of these studies could be due to the different sampling methods and/or regional dynamics. Sampling methods are important in determining the diversity and density (Heatwole 2003). Visual scanning of the litter may be ineffective, and for accurate measurements litter should be removed from the plot during the sampling (Heatwole 2003). However, as previously mentioned, removal of litter from the plots constitutes destructive sampling and in the present study, the litter and vegetation formed an important tool for differentiating the undisturbed from the disturbed sites.

Deforestation and fragmentation commonly cause species losses from tropical forests (Nair 1991; Pearman 1997; Didham *et al*. 1998; Gupta 1998; Waldman & Tocher 1998; Kolozsvary & Swihart 1999; Steininger *et al.* 2001). In the WG, amphibians are facing habitat loss induced by deforestation and fragmentation (Daniels 1992, 1999; Molur & Walker 1998; Bennett 2000), which have led to the formation of isolated patches and an unusual distribution of amphibian species (Vasudevan *et al.* 2001). Amphibians are unique in their biology and the local environment influences their communities (Daniels 1999). Hence, to implement a conservation programme, it is important to know the distribution pattern within fragmented habitats. Amphibians show a non-random distribution in response to landscape attributes and fragmentation (Kolozsvary & Swihart 1999). In tropical wet forest, diversity and assemblage structure vary in relation to forest structure and management (Pearman 1997). The KNP in general has high biodiversity (Hussain *et al.* 1999), but the differences in amphibian species richness and density are prominent among disturbed and undisturbed sites (Table 3). These disturbed and undisturbed sites are clearly demarcated by habitat criteria (Table 1). Resource distribution has proven to be an influential factor on the behavioural variation and breeding ecology of certain amphibians (Marsh *et al.* 2000; Marsh 2001). Since the habitat is an important resource, the study reveals the influence of changes in habitats on the diversity and distribution of amphibians. Human activities in the KNP and subsequent habitat fragmentation are clearly related to the patchy distribution of sensitive species of amphibians. However, few species are found in disturbed sites at low density (except *B. melanostictus)*. Caecilians constituted 14% to the total species richness and were confined to undisturbed habitats, indicating the unique distribution of some species. The complex amphibian assemblages of the KNP formed two categories, that of species that require specific habitat and undisturbed sites and the other of species that can occur in a wide range of habitats, both disturbed and undisturbed. Since 22 of the species of amphibians were restricted to undisturbed sites, these are highly vulnerable to further habitat degradation, fragmentation or human intervention.

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Appendix I Amphibians of Kudremukh National Park with adult microhabitat, seasonality and distribution. * Species endemic to the WG. The names in parenthesis are those suggested by Dubois (1992). Adult microhabitat: 1 = open aquatic (not covered by canopy), 2 = closed aquatic (covered by high canopy or dense marginal weeds), 3 = semi-aquatic with ground vegetation cover, 4 = semi-aquatic with litter, 5 = semi-aquatic with seepage, 6 = open terrestrial (not covered by tree canopy, comprises sparse herbs and grasses), 7 = closed terrestrial, 8 = arboreal bush dwellers, 9 = arboreal, bark and canopy dwellers. Seasonality: 1 = available throughout the year, 2 = abundant in monsoon, 3 = available in monsoon and post monsoon. Distribution: 1 = undisturbed sites, 2 = disturbed and undisturbed sites.

Species	*Adult microhabitat*	*Seasonality*	*Distribution*
Anura: Bufonidae			
1. *Ansonia ornata**	2	3	1
2. *Bufo beddomii**	7	2	2
3. *B. hololius*	6	2	1
4. *B. melanostictus*	6	1	2
Anura: Microhylidae			
5. *Microhyla ornata*	3	1	2
6. *M. rubra*	3	1	1
7. *Ramanella montana**	6	2	2
Anura: Ranidae			
8. *Micrixalus gadgili**	4	2	1
9. *M. saxicola**	2	1	2
10. *Nyctibatrachus aliciae**	5	1	2
11. *N. hussaini**	2	2	1
12. *N. major**	2	1	1
13. *N. pygmaeus**	2	1	1
14. *N. sanctipalustrius**	2	1	1
15. *Rana aurantiaca**	4	1	1
16. *R. beddomii** (*Indirana beddomii*)	7	3	1
17. *R. brachytarsus** (*Indirana brachytarsus*)	4	2	1
18. *R. brevipalmata** (*Limnonectus bravipalmatus*)	4	3	1
19. *R. curtipes**	7	3	2
20. *R. cyanophlyctis* (*Euphlyctis cyanophlyctis*)	1	1	2
21. *R. leithii** (*Indirana leithii*)	5	1	1
22. *R. keralensis** (*Limnonectus keralensis*)	3	1	1
23. *R. limnocharis* (*Limnonectus limnocharis*)	3	1	2
24. *R. semipalmata** (*Indirana semipalmatus*)	5	1	2
25. *R. temporalis*	4	1	2
26. *R. tigerina* (*Haplobatrachus tigerinus*)	1	2	2
27. *Tomopterna breviceps*	7	2	1
28. *T. rufescens**	7	1	2
Anura: Rhacophoridae			
29. *Philautus beddomii**	8	2	1
30. *P. charius**	8	2	2
31. *P. femoralis*	8	2	2
32. *P. glandulosus**	8	2	2
33. *P. leucorhinus**	8	2	2
34. *P. nasutus*	8	2	2
35. *Polypedates maculatus*	9	2	2
36. *Rhacophorus malabaricus**	9	2	2
Apoda: Caecilidae			
37. *Gegeniophis carnosus**	5	1	1
Apoda: Ichthyophidae			
38. *Ichthyophis beddomii**	4	1	1
39. *I. bombayensis**	7	2	1
40. *I. malabarensis**	7	2	1
41. *I. tricolor**	5	3	1
Apoda: Uraeotyphlidae			
42. *Ureotyphis narayani**	5	1	1

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