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Assessment of Herpetofaunal Assemblage in Phakot and Pathri Rao Watershed Areas, Uttarakhand, India

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ABSTRACT

We studied reptiles and amphibians in Phakot and Pathri Rao Watershed Areas falling in middle Himalayas and Shiwalik, respectively. Adaptive Cluster Sampling Method was used for forest floor reptile and stream transect for stream reptiles and amphibians. 10 and 12 species of reptiles were recorded in Phakot and Pathri Rao watershed areas, respectively. Similarly 4 species of amphibians were recorded in Phakot and 9 species in Pathri Rao. In total 16 species of reptiles were recorded and 9 species of amphibians. Forest floor density of reptiles in Phakot and Pathri Rao was 46.26 ha^{-1} and 86.9 ha^{-1}, respectively. Reptilian diversity of Pathri Rao and Phakot was 0.825 and 0.692, respectively. Reptilian richness was higher in Pathri Rao (2.37) compared to Phakot (1.79). Amphibian density, diversity and richness were 15.6 ha^{-1}, 0.47 and 0.77 in Phakot respectively. Amphibian density in Pathri Rao was 22.6 ha^{-1}. The diversity and richness values were 0.57 and 1.29, respectively. Comparison showed Pathri Rao Watershed to be more rich and diverse than Phakot because of undisturbed habitat, broad and slow stream and more forest litter.

Key Words: Reptiles, Amphibians, Watershed, Diversity, Richness.

INTRODUCTION

Amphibians and Reptiles (Collectively called herps) are two distinct but important classes of vertebrates (Zug et al. 2001) forming a major constituent of the fauna inhabiting tropical forest. Reptiles and amphibian are highly diverse in their morphology and ecology and have a wide distribution though avoiding extreme environments. The reptilian fauna of India is largely dominated by Indo-Chinese elements. Relicts of which are found in high rainfall regions of Peninsular and North East India (Daniel 2002). About 484 species of reptiles and 219 species of amphibians are reported from India. Most of these are confined to two major centers i.e. Western Ghats and North East showing a high degree of endemism (Ishwar et al. 2001, Kumar et al. 2001). A recent assessment based on IUCN criteria showed that nearly 57% of amphibians in India are 'Threatened' (Vasudevan 2001).

Despite high endemism, herpetofauna in India has received poor attention. Unlike birds and mammals, herpetofauna has not been studied in detail in India (Vasudevan et al. 2001). Only few studies including Inger et al. (1987), Bhupathy and Kannan (1997) and Kumar et al. (2001) have been carried out in India. Even these studies were restricted to rainforests of Western Ghats. Gibbons et al. (2001) enumerated six causes of global decline in herpetofauna. These causes, to a great extent, are also present in India. It is very much possible that this rich herpetofauna is getting lost even before it gets recorded. We present and discuss the species composition and abundance of the herpetofauna of the two watershed areas.

The study was carried out in Phakot and Pathri Rao Watersheds in Garhwal Himalayas in Uttarakhand state (Figure 1). The detailed description of the study area is provided in Dar et al. (2008).

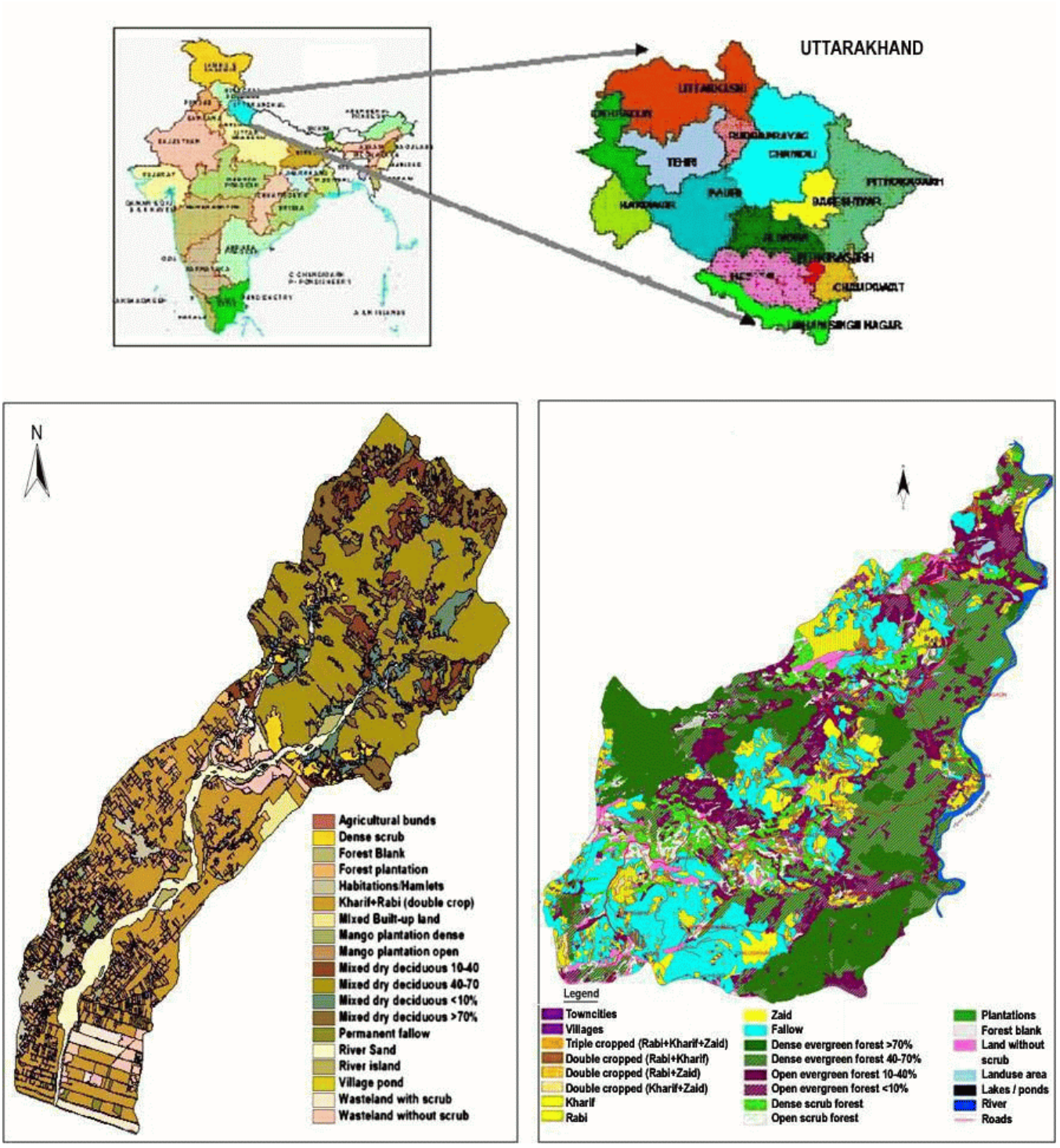

Figure 1. Map of Pathri Rao and Phakot Watershed Area in Garhwal Himalayas, Uttarakhand.

METHODS

Reptiles were sampled using the Adaptive Cluster Sampling as described by Ishwar et al. (2001). The method is supposed to give better estimates of the density of animals. The basic sampling unit used was 5m × 5m randomly laid quadrats. If a reptile was sighted in one of these quadrats (called primary

quadrats), additional quadrats (called secondary quadrats) of the same dimension were searched on the four sides of the primary quadrat. One m gap was maintained between the primary and secondary quadrats. If any of these quadrats had animals, further quadrats were laid around them until the quadrat with reptile was surrounded by the quadrats without animals. The whole network of quadrats with animals then becomes a cluster. If the primary quadrat did not have any animal, the sampling was carried out in the next randomly selected quadrat. In order to minimize the chances of missing animals during search efforts, two observers searched the quadrat from opposite sides towards the center. In addition to adaptive cluster sampling method, quadrats of 5m × 1000m along the stream were established (discussed elsewhere). In Phakot watershed, 18 permanent quadrats were laid and monitored for three seasons, amounting to 56 primary quadrats with an addition of 52 secondary quadrats. In Pathri Rao watershed 30 permanent quadrats were laid amounting to 276 quadrats (including 44 primary quadrats and 232 secondary quadrats in two seasons.

The amphibian community was sampled using the methods described by Vasudeven et al. (2001). Amphibians were sampled using a combination of cluster sampling and visual encounter. Opportunistic records were also maintained. Quadrats of 5m × 1000m along the stream were established. Stream was considered as 'Centre of quadrat' and sampling was carried on both sides of the stream simultaneously. Loose rocks, and leaf litter was carefully turned and cavities were prodded for amphibian species. In Phakot watershed three stream transects of 1000m were established and monitored during summer. Three seasonal streams namely Pather Saut, Chirak, and Harnol pass through the study area and were utilized to lay stream transects. In this area sampling was carried out in monsoon when there was water, as the streams remain dry for the rest of the year except at some places in Harnol where water remains till mid summer. Data were summarized and density was calculated for each species. Shannon-Weiner Index (H) was used for measuring diversity, Simpson's index was used for calculating evenness and Margalef's diversity index (RI) was used to measure richness of species in different transects and in different seasons.

RESULTS

Reptiles in Phakot and Pathri Rao Watershed

Ten species of reptiles in Phakot watershed and 12 species in Pathri Rao watershed were recorded. In total 16 species of reptiles were recorded (Table 1, Figure 2). Reptilian density was 46.26 individuals ha^{-1} in Phakot watershed. Overall diversity, richness and evenness of reptiles was 0.69, 1.79 and 0.90, respectively in Phakot watershed. There was seasonal variation in density (Table 2). Density of reptiles was highest in summer (92 individuals ha^{-1}), followed by monsoon (62.4 individuals ha^{-1}) while it was lowest in winter (28 individuals ha^{-1}). Density of reptiles in the hemal stream was 2.67 individuals ha^{-1}. Diversity, richness and evenness were 0.70, 2.16 and 0.88, respectively.

Table 1. Checklist of reptiles recorded in Pathri Rao Watershed Area and Phakot Watershed Area.

Common Name and Scientific Name	Watershed	
	Pathri Rao	Phakot
Snake Skink, *Riopa puntata*	X	X
Little Skink, *Mabuya macularia*	X	–
Forest Calotes, *Calotes rouxi*	X	X
Common Garden Lizard, *Calotes versicolor*	–	X
Northern House Gecko, *Hemidactylus flaviviridis*	X	X
Kashmir Agama, *Agama tuberulata*	X	X
Blind Snake, *Ramphotyphlops braminus*	X	–
Buffstriped keelback, *Amphiesma stolata*	X	X
Indian King Cobra, *Ophiophagus hannah*	X	–
Cobra, *Naja naja*	X	X
Rat Snake, *Ptyas mucosus*	X	
Vine Snake, *Ahaetulla nasutus*	–	X
Cat Snake, *Bioga trogonata*		X
Bronze Back or Tree Snake, *Dendrelophis tristis*	–	X
Indian Monitor Lizard, *Varanus bengalensis*	X	–
Indian Soft Shell Turtle, *Aspideretes gangeticus*	X	–

Table 2. Diversity, richness and evenness of reptiles in Phakot Watershed Area during three seasons.

Index	Summer	Monsoon	Winter
Diversity	0.555	0.574	0
Richness	1.542	1.443	1.443
Evenness	0.925	0.958	1.00

Figure 2. Indian Bull Frog (*Hopbatrachus tigerinus*) (a) and Indian Cobra (*Binocellate cobra naja naja*) in Pathri Rao Watershed area (b).

Density of snakes was highest in monsoon (31.2 individuals ha^{-1}), followed by winter (14.8 individuals ha^{-1}) and lowest in summer (13.2 individuals ha^{-1}). Combined density of rest of the reptile species during the summer, monsoon and winter seasons was 80 individuals ha^{-1}, 31.2 individuals ha^{-1} and 14.8 individuals ha^{-1}, respectively. Agamids were most abundant (51 individuals ha^{-1}) followed by snakes (34 individuals ha^{-1}) and Gecko (11 individuals ha^{-1}). Diversity of reptiles was highest in monsoon closely followed by summer. Richness was however higher in summer than monsoon. About 80% of the clusters were either empty or contained one individual. Seven of the clusters had reptilian density between 0 to 1.2 individuals ha^{-1} and 8 clusters had density between 0.2 to 0.3 individuals ha^{-1}. Similarly, 38% of the clusters consisted of only one quadrat whereas, 50% of clusters were single (primary quadrat along with four secondary quadrats) and only 11.12% cluster were double (primary quadrat and two rows of secondary quadrats).

Table 2. Diversity, richness and evenness of reptiles in two seasons in Pathri Rao Watershed Area.

Index	Winter	Summer
Diversity	0.724	0.892
Richness	2.207	2.378
Evenness	0.843	0.941

Reptilian diversity, richness and evenness in Pathri Rao watershed were 0.82, 2.37 and 0.88, respectively. Overall density of reptiles in Pathri Rao watershed was 86.9 individuals ha^{-1} (Table 2). Density of reptiles in winter and summer was 25 individuals and 148 individuals ha^{-1}, respectively.

Seven quadrats during winter and three quadrats during summer were found without any reptilian species. Overall clusters with single species were highest (31.82%) followed by cluster with 3 species (27.28%). Single species quadrats were highest in summer (45%) in comparison to winter (18%). During winter no cluster was seen with 4 or more species. 27% clusters in both the seasons were having three species.

Density of Agamids was highest in winter (54.4 individuals ha^{-1}) followed by Skinks (40.81 individuals ha^{-1}). However, the density of skinks was highest in summer (55.81 individuals ha^{-1}). Among species, calotes showed highest density in winter (48.97 individuals ha^{-1}) and snake density was highest in summer (40.31 individuals ha^{-1}). Density of Indian Monitor Lizard showed 6 fold increase from winter (2.72 ha^{-1}) to 15.52 ha^{-1} in summer. Snake density which included rat snake (*Ptyas mucosus*), and buff-striped keelback (*Amphiesma stolata*) was highest in summer (9.30 individuals ha^{-1}).

In terms of density per quadrat, 17 quadrats showed density between 0.03 to 0.06 individuals/quadrat. Only 8 quadrats had reptilian density of more than 0.09 individuals/quadrat. In terms of network of cluster, 25% quadrats were single where as 54.5% were constituted by single cluster consisting of primary

quadrat with four surrounding secondary quadrats. Only 4.55% cluster consisted of three or more cluster networks.

Correlation of reptile density with habitat variables showed positive correlation with slope ($r=0.211$, $P<0.05$) and litter cover ($r=0.269$, $P<0.01$) and negatively correlation with moisture though it was not significant.

During monsoon three stream transects were sampled. Seven species were encountered. It included Soft shell turtle (*Aspideretes gangeticus* Cuvier), Kashmir Agama (*Agama tuberulata* Hardwicke & Gray), Indian monitor lizard (*Varanus bengalensis* Schneider). Pather Saut had highest reptilian density of 5 individuals ha^{-1}, followed by chirak and Harnol (2 individuals ha^{-1}) each. Chirak Rao was richer (1.44) and more diverse (0.45) than Pather Saut. Harnol Saut had highest richness followed closely by Pather Saut. However, in terms of diversity, Chirak Rao was more diverse. Reptilian diversity was higher in summer (0.89) than winter (0.72). Richness too showed the similar pattern in Pathri Rao watershed. Comparison between two watersheds showed that Pathri Rao watershed was more rich and diverse than Phakot watershed.

Amphibian in Phakot and Pathri Rao Watershed

Table 4 gives the checklist of amphibians recorded in Phakot watershed and Pathri Rao watershed, respectively. Four species were recorded in Phakot watershed and nine species in Pathri Rao watershed. Four species that were recorded in Phakot watershed were also present in Pathri Rao watershed. In total nine species were recorded during this study.

Table 4. Checklist of amphibians recorded in Pathri Rao Watershed Area and Phakot Watershed Area.

Common Name and Scientific Name	Watershed	
	Pathri Rao	Phakot
Common Indian Toad, *Bufo melanostictus* Schneider	X	X
Himalayan Toad, *Bufo himalayanus* Gunther	X	–
Ornate Microhylid, *Microphyla ornate*	X	–
Himalayan Torrent Frog, *Amolops mamoratus* Blyth	X	X
Scittering Frog, *Euphlyctis cyanophlyctis* Schneider	X	X
Indian Bull Frog, *Rana tigerinus* Daudin	X	–
Jerdon's Bull Frog, *Rana crassa* Jerdon	X	–
Himalayan Bull frog, *Rana leibgil* Gunther	X	–
Indian Cricket Frog, *Limnonectes limnocharis*	X	X

Overall amphibian diversity, richness and evenness was 0.47, 0.77 and 0.82 in Phakot watershed. Diversity and richness was highest on Garsera transect followed by Lamyali transect. Six individuals of two species were encountered on Bagodi transect. 14 individuals of 4 species were encountered on Garsera transect and 27 individuals of 3 species were encountered on Lamyali transect with density of 27 individuals ha^{-1}. The overall amphibian density of Hemal stream was 15.6 individuals ha^{-1}.

Amphibian density was 22.6 individuals ha^{-1} in Pathri Rao watershed. The amphibian density in Pather Saut, Chirak and Harnol was 7, 0.5 and 52.7 individuals ha^{-1}, respectively. In terms of abundance of individual species, density of Scittering frog (*Euphlyctis cyanophlyctis* Blyth.) was high in Pather Saut (3 individuals ha^{-1}) and Harnol (6.25 individuals ha^{-1}).

A total of 8 species with 226 individuals were encountered in Harnol stream followed by Pather Saut (2) and only one species was encountered in Chirak Rao. Harnol was found to be most diverse and rich as compared to other streams. The overall diversity of Pathri Rao watershed area was 0.57. The richness and evenness was 1.29 and 0.71. There was weak correlation of amphibian density with different microhabitat features. Density was positively correlated with all microhabitat factors except canopy cover and fallen logs. The correlation was significant with respect to slope ($r=0.366$, $P<0.05$) and litter depth ($r=0.486$, $P<0.01$).

DISCUSSION

Species in a reptile assemblage are not randomly distributed in space either horizontally or vertically, but occupy discrete microhabitats (Heatwole 1982). There were some difference in abundance among the major taxa, with agamids more abundant than snakes and skinks. Together with skinks, agamids formed dominant taxa in Pathri Rao watershed. Snakes were more abundant in Phakot watershed in comparison to Pathri Rao watershed, but contributed a small portion of forest floor reptiles in both the sites. Low abundance of snakes could be due to their mobile nature and thus escape detection during sampling.

Reptiles showed positive correlation with leaf litter. This was particularly more evident in case of skinks and agamids. The association of gecko, skinks and lizards with microhabitat availability of has already been earlier shown (Heatwole 1977, Howard and Haily

1999, Kumar et al. 2001, Vijayakumar et al. 2006). Agamids which were dominated by calotes preferred more rocky and open canopy than skinks. The specific habitat features are essential for leaf litter reptiles as they can meet the conflicting demands of thermo-regulation, predator avoidance and participation in other activities (Lima and Dill 1990). Cool and humid environment below litter provide good microclimatic conditions for arthropods, which is a major prey base for the forest floor reptiles (Kumar et al. 2001). Since snakes are predatory in nature, therefore their local distribution might be influenced by distribution of their prey abundance.

The density of reptiles was highest in summer as compared to monsoon in Phakot watershed which seems contrary to notion. However the high density was due to high density of non snake reptiles including geckos, agamids etc. as compared to their density during monsoon. It might be due to the fact that snakes go for aestivation during summer.

The overall reptilian density in Pathri rao watershed was 66.4 individuals ha^{-1}. This was much lower than 154 individuals ha^{-1} in Panama (Ingler 1980) and 108 individuals ha^{-1} in Kalakad Mundan-thurai Tiger Reserve in Western Ghats (Kumar et al. 2001). The obvious reason seems that both the above studies were conducted in tropical rainforest whereas; this study was conducted in sub-tropical and temperate areas of Shivalik and middle Himalayas.

Change in reptilian abundance along altitudinal gradient has been documented earlier (Fauth et al. 1989, Bhupathy and Kannan 1997). The results in Phakot watershed showed decline of density with altitude. Porter (1972) believed that it might be primarily due to decline in temperature. It seems logical since, reptiles are ectothermic, temperature plays very important role in their ecology.

Amphibians are soft skin and sensitive to temperature and precipitation. The higher density of amphibian in harnol saut could be explained based on the fact that water remains in this stream for longer duration (late winter) and greater width of the stream than other two stream. Hemal stream in Phakot watershed is perennial therefore amphibians were common but they avoided deep water. Amphibians also avoided fast flowing water. Amphibian density was highest in Garsera, followed by Lamyali. The stream was wide at Lamyali and trifurcated at Garsera which resulted in slowing of the flow and thus creating stagnant pools for species like Scittering frog to flourish. Low density in Bagodi may be due to fast flow of water. The stream in Bagodi is only few meters wide and water flows from an elevation of 669 m to 607 m. Heenar and Mcloskey (1998) also found negative correlation of amphibians with deep water. Amphibians in both the areas showed positive correlation with litter cover and litter depth. Corn (1994) noted positive association of *Enstaina* (an amphibian) with litter depth and grass cover. Litter depth may provide a wider range of microhabitat, allowing more individuals and species to coexist in the litter microhabitat (Fauth et al. 1989) or provide refuge from predation (Liberman 1986). Liberman and Dock (1982) argued that litter may sustain large arthropod prey population. Block and Morrison (1998) believed that litter depth is an important factor in habitat selection in amphibians and reptiles.

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