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ECOLOGICAL STATUS OF THREE MICRO WATERSHEDS IN WESTERN HIMALAYA

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ABSTRACT

Ecological status of a particular region is determined by assessing its biodiversity, prevailing conditions of the environment and their interactions. Biodiversity assessments in micro watershed across altitudinal gradients of Western Himalaya reveal that phytodiversity includes a total of 2276 individuals from 75 woody species belonging to 38 families. Among the three micro watersheds, Mandhala was species rich with 43 species followed by Moolbari (39) and MeGad (9). In Mandhala most of the species are thorny shrubs and rarely attain tree forms due to severe anthropogenic disturbances, which also yielded very low basal area. Moolbari had the highest basal area, which had dominant species *Quercus leucotricophora* and *Q. glauca*. MeGad, a high altitude area was mostly dominated by *Abies pindrow, Picea smithiana* and *Pinus wallichiana*.

Faunal investigations enumerated 115 butterfly species, 14 amphibian and 136 bird species. Butterflies in the region were oriental and palaearctic in origin representing nine families. Similarly, 14 species amphibians belonging to 5 families were sighted during the field investigations. *Paa minica* is vulnerable and *Amolops chakrataensis* is data deficient according to IUCN status and these two are endemics of Himalayan foot hills. Among the three watersheds, Mandhala, lying in Shivaliks has higher faunal diversity followed by Moolbari. Amphibians were not encountered in MeGad microwatershed during Aug-Sept 07. In total 136 bird species were recorded from three watersheds, the maximum number of bird species occurred in Mandhala region (104) followed by Moolbari (57) and Me Gad (35).

Key words : Biodiversity, Ecological status, Floral and faunal diversity, Watershed, Altitudinal gradients, Western Himalaya

Introduction

Three watersheds viz., Mandhala, Moolbari and Me Gad representing lower, middle and upper Himalayas respectively in the state of Himachal Pradesh were chosen by the Ministry of Science and Technology, Government of India for implementing a coordinated, multi disciplinary and multi institutional programme "Bio-geo database and ecological modeling for Western Himalayas". The Himalayas are rich in natural resources; however over the years, Himalayan environment is increasingly being threatened due to various unplanned human activities with excessive exploitation of natural resources. It is imperative to develop strategies for sustainable management to commensurate with the increasing human pressure on the natural resources.

Himachal Pradesh is an important part of Western Himalaya covering about 11% of total Himalayan land mass. Mountain ranges in the state include Shivaliks and Trans–Himalayas with altitudes ranging from 350 to 7000 m amsl. Winter (December–February), pre-monsoon (March–June), monsoon (July–September) and post-monsoon (October–Novermber) are major seasons in the region. Precipitation varies from snowfall to rainfall that ranges from 1000 to 2500 mm. Temperature varies from sub-zero ranges of -30° to -40°C (in winter) at higher altitudes, whereas in the plains it ranges between 8° to 40°C. Many rivers like Beas, Sutlej, Chenab, Ravi and Yamuna originate from this region. The climate is distinguished in three axes: (i) a vertical axis determined by the effect of altitude on temperature; (ii) a transverse axis determined by topography along which rain shadow effects cause decreasing precipitation and increasingly extreme (continental) temperature fluctuations from SW to NE across the main ranges; (iii) a longitudinal axis determined by a geographical trend of decreasing monsoon precipitation (June-September) and increasing winter snowfall (December-April) from SW to NW along all the ranges. The third axis is important in determining major ecological trends over the entire length of the Himalayan chain, but it is less important than the other two axes in determining the ecology of localities within Western Himalaya (Gaston *et al.*,1983).

The vegetation of Himachal Pradesh can be broadly classified into (i) tropical-below 1000 m, (ii) sub-tropical- between 1800-2000 m, (iii) temperate-between 1800-3500 m, (iv) subalpine- between 3500-4000 m, and (v) alpine- above 4000 m. However, these may overlap depending upon the location, topography

Biodiversity in three micro watersheds across altitudinal gradients of Western Himalaya confirm the ecological distinctness and highlight the need for conservation

and climatic conditions. The enormous variations in the altitude, latitude and longitude of the Himalayas have added to the multiplicity of habitats and provide diverse microclimates and ecological niches for all the living beings. Also, the Western Himalayan flora is species deficient whereas, the eastern Himalayan flora is species rich (Chowdhery, 1999). The Western Himalayan region which includes Jammu and Kashmir, Himachal Pradesh and hilly regions of Uttar Pradesh receives very less rain compared to its eastern counterpart, the Eastern Himalaya. As a result the Western Himalayan flora in due course of time has evolved and established itself as drought resistant and cold loving while the Eastern Himalayan flora has developed into moist evergreen type. The focus of the current communication is to assess the diversity and distribution of flora and fauna in select watersheds of Western Himalaya.

Objectives

The major objectives of this study are to assess:

i. Diversity and distribution of flora in the three micro watersheds;

ii. Diversity and distribution of selected fauna, namely butterfly, amphibians and birds in the region.

Material and Methods

Study area

The location of three micro watersheds, which form a part of Chandrabagha, Sutlej and Yamuna river basins is given in Fig. 1. Details of the geography of the study area are given in Table 1. Plate 1 depicts the panoramic view of the studied watersheds.

Mandhala: This area has mixed deciduous forests in an altitude below 1100 m. The prominent trees and shrubs found here are *Flacourtia montana, Acacia catechu, Grewia optiva, Toona ciliata, Albizia procera, Haldina cordifolia, Acacia* sp., *Lannea coramandelica, Mitragyma parviflora*, along with *Nyctanthus arbor-tristis, Carissa apaca, Dodonaea viscose* and *Woodfordia fruticosa*. Most of the forests here have been deforested and hill ranges are completely covered with *Lantana camera* an exotic invasive weed. Also scattered trees of *Holoptelia integrifolia, Dalbergia sisoo, Morus nigra*, etc. occur along the field bunds and other open lands. Figure 1 depicts the drainage network in Mandhala watershed.

Moolbari : Vegetation in this watershed consists of mixed deciduous (till an altitude of 1500 m) and sub-tropical pine forest (beyond 1500 m). Apart from *Pinus,* other species are *Pyrus pashia, Rubus ellipticus, Berberis* sp, and in moist localities species of *Quercus leucotrichophora* and *Q. glauca* and *Rhododendron arboretum*. Exposed hill slopes in pine forests have *Euphorbia royleana*. Between 1800-2300 m, oak forests species such as *Quercus leucotrichophora*, *Q. glauca* dominate along with *Rhododendron arboretum, Lyonia ovalifolia, Persia* sp., *Myrica esculenta*, *Acer oblongum, Cedrus deodar,* etc.

MeGad : This watershed lies in cold desert and comprises of temperate, sub-alpine and alpine vegetation. *Temperate vegetation* consists of woody trees at an altitude of 2500-3200 m such as *Pinus wallichiana, Juniperus recurva, Picea smithiana, Abies pindrow*, *Cedrus deodara*. Along the streams and irrigated canals are planted trees of *Salix* and *Populus* sp. Sub-alpine vegetation include stunted, scattered bushes of *Juniperus communis, Berberis* sp., etc along with herbaceous species such as *Ranunculus, Pedicularis, Potentilla, Polygonum, Geranium, Anemone, Corydalis*, etc. Up to 4000 m consists Alpine vegetation of herbaceous species such as *Swertia, Silene, Potentilla, Cordalis, Taraxacum, Astralagus, Rheum, Polygonum, Artimisia, Primula* etc., occur. Alpine meadows provide one of the most spectacular and colourful view. Majority of the alpine meadows are perennial in nature and perenate through rhizomes, root stocks, runners, suckers, bulbs, tubers or bulbils. Common herbaceous species here are *Saxifraga, Arenaria, Aster, Polygonum, Primula, Potentilla, Selinum, Taraxicum, Astralagus, Geranium, Senecio, Saussurea, Swertia, Erigeron, Corydalis, Rheum,* etc. Terrestrial orchids such as *Goodyera, Malaxis,* etc. are also seen here (Murti, 2001; Aswal and Mehrotra, 1994).

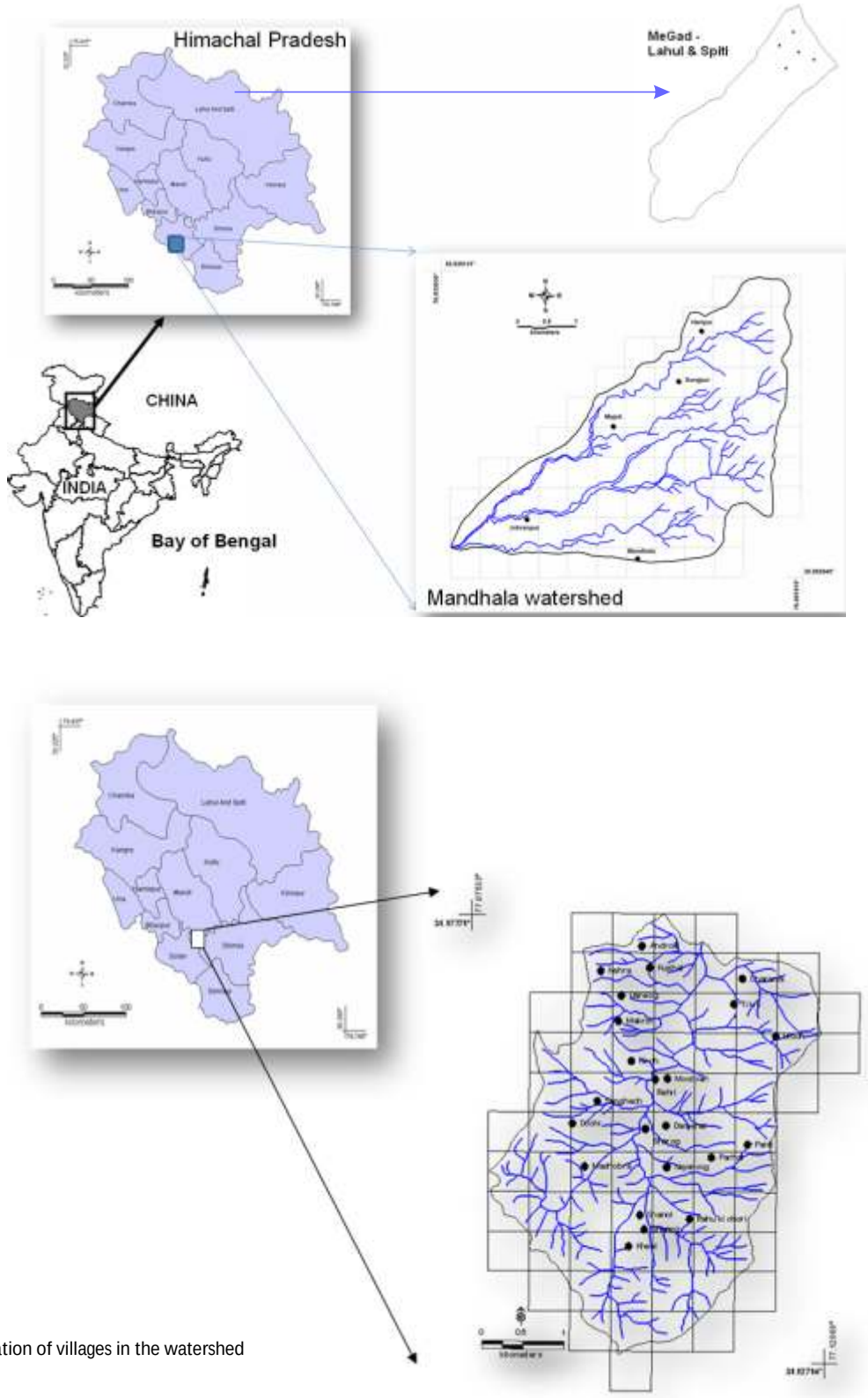
Methods

Vegetation Sampling : Systematic sampling was carried out in all three micro watersheds (Moolbari, Mandhala, and MeGad) with belt transects of 250 x 4 m. In each transect, for each tree GBH in cm (Girth at Breast Height, approximately at 130 cm above ground) and height in

Table 1: Geographical details of studied micro watersheds

Micro watersheds	District	Main watershed	Latitude (°N)	Longitude (°E)	Altitude (m amsl)	Area (km^2)
Mandhala	Solan	Yamuna	30.87-30.97	76.82-76.92	400-1100	14.5
Moolbari	Shimla	Sutlej	31.07-31.17	77.05-77.15	1400-2000	10.0
MeGad	Lahaul and Spiti	Chandrabhaga	32.64-32.74	76.46-76.74	2900-4500	45.0

metre is noted along with its identification. Unidentified plants were labelled and pressed in herbaria for later identification. Coordinates were marked using GPS (Global Positioning System) at every 100 metres interval and at the start and end points in each transect. Litter weight is measured in four 1 m X 1 m quadrat within each transect. Using densiometer, canopy cover is measured at start, end point and at 100 metre intervals in each transect. Also, relative humidity and air temperature was taken at every 100 m and at the start and end of the transect.



* indicates the location of villages in the watershed

Fig. 1: Moolberi, Mandhala and Me Gad-Lahul and Spiti watersheds, Himachal Pradesh

Faunal Sampling : Focus of faunal studies are on bioindicator taxa such as butterflies, amphibians and birds.

Butteflies : In selected localities, transect based sampling (250x4 m) as well as opportunistic sampling of butterflies was carried out. Most of the butterflies were identified in the field and others were photographed and identified later with the available keys (Evans, 1932; Wynter-Blyth, 1940-1946, 1957; Erhardt, 1985; Thomas and Malorie, 1985; Mani, 1986; Leps and Spitzer, 1990; New, 1991; Scoble, 1992; Wood and Samways, 1992; Kim, 1993; Pollard and Yates, 1993; Samways, 1994; New *et al.*, 1995; Molina and Palma, 1996; Parmesan, 1996; Swengel, 1996; Blair and Launer, 1997; Spitzer *et al.*, 1997; Manel, *et al.*, 1999; Stork *et al.*, 2003; Arora *et al*., 2005). The data was analyzed (Table 2) to calculate species diversity (using Shannon-Weiner diversity index), importance value index (IVI), etc. (Ramachandra *et al.*, 2007)

Amphibian: Amphibians are highly seasonal and majority of them breed during monsoon. Hence, field work was carried out and identified amphibians during July-August 2007 in major land-use categories like waterbodies (streams of 1° and 2°), forests, agriculture fields, and open area between 19:00-21:00 h. We have invested 2 man-hour searches on each night. Number of individuals, sampling co-ordinates and habitat characteristics were also noted (Gaston *et al.*, 1983; Kremen, 1992; Manel *et al.*, 1999; Mehta, 2005a,b; Beebee and Griffiths, 2005).

Birds: Time constrained sampling of 1 hour in each habitat types during morning and evening was carried out and cataloged using standard keys (Ali, 1989; Grimmet *et al.*, 1998; Laiolo, 2003; Manel *et al.*, 1999). The co-ordinates were taken at the start and end point of transects using GPS and species alongwith their numbers were also recorded.

Results and Discussion

Vegetation: Vegetation studies in the Himalyan region dates back to the early 19th century by Troup (1921); Champion (1921); Osmaston (1923); Schweinfurth

Table 2: Indices computed to assess the biodiversity status

Index	Equation	Remarks
Density	$\frac{\text{Number of species A}}{\text{Area sampled } (m^2)}$	Compactness with which a species exists in an area.
Relative Density	$\frac{\text{Density of species A} \times 100}{\text{Total density of all species}}$	
Dominance	$\frac{\text{Basal area of species A}}{\text{Area sampled } (m^2)}$	The occupancy of a species over an area
Relative dominance	$\frac{\text{Dominance of species A} \times 100}{\text{Total dominance of all species}}$	
Frequency	$\frac{\text{Number of quadrats with species A}}{\text{Total number of quadrats sampled}}$	The repeated occurrence of a species
Relative Frequency	$\frac{\text{Frequency of species A} \times 100}{\text{Total frequency of all species}}$	
Important Value Index (IVI)	R. density + R. frequency + R. basal area	
Abundance	$\frac{\text{Number of individuals of a species} \times 100}{\text{Number of sampling units}}$	
Numerical species Richness	$\frac{S-1}{\log N}$	S= Number of species N= Number of Individuals
Simpson Diversity index	$\frac{n_i (n_i-1)}{N(N-1)}$	N_i= Number of individuals in each species N= Total number of individuals
Simpson dominance index	Dominence = $(n_i/N)^2$	
Shannon Weiner's Index	$H' = - P_i \ln P_i$	$P_i = n_i/N$
Pielou's evenness measure	$E=H'/\log S$	H'= Shannon-Weiner's index S= Number of species

(1957); Puri (1960) and Champion and Seth (1968). Quantitative assessments of vegetation in western and central Himlaya were carried out by Saxena (1979); Negi (1979); Ralhan *et al.* (1982); Saxena and Singh (1982a,b); Tewari (1982); Tewari and Singh (1985); Upreti *et al.* (1985); Singh and Singh (1984 a, b and c); Singh *et al.* (1985). Singh and Singh (1987); Rikhari *et al.* (1989); Tewari *et al.* (1989); Reddy (1989); Lodhiyal (1990); Rawal (1991); Singh and Rawat (1999) and Rana *et al.* (2010). Plate 2 depicts the floral diversity across watersheds (high altitude, mid and low altitudes). Ecological studies in the Kumaun region in the eastern part of Western Himalaya has been done by Adhikari (1992, 1995). In this backdrop, this study was undertaken to assess the floral diversity in the study areas which are ecologically distinct and hitherto least studied region. Quantitative assessment of woody species in the three micro watersheds is detailed in Table 3. Transects are named with first two letters of the microwatershed (abbreviations Ma: Mandhala, Mo-Moolbari and Me: Me Gad). Transect wise analysis in each of the micro watershed is discussed below.

Moolbari: Total number of species (15 species) and number of individuals (188) was high in Mo-15, which is *Rhododendron arboreum* and *Quercus* mixed forest. Mo-4 was species deficient (5 species) as these forests were dominated by *Quercus glauca*. Mo-1 had the highest basal area contributed mainly by *Quercus glauca* followed by *Quercus leuchotrichophora*. Mo-15 showed highest Pielou species richness value of 2.67, while it was lowest in Mo-4 with 0.92. Shannon diversity was highest in Mo-15 (1.72). This is due to the presence of several evergreen species such as *Persea, Euonymous, Myrica* sp. etc., in the valleys. The higher slopes generally has *Quercus* species, mixed with *Rhododendron*. With dominance value of 0.73, Mo-11 showed the highest

Table 3 : Micro watershed wise Vegetation analysis

Watershed	Transect	Species	Individuals	Basal area (m^2)	Shannon's	sim-div	Pielou
Mandala	Ma-1	16	66	0.597	2.113	0.79	0.762
	Ma-2	21	77	1.242	2.655	0.901	0.872
	Ma-3	16	43	0.899	2.403	0.872	0.867
	Ma-4	13	29	0.406	2.240	0.861	0.873
	Ma-5	5	9	0.538	1.465	0.741	0.910
	Ma-6	12	84	0.569	1.454	0.572	0.585
	Ma-7	5	11	0.071	1.160	0.562	0.720
	Ma-8	6	76	0.432	0.637	0.264	0.356
	Ma-9	3	27	0.553	0.727	0.412	0.662
	Ma-10	6	9	0.261	1.677	0.790	0.936
	Ma-11	8	16	0.210	1.890	0.820	0.909
Moolbari	Mo-1	10	158	3.471	1.564	0.707	0.679
	Mo-2	11	129	3.137	1.428	0.658	0.595
	Mo-3	7	89	3.059	1.095	0.593	0.563
	Mo-4	5	75	2.198	0.694	0.354	0.431
	Mo-5	9	85	2.388	1.256	0.563	0.572
	Mo-6	6	83	2.335	1.057	0.577	0.590
	Mo-7	6	101	2.407	1.107	0.552	0.618
	Mo-8	6	66	2.509	1.325	0.652	0.740
	Mo-9	11	64	1.668	1.330	0.563	0.555
	Mo-10	8	79	1.458	1.454	0.682	0.699
	Mo-11	6	108	1.131	0.626	0.268	0.349
	Mo-12	8	62	1.351	1.298	0.621	0.624
	Mo-13	12	131	3.235	1.002	0.405	0.403
	Mo-14	13	102	2.695	1.480	0.631	0.577
	Mo-15	15	188	2.893	1.727	0.759	0.638
	Mo-16	7	58	0.730	1.301	0.626	0.669
MeGad	Me-1	4	39	2.050	0.908	0.523	0.655
	Me-2	3	31	2.361	0.923	0.564	0.840
	Me-3	3	31	3.507	0.668	0.398	0.608
	Me-4	3	18	1.995	0.426	0.204	0.388
	Me-5	1	1	0.207	0	0	0
	Me-6	3	22	2.520	0.937	0.558	0.853
	Me-7	2	30	4.056	0.637	0.444	0.918
All	Mandhala	446	43	6.664	2.688	0.842	0.706
	Moolbari	1649	39	39.94	1.805	0.695	0.493
	MeGad	177	9	16.70	1.428	0.720	0.650

species dominance and had low Simpson value (0.34). This higher dominance is mainly due to *Quercus leucotrichophora,* which has 92 individuals and only 16 individuals of all other species.

The higher dominance of *Quercus leucotricophora* is reflected in the IVI value of 109.40, which is the highest for Moolbari water shed (Table 4). This is followed by *Quercus glauca* with 62.18. *Pinus roxburghii* is found extensively covering some of the slopes and has an IVI of 16.49. Mixed with these dominant species are species of *Acer oblongum* with IVI of 13.39, *Myrica esculenta* with 13.01. *Rhododendron arboreum* with IVI of 9.08 mostly occurred in Mo-15, which is relatively wetter compared to other transects. Other species such as *Cedrus deodara* with IVI of 8.01 occured in valleys and *Pyrus pashia* with 6.98 is scattered throughout the watershed.

Mandhala: Eleven transects were laid in Mandhala water shed area. Total individuals recorded in these transects were 447 with the highest number of individuals (84) recorded in Ma-6. *Acacia catechu* with higher number of individuals constitutes a dominant species. This species was planted earlier by forest department under

Table 4: IVI for woody species in Mandhala, Moolberi and Me Gad watersheds

	Mandhala watershed			Moolbari watershed			MeGad watershed	
Sl	Species	IVI	Sl	Species	IVI	Sl	Species	IVI
1	*Acacia catechu*	61.19	1	*Quercus leucotricophora*	109.4	1	*Abies pindrow*	94.61
2	*Flacourtia indica*	28.51	2	*Quercus glauca*	62.18	2	*Pinus wallichiana*	83.30
3	*Mangifera indica*	26.04	3	*Pinus roxburghii*	16.49	3	*Picea smithiana*	58.58
4	*Lannea coromandelica*	19.07	4	*Acer oblongum*	13.39	4	*Salix denticulate*	27.34
5	*Anogeissus latifolia*	15.35	5	*Myrica esculenta*	13.01	5	*Juglans regia*	9.70
6	*Dalbergia sissoo*	9.45	6	*Rhododendron arboreum*	9.08	6	*Malus baccata*	7.72
7	*Mitragyna parviflora*	9.39	7	*Cedrus deodara*	8.01	7	*ui-Krown*	7.07
8	*Grewia optiva*	8.58	8	*Pyrus pashia*	6.98	8	*Cassia* sp	5.85
9	*Cassia fistula*	7.99	9	*Grewia* sp	6.04	9	*Juniperus macropoda*	5.83
10	*Woodfordia fruticosa*	7.88	10	*Pistachia integrima*	5.74			
11	*Azadirachta indica*	7.42	11	*Lyonia ovalifolia*	5.32			
12	*Eucalyptus*	7.18	12	*Species A*	4.57			
13	*Butea monosperma*	6.28	13	*Euonymus tingens*	3.51			
14	*Dodonea viscosa*	6.24	14	*Punica granatum*	3.23			
15	*Murraya koenigii*	4.96	15	*Euphorbia roylena*	2.72			
16	*Carissa spinarium*	4.78	16	*Species B*	2.53			
17	*Syzgium cumini*	4.74	17	*Ficus nemoralis*	2.02			
18	*Phoenix sylvestris*	4.73	18	*Berberis aristata*	1.78			
19	*Adina cordifolia*	4.68	19	*Euonymus hamiltoniaus*	1.78			
20	*Species 1*	4.54	20	*Bauhinia variegate*	1.74			
21	*Acacia nilotica*	3.84	21	*Prunus cerasoides*	1.73			
22	*Ficus racemosa*	3.72	22	*Celtis australis*	1.69			
23	*Pinus roxbhurghii*	3.50	23	*Persea* sp	1.65			
24	*Randia* sp	2.99	24	*Grewia optiva*	1.59			
25	*Acacia leucophloea*	2.97	25	*Cupressus torulosa*	1.29			
26	*Zanthoxylum alatum*	2.81	26	*Euonymus* sp	1.17			
27	*Holoptilia integrifolia*	2.64	27	*Tiliaceae*	1.17			
28	*Morus nigra*	2.54	28	*Toona ciliata*	1.12			
29	*Albizzia lebbeck*	2.51	29	*Species* C	0.89			
30	*Bambusa* sp	2.14	30	*Species* D	0.87			
31	*Species 4*	2.09	31	*Hypericum*	0.86			
32	*Species 2*	2.09	32	*Ficus pumila*	0.85			
33	*Leucena leucocephala*	1.92	33	*Species* E	0.83			
34	*Diospyros montana*	1.71	34	*Species* F	0.82			
35	*Jasminum multiflora*	1.64	35	*Ficus* sp	0.80			
36	*Pyrus pashia*	1.44	36	*Cornus capitata*	0.79			
37	*Hamiltonia suveolens*	1.42	37	*Vitis vinifera*	0.79			
38	*Zizypus mauritiana*	1.42	38	*Rhamnus* sp	0.79			
39	*Punica granatum*	1.41	39	*Rubus ellipticus*	0.78			
40	*Species 5*	1.27						
41	*Nyctanthus arbor-tristis*	1.18						
42	*Ipomea carnea*	1.18						
43	*Lantana camara*	1.16						

afforestation programme. Lower number of individuals was recorded in Ma-5 and Ma-10 with severe degradation. Species richness was more in Ma-2 with 21 species and lowest in Ma-9 with 3 species. Basal area was highest in Ma-2 and lowest in Ma-7. Table 3 details transect-wise data for all three micro watersheds. The higher species diversity and basal area in Ma-2 can be attributed to the fenced protection provided by the farmers residing in the region that has ensured the survival of saplings. Hills adjoining this transect without fencing were totally barren, filled with impenetrable thickets of *Lantana* shrubs. The highest diversity was in Ma-2, which also has highest Shannon value of 2.6, Simpson diversity of 0.9 and dominance value of 0.09. The least diversity was in Ma-8 dominated by *Acacia catechu* with Shannon value of 0.63 and dominance of 0.73. *Acacia catechu* had the highest IVI of 61.19, followed by *Flacourtia indica* (28.51), *Mangifera indica,* (26.04), *Odina* (19.07), and *Anogeissus latifolia* (15.35) as listed in Table 4. Dominating deciduous trees in the region are *Acacia catechu*, *Flacourtia indica, Anogeissus latifolia* and *Odina wodiyer.*

MeGad: This micro watershed is relatively species poor. However, basal area was highest in Me-7 with 4.05 contributed by *Abies pindrow* and *Pinus wallichiana*. The lowest basal area was in Me-5 with 0.27, predominantly sub-alpine grasslands with scattered trees. The overall species diversity in MeGad was very low with Shannon diversity of 0.9 in Me-1, with only 4 species in entire transect. Me-5 is a alpine grassland and cultivated in some areas had only one species with lowest diversity.

Abies pindrow with 94.61 and *Pinus wallichiana* with 83.30 show a very high IVI value (Table 4). These are followed by *Picea smithiana* (58.58) and *Salix denticulate* (27.34).

Discussion

Mandhala, Moolbari, and Me Gad micro watersheds had a total of 2276 individuals from 75 woody species from 34 belt transects, relatively higher than earlier reports (Singh and Rawat, 1999; Rana *et al.*, 2010). A total of 38 families were recorded, of which Fabaceae had the highest number of species (7), followed by Rosaceae, Pinaceae and Moraceae (5 each). The highest number of individuals per species was *Quercus leucotriphora* with 811 individuals followed by *Q. glauca* (394), *Acacia catechu* (157)*, Myrica esculenta* (73), *Pinus roxbhurghii (*72*), Abies pindrow* (70) and *Flacourtia indica (*68).

Species richness was highest in Mandhala (45 species) followed by Moolbari (39) and MeGad (9). Although Mandala had the highest species diversity, it had lowest dominance. Most of the species are thorny shrubs and rarely attain tree forms due to severe anthropogenic disturbances in this watershed, hence very low basal area is observed compared to number of other species. In Moolbari, which had the highest basal area (39.94) was mainly contributed by *Quercus leucotricophora* and *Q. glauca*. In Mandhala, the negligible basal area found was due to absence of large trees as in Moolbari or MeGad, due to the earlier deforestation and extensive encroachment of forestland by obnoxious weed *Lantana camara*. This shrub has totally covered the lower slopes in Mandhala making it an unsuitable habitat for wildlife as well as domesticated animals. Also regeneration of forest plant species has totally ceased due to the permanent cover created by this bush.

Overall *Quercus* species dominated in the Moolbari watershed area, while deciduous species such as *Acacia catechu, Flacourtia indica* dominated in Mandala watershed. MeGad, a high altitude area was dominated by *Abies pindrow, Picea smithiana* and *Pinus wallichiana,* which is reflected in the IVI values (Table 4).

Faunal diversity

Butterfly: The present study enumerated 115 butterfly species of oriental and palaearctic origin representing nine families. Nympahlidae is the dominant family (32 sp.) followed by Pieridae (19 sp.), Lycaenidae (16 sp.), Satyridae and Papilionidae (12 sp. each), Hesperridae (10 sp.), Danaidae (8 sp.), Erycidae (4 sp.) and Acraeidae (2 sp.). Table 5 details the butterflies in the three micro watersheds identified based on standard keys (Wynter-Blyth, 1940-1946, 1957; Thomas and Malorie, 1985; Mani, 1986; Leps and Spitzer, 1990; New 1991; Scoble, 1992; Wood and Samways, 1992; Kim, 1993; Pollard and Yates, 1993; Samways, 1994; New *et al.*, 1995; Molina and Palma, 1996; Parmesan, 1996; Swengel, 1996; Blair and Launer, 1997; Spitzer *et al.*, 1997; Stork *et al.*, 2003)

- The family Papilionidae is commonly known as Swallowtail family, comprising some of the larger butterflies. In the study area, this family representing two sub-families viz., Parnasiinae (Apollos) and Papilioninae. Three species of apollos namely *Parnassius hardwickii hardwickii* (Common Blue Apollo) in Moolbari watershed and *Parnassius delphius* (Banded Apollo) and *Parnassius charltonius* (Regal Apollo) in the open grassy and rocky areas of Megad watershed were seen. The sub-family Papilioninae represented by *Papilio protenor protenor* (Spangle) and *Chilasa agestor* (Tawny Mime).
- The Family Pieridae commonly known as Whites

Table 5: Butterfly species across three micro watersheds of Himachal Pradesh

Sl. No.	Family	Species	Moolbari	Mandhala	Megad
1	Papilionidae	*Parnassius hardwickii hardwickii*	+		
2		*Parnassius delphius*			+
3		*Parnassius charltonius*			+
4		*Papilio polyctor polyctor*	+	+	
5		*Papilio polytes romulus*	+	+	
6		*Papilio demoleus*	+	+	
7		*Papilio protenor protenor*	+		
8		*Graphium serpedon*	+		
9		*Graphium agamemnon*		+	
10		*Graphium doson*		+	
11		*Chilasa clytia clytia*	+		
12		*Chilasa agestor*	+		
13	Pieridae	*Appias lalage*	+		
14		*Appias libythea*	+		
15		*Cepora nerissa phryne*	+	+	
16		*Catopsilia pomona*	+	+	
17		*Catopsilia pyranthe pyranthe*	+		
18		*Eurema brigitta rubella*	+	+	
19		*Eurema laeta laeta*	+		
20		*Eurema hecabe*	+	+	
21		*Ixias marianne*	+		
22		*Ixias pyrene*	+	+	
23		*Pieris canidia indica*	+	+	+
24		*Pieris brassicae nepalensis*			+
25		*Delias eucharis*		+	
26		*Pareronia valeria*		+	
27		*Aporia nabellica*			+
28		*Baltia butleri*			+
29		*Colias eogene eogene*			+
30		*Colias fieldii*			+
31		*Pontia daplidice moorei*			+
32	Danaidae	*Danaus chrysippus*	+	+	
33		*Danaus genutia*	+	+	
34		*Euploea core core*	+	+	
35		*Euploea mulciber mulciber*	+		
36		*Parantica sita sita*	+		
37		*Tirumala limniace*	+	+	
38		*Tirumala septentrionis*	+	+	
39		*Parantica aglea*		+	
40	Satyridae	*Mycalesis francisca sanatana*	+		
41		*Mycalesis mineus mineus*	+		
42		*Mycalesis perseus*		+	
43		*Ypthima asterope*	+	+	
44		*Ypthima nareda nareda*	+		
45		*Ypthima baldus baldus*		+	
46		*Melanitis leda leda*		+	
47		*Orsotriaena medus*		+	
48		*Aulocera loha*			+
49		*Aulocera swaha swaha*			+
50		*Callerebia annada*			+
51		*Callerebia shallada*			+
52	Nymphalidae	*Nymphalis* (*Aglais*) kashmirensis	+		
53		*Nymphalis* (*Aglais*) ladakensis	+		+
54		*Argyreus hyperbius hyperbius*	+	+	
55		*Ariadne merione*	+	+	
56		*Athyma opalina*	+		
57		*Athyma perius*	+	+	
58		*Athyma asura*	+		
59		*Mimathyma ambica ambica*	+		

Sl. No.	Family	Species	Moolbari	Mandhala	Megad
60		*Cyrestis thyodamas thyodamas*	+		+
61		*Hestina persimilis*	+		
62		*Hestina* sp.			+
63		*Euthalia lubentina*	+		
64		*Euthalia aconthea garuda*		+	
65		*Hypolimnas bolina*	+	+	
66		*Hypolimnas misippus*	+	+	
67		*Junonia iphita*	+	+	
68		*Junonia hierta*	+	+	
69		*Junonia orithya*	+	+	
70		*Junonia lemonias persicaria*	+	+	
71		*Junonia almana*	+	+	
72		*Junonia atilites*		+	
73		*Kallima inachus*	+		
74		*Kaniska canace canace*	+		
75		*Neptis hylas*	+	+	
76		*Neptis* sp.			+
77		*Phalanta phalanta*	+	+	
78		*Polyura athamas athama*	+		
79		*Vanessa cardui*	+	+	
80		*Vanessa indica*	+		+
81		*Limenitis procris*		+	
82		*Childrena childreni*			+
83		*Melitaea arceisa*			+
84	Acraeidae	*Acraea terpsicore*	+	+	
85		*Acraea issoria*	+		
86	Erycinidae	*Dodona durga*	+		
87		*Lybythea celtis lepita*	+		
88		*Lybithea myrrha*	+		
89		*Abisara echerius suffusa*		+	
90	Lycaenidae	*Lycaena phlaeas*	+		
91		*Lycaena kasyapa*			+
92		*Aricia agestis nazira*	+		
93		*Castalius rosimon*	+	+	
94		*Chrysozephyrus* sp.	+		
95		*Heliophorus sena*	+		
96		*Pseudozizeeria maha*	+	+	
97		*Tajuria cippus*	+		
98		*Zizula hylax*	+		
99		*Euchrysops cnejus*		+	
100		*Jamides celeno*		+	
101		*Chilades pandava pandava*			+
102		UI			+
103		UI			+
104		*Polyommatus stoliczkanus janetae*			+
105		*Thecla* sp.			+
106	Hesperiidae	*Borbo cinnara*	+		
107		*Coladenia indrani indrani*	+		
108		*Pelopidas sinensis*	+		
109		*Pelopidas mathias mathais*	+		
110		*Polytremis eltola*	+		
111		*Spialia galba*	+		
112		*Suastus gremius*	+		
113		*Telicota pythias*	+		
114		*Sarangesa dasahara dasahara*		+	
115		*Udaspes folus*	+	+	

or Yellows seen in MeGad watershed are *Pieris brassicae nepalensis* (Large Cabbage White), *Aporia nabellica* (Dusky Blackvein), *Pontia daplidice moorei* (Bath White) and *Colias* sp.

(Clouded yellows).

- More species of the family Satyridae and Nymphalidae were recorded during the survey. *Nymphalis* (Aglais) *kashmirensis* (Common Tortoiseshell), *Nymphalis* (*Aglais*) *ladakensis* (Ladakh Tortoiseshell), *Vanessa indica* (Red Admiral), *Kaniska canace canace* (Blue Admiral), *Aulocera* sp. (Satyrs), *Callerebia* sp. (Arguses) *and Melitaea arceisa (*Blackvein Fritillary) were recorded in Moolbari and Megad watersheds.
- Family Erycinidae is commonly known as family of Beaks, Punches and Judies, which are represented by *Dodona durga* (Common Punch), *Lybithea* sp. *(Beaks)* in Moolbari and *Abisara echerius suffusa* (Plum Judy) in Mandhala watershed.
- Lycaenidae is commnly known as family of Blues are represented by *Heliophorus sena* (Sorrel Sapphire), *Tajuria cippus* (Peacock Royal) and *Chrysozephyrus* sp. (Hairstreak) in Moolbari watershed and *Lycaena kasyapa* (Green Copper)

Table 6: Amphibian diversity in the three micro watersheds of Himachal Pradesh

Species#	Mandhala	Moolbari	Megad	IUCN status
Bufonidae				
Bufo himalayanus	0	1	0	Least concern
Bufo sp.	1	1	0	
*Bufo stomaticus**	1	1	0	Least concern
Duttaphrynus melanosticuts	1	1	0	Least concern
Microhylidae				
Microhyla ornate	1	0	0	Least concern
Dicroglossidae				
Euphlyctis cyanophlyctis	1	0	0	Least concern
*Fejervarya limnocharis**	0	1	0	Least concern
Fejervarya sp.	1	0	0	Least concern
Hoplobatrachus crassus	1	0	0	Least concern
*Hoplobatrachus tigerinus**	1	0	0	Least concern
Paa minica	1	1	0	Vulnerable
Sphaerotheca breviceps	1	0	0	Least concern
Ranidae				
Amolops chakrataensis	0	1	0	Data deficient
Rhacophoridae				
Polypedates maculates	1	0	0	Least concern
Species richness	10	6	0	

Nomenclature based on Frost *et al.* (2006)
* Observation by Zoological Survey of India.

Table 7: Relative abundance (individuals/hour of search) of amphibians recorded during the study.

Species	Mandhala	Moolbari	MeGad
Bufonidae			
Bufo himalayanus	0	1	0
Bufo sp.	15		
Duttaphrynus melanosticuts	1	10	0
Microhylidae			
Microhyla ornate	2	0	0
Dicroglossidae			
Euphlyctis cyanophlyctis	39	0	0
Fejervarya rufescens	5	0	0
Hoplobatrachus crassus	2	0	0
Paa minica	1	8	0
Sphaerotheca breviceps	2	0	0
Ranidae			
Amolops chakrataensis	0	1	0
Rhacophoridae			
Polypedates maculates	4	0	0
Shannon's index	1.43	1.01	0
Simpson's index	2.8	2.41	0

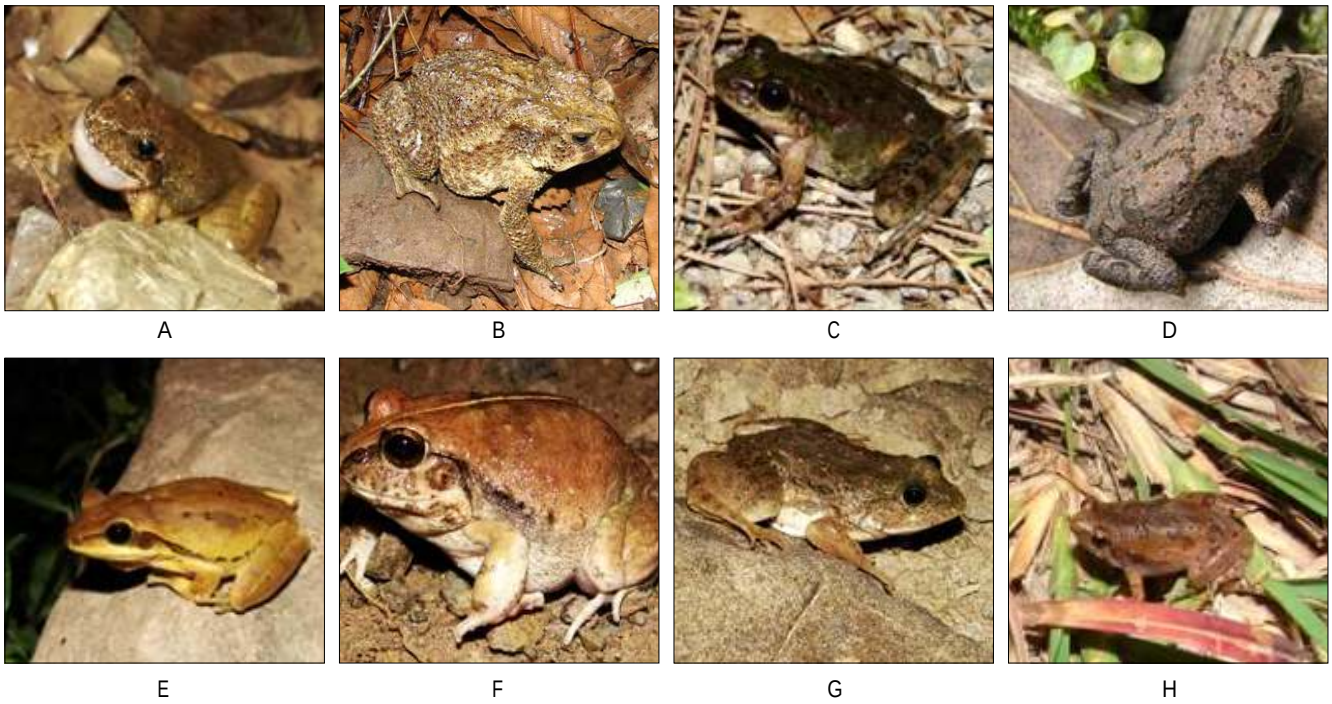


Fig. 2 : Amphibians from Moolbari and Mandhala watersheds. A. *Paa minica* B. *Bufo himalayanus* C. *Amolops chakrataensis* D. *Bufo* sp. E. *Polypedates maculates* F. *Sphaerotheca breviceps* G. *Euphlyctis cyanophlyctis* H. *Microhyla ornata*

Plate 1: Mandhala, Moolbari and MeGad Watersheds, Himachal Pradesh

Plate 2: Vegetation profile in the watersheds

and *Polyommatus stoliczkanus janetae (Common Meadow Blue)* in Megad watershed.

Amphibians: In the present study, 14 species were observed belonging to 5 families and diversity is listed in Table 6. Of the 5 families, Dicroglossidae represents 7 species, followed by Bufonidae (4) and Microhylidae, Ranidae and Rhacophoridae (1 species each). Six species are first reported from this study.

Table 7 details the relative abundance in three watersheds comparable to the earlier reports (Mehta, 2005a, b; Beebee and Griffiths, 2005). Figure 2 depicts few amphibians recorded during this study. Mandhala watershed located_in the Shivaliks is bestowed with numerous ponds, pools, streams and rivers. Most of the streams and river drain off the rainwater as soon as it rains, without any water retaining in the streams. Only ponds and pools retain water for considerable time and

Table 8: Habitat wise bird species richness in Moolbari, Mandhala and Me Gad watersheds

Habitat	Number of Species -watershed		
	Moolberi	Mandhala	Me Gad
Forest	25	65	29
Forest and Agriculture	33	42	
Riverine	35	43	
Agriculture	21	47	23
Glacier			11

Table 9: Comparative distribution of bird species in the three watersheds

Scientific names	Species	Number	Mandhala	Moolbari	MeGad
Ocyceros biprostris	Indian Grey Hornbill	11	-	+	-
Dicrucrus leucophaeus	Ashy drango	1	-	+	-
Prinia socialis	ashy prinia	7	+	-	-
Terpsiphone paradisi	Asian paradise flycatcher	10	+	+	-
Stachyris pyrrhops	Black chinned babbler	2	+	-	-
Francolinus francolinus	Black Francolin	2	+	-	-
Certhia himalayana	bar tailed tree creeper	6	-	+	-
Hirundo rustica	Barn swallow	9	-	-	+
Ploceus philippinus	Baya weaver	4	+	-	-
hypsipetes leucocephalus	Black bulbul	31	+	+	-
Dicrucrus macrocercus	Black drongo	83	-	+	-
Ictinaetus malayensis	black eagle	7	+	+	-
Parus Xanthogenys	Black lored tit	13	+	+	+
Phoenicurus ochruros	Black redstart	2	-	+	-
Elanus caeruleus	black shouldered kite	1	+	-	-
Psittacula roseata	blossom headed parakeet	6	-	+	-
Nyctyornis athertoni	Blue bearded bee eater	2	-	+	-
Monticola cynclorhynchus	Blue capped rock thrush	2	-	+	-
Megalaima asiatica	blue throated barbet	1	-	+	-
Myophonus caeruleus	Blue whistling thrush	30	-	+	+
Sturnus pagodarum	brahminy myna	8	+	-	-
Megalaima zeylanica	brown headed barbet	1	-	+	-
bubulcus ibis	cattle egret	13	+	-	-
Motacilla citreola	citrine wagtail	5	-	-	+
Turdoides caudatus	common babbler	6	+	-	-
Falco tinnunculus	common kestrel	1	-	-	+
Alcedo atthis	Common Kingfisher				
Acridotheres tristis	common myna	146	+	+	-
Megalaima haemacephala	coppersmith barbet	4	+	-	-
Centropus sinensis	Greater coucal	2	+	-	-
Melophus lathami	crested bunting	14	+	-	-
Spilornis cheela	crested serpent eagle	1	+	-	-
Aethopyga siparaja	crimpson sunbird	1	+	-	-
Phylloscopus fuscatus	Dusky warbler	33	+	+	+
Streptopelia decaocto	eurasian collared dove	1	+	+	-
Carduelis carduelis	European goldfinch	2	-	-	+
Rhipidura aureola	White browed fantail	1	+	-	-
Serinus pusillus	fire fronted serin	23	-	-	+
Dicaeum agile	Thick billed flowerpecker	2	+	-	+
Oriolus oriolus	golden oriole	9	+	-	-
Parus major	Great tit	3	+	+	+
Merops orientalis	green bee eater	3	+	+	-
Treron sphenura	Wedge tailed green pigeon	12	+	+	-
Prinia hodgsonii	Grey breasted prinia	31	+	-	-
Dendrocopos canicapillus	grey capped pygmy woodpecker	2	-	+	-
Culicicapa ceylonensis	Grey headed flycatcher	3	-	+	-
Seicercus xanthoschistos	grey hooded warbler	19	+	+	-
Saxicola ferrea	Grey bushchat	1	-	+	-
Lanius minor	Lesser grey shrike	7	-	-	+

Scientific names	Species	Number	Mandhala	Moolbari	MeGad
Dendrocitta formosae	Grey tree pie	7	-	+	-
Hierococcyx varius	Common hawk cuckoo	8	+	-	-
Megalaima virens	Himalayan barbet	4	-	+	-
Pycnonotus leucogenys	Himalayan bulbul	151	+	+	-
Dendrocopos himalayensis	Himalayan woodpecker	2	-	+	-
Upupa epops	hoopoe	11	+	-	+
corvus splendens	house crow	11	+	+	+
Passer domesticus	house sparrow	185	+	+	+
Apus affinis	house swift	17	+	-	-
Phylloscopus humei	hume's warbler	6	-	-	+
Cuculus micropterus	indian cuckoo	6	+	-	-
Pavo cristatus	Indian peafowl	15	+	-	-
Saxicoloides fulicata	indian robin	64	+	-	-
Aegithina tiphia	iora	2	+	-	-
Turdoides striatus	jungle babbler	133	+	+	-
Corvvus macrorhynchos	Jungle crow	142	+	+	+
Lophura leucomelanos	Kalij pheasant	15	+	+	-
Eudynamys scolopacea	Koel	15	+	+	-
Bubo bubo	Eurasian Eagle owl	2	-	-	+
Streptopelia sengalensis	laughing dove	1	+	-	-
Phylloscopus chloronotus	lemon rumped warbler	14	-	-	+
Dinopium javanense	lesser flameback woodpecker	3	+	-	-
Sylvia curruca	lesser white throat	2	-	-	+
Picus chlorolophus	Lesser yellow nape woodpecker	3	-	+	-
Phalacrocorax niger	little carmorant	3	+	-	-
Egretta garzetta	little egret	21	+	-	-
Tachybaptus ruficollis	little grebe	2	+	-	-
Copsychus saularis	magpie robin	5	+	+	-
Spizaetus nipalensis	mountain hawk eagle	1	+	-	-
Treron bicincta	Orange breasted green pigeon	2	+	+	-
Streptopelia orientalis	Oriental turtle dove	47	+	+	+
Anthus rufulus	paddyfield pipit	2	-	-	+
Milvus migrans	paraiah kite	3	+	-	-
Psittacula eupatria	alexandrine parakeet	6	+	-	-
Francolinus pondicerianus	Grey Francolin	6	+	-	-
Falco peregrinus	peregrine falcon	11	-	-	+
Saxicola caprata	pied bushchat	26	+	-	-
Clamator jacobinus	pied cuckoo	5	+	-	-
Psittacula cyanocephala	Plum headed parakeet	4	+	-	-
Ardeola grayii	pond heron	2	+	-	-
Nectarinia zeylonica	purple rumped sunbird	3	+	+	-
Nectarinia asiatica	Purple sunbird	39	+	+	-
Urochssa erythrorhyncha	Red billed blue magpie	21	-	+	-
Streptopelia tranquebarica	red collard dove	2	+	-	-
Gallus gallus	Red jungle fowl	3	+	+	-
Hirundo daurica	Red rumped swallow	48	+	+	-
Pycnonotus cafer	Red vented bulbul	73	+	+	-
Vanellus indicus	Red wattled lapwing	4	+	-	-
Acrocephalus dumetorum	Blyth's reed warbler	1			
Sterna aurantia	river tern	1	+	-	-
columba livia	rock pigeon	201	+	+	+
Psittacula krameri	rose ringed parakeet	26	+	-	-
Lanius schach	Long tailed shrike	91	-	-	+
Oenanthe pleschanka	rufous tailed wheatear	13	-	-	+
Tringa stagnatilis	Marsh sandpiper	1	-	-	+
Lophura nycthemera	Silver pheasant	6	-	+	-
Ficedula tricolor	Slaty blue flycatcher	1	-	+	-
Psittacula himalayana	Slaty headed parakeet	52	-	+	-
Megalaima viridis	White cheeked barbet	10	+	-	-
Streptopelia chinensis	Spotted dove	49	+	+	-
Enicurus maculatus	Spotted forktail	2	-	-	+

Scientific names	Species	Number	Mandhala	Moolbari	MeGad
Lonchura punctulata	spotted munia	11	+	-	-
Athene brama	spotted owllet	3	+	+	-
Saxicola torquata	Common stone chat	2	-	+	-
Garrulax lineatus	streaked laughing thrush	35	-	+	-
Aethopyga gouldiae	MRS Gould's Sunbird	1	+	-	-
Orthohotomus sutorius	tailor bird	8	-	+	-
Dendrocitta vagabunda	tree pie	15	+	-	-
Sitta frontalis	velvet fronted nuthatch	2	-	-	+
Eumyias thalassina	Verditer flycatcher	2	-	+	-
Tichobroma muraria	wallcreeper	2	-	+	-
Chlidonias hybridus	whiskered tern	1	-	-	+
Lonchura malabarica	Indian silverbill	2	+	-	-
Dicrurus caerulescens	white bellied drongo	4	+	-	-
Halcyon smyrnensis	White breasted kingfisher	12	+	+	-
Chaimarrornis leucocephalus	white capped redstart	5	-	-	+
Zosterops palpebrosus	White eye	24	+	+	-
Parus nuchalis	white naped tit	2	-	-	+
Garrulux albogularis	White throated laughing thrush	6	-	+	-
Hirundo smithii	wire tailed swallow	16	-	+	-
Prinia flaviventris	yellow bellied prinia	1	+	-	-
Dendrocopos mahrattensis	Yellow crowned woodpecker	1	-	+	-
Chrysomma sinense	yellow eyed babbler	4	+	-	-
Carduelis spinoides	Yellow breasted greenfinch	36	-	-	+
Phoenicoptera treron	Yellow footed green pigeon	4	+	-	-
Motacilla flava	yellow wagtail	15	-	-	+
Acridotheres fuscus	Jungle myna				

could be one of the reasons that majority of the amphibians observed from the regions are pool breeders dominated by *Euphlyctis cyanophlyctis*, *Microhyla ornata*, *Fejervarya* sp. and *Polypedates maculates*. *Sphaerotheca breviceps*, a burrowing frog was observed in the dry beds of river. *Euphlyctis cyanophlyctis* was found in both streams as well as in pools. Moolbari watershed belongs to the mid Himalayan ranges and many streams originate forming a network. As it has higher elevation and more streams, frogs that breed in streams predominate the region. *Paa minica* was observed in almost all streams with water, and having canopy cover. In agriculture fields and forested areas, *Bufo himalayanus* and *Duttaphrynus melanostictus* were recorded. Altitude and extreme temperature in MeGad watershed appears inhospitable to amphibians as it is evident from their absence while recordings during this fieldwork.

Avifauna diversity and richness : Sampling was done following the standard protocol (Ali, 1989; Grimmet *et al.*, 1998; Laiolo, 2003) in different habitat types: forests, glacier, agriculture and forests, riverine, and agriculture. Habitatwise speces richness is given in Table 8 for Moolbari, MeGad and Mandhala watersheds respectively. The distribution of bird species in the three watersheds is summarised in Table 9. Eight species of birds common to all three watersheds, in an altitude of 400 to 4000 m. 31 species common to Mandhala and Moolbari watershed, in the altitudanal range of 400 to 2000 m. Nine species common to Moolbari and Me Gad Watersheds. The habitat wise study revealed that bird species richness is more in forest patches of Mandhala and MeGad Watersheds, whereas, forest and agriculture mixed habitats in Moolbari had more species. In total, 136 bird species were recorded in three watersheds. Mandhala watershed records highest number of species (105) followed by Moolbari (57) and Megad (35).

Conclusion

Mandhala, Moolbari, and Me Gad micro watersheds had a total of 2276 tree individuals from 75 woody species from 34 belt transects. A total of 38 families were recorded, of which Fabaceae had the highest number of species (7), followed by Rosaceae, Pinaceae and Moraceae (5 each). The highest number of individuals per species was *Quercus leucotriphora* with 811 individuals followed by *Q.glauca* (394), *Acacia catechu* (157), *Myrica esculenta* (73), *Pinus roxbhurghii (*72), *Abies pindrow* (70) and *Flacourtia indica (*68). Species richness was highest in Mandhala (45 species) followed by Moolbari (39) and MeGad (9). *Quercus* species dominated in the Moolbari watershed area, while deciduous species such as *Acacia catechu, Flacourtia indica* dominated in Mandala watershed. MeGad, a high altitude area was dominated by *Abies*

pindrow, Picea smithiana, and *Pinus wallichiana,* which is reflected in the IVI values. Occurrence of perennial streams in the watershed dominated by native vegetation compared to the seasonal streams in in monoculture plantations, highlight the need for appropriate watershed management strategies to ensure the sustenance of water.

115 butterfly species of oriental and palaearctic origin representing nine families. Nympahlidae is the dominant family (32 sp.) followed by Pieridae (19 sp.), Lycaenidae (16 sp.), Satyridae and Papilionidae (12 sp. each), Hesperridae (10 sp.), Danaidae (8 sp.), Erycidae (4 sp.) and Acraeidae (2 sp.). 14 amphibian species were observed belonging to 5 families. Of the 5 families, Dicroglossidae represents 7 species, followed by Bufonidae (4) and Microhylidae, Ranidae and Rhacophoridae (1 species each). Six species are first reported from this study. Regarding bird diversity, 136 bird species were recorded in three watersheds. Mandhala watershed records highest number of species (105) followed by Moolbari (57) and Megad (35).

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पि'चमी हिमालय के तीन सूक्ष्म जल संभरों की पारितंत्रीय स्थिति

टी.वी. रामचंद्र, एन.वी. जोशी, जी.आर. राव, जी. धनपाल, के.वी. गुरूराजा तथा अमित एस. यादव

सारांश

किसी भी क्षेत्र की पारितंत्रीय स्थिति का निर्धारण वहां की जैवविविधता और पर्यावरणीय स्थितियों की अन्त:fØया के आधार पर किया जाता है। पि"चमी हिमालय के तुंगीय घटकों के सूक्ष्म जलसंभरों के जैवविविधता आकलन से पता चलता है कि पादप वैविध्य में 38 कुलों की 75 का"ठीय प्रजातियों के 2276 एकल "ाामिल हैं। प्रजाति समृद्धि के मामले में तीन सूक्ष्म जलसंभरों में से मंधाला का स्थान प्रथम ¼43 प्रजातियां½, मूलवाड़ी का स्थान द्वितीय ¼39 प्रजातियां½ तथा मेगाड का स्थान तृतीय ¼9½ है। मंधाला में अधिकांश प्रजातियां कंटीली झाड़ियां हैं। जो मानवीय fØया-कलापों के कारणव ृक्षक ारू पक मह ैल ेप ातीह ै।इ नकाअ ाधारक्ष ेत्रभ ीक मर हताह ै।म ूलबाड़ीक ाअ ाधारक्ष ेत्रस वोंच्चह ै।ि जसमेंम ुख्यत: *क्वेरकस ल्यूकोट्रिकोफोरा* तथा *क्वे. ग्लायुका* पाये जाते है। मेलगाड़ के उच्च तुंगीय भागों में मुख्यत: *एबीस पिंडरो, पीसिया स्मिथियाना* तथा *पाइनस वाल्कियाना* पाये जाते है।

जीव जन्तुओं में तितलियों की 115, उभयचरों की 14 तथा पक्षियों की 136 प्रजातियां पाई जाती हैं। इस क्षेत्र में पूर्वी और पुराजीवी तितलियों के नौ कुलों का प्रतिनिधित्व है। इसी प्रकार कार्यक्षेत्रीय खोजों के समय पांच कुलों के 14 उभरचर देखे गये। आई यू सी एन की स्थिति के अनुसार पा-माइनिका संवेदनशील है, *अमोलोपस चक्राटेनिसिस* का डाटा अपूर्ण है और ये दोनों हिमालय की तलहटियों में देशज् हैं। तीन जलसंभरों में मंधााला ¼शिवालिक½ में जीव-जन्तु वैविध्य सर्वाधिक है। जिसके बाद मूलबाड़ी का स्थान है। अगस्त-सितम्बर 2007 में मीगाड सूक्ष्म जल संभर में उभयचर नहीं देखे गये। तीनों जल संभरों में कुल 136 पक्षी प्रजातियां रिकार्ड की गई। जिनमें से मंधाला में सर्वाधिक 104, मूलबाड़ी में 57 तथा मीगाड़ में 35 पक्षी प्रजातियां शामिल हैं।

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