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RESEARCH ARTICLE

Can picnic influence floral diversity and vitality of trees in Bhawal National Park of Bangladesh?

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Abstract We examined the impact of picnic activities on forest diversity, structure, regeneration and vitality of tree species in the Bhawal National Park of Bangladesh. The study area was classified as a non-used, occasionally used and frequently used area on the basis of the intensity of the picnic activities. A total of 43 plant species were enumerated in the whole study area. The highest plant species richness (41 species) was observed in the non-used area whereas the lowest species richness (11 species) in the frequently used area. The diversity index decreased with the increase of picnic intensity whereas the concentration of dominance increased. Density of other plant groups except the density and basal area of the mature trees showed a declining trend from the non-used to frequently used area. The frequently used area exhibited very poor regeneration. Tree vitality decreased with the increase of picnic intensity. The relevance of our study as a basis for further research to determine the impact of tourism on biodiversity in Bangladesh is discussed.

Key words species richness, diversity index, concentration of dominance, regeneration, intensity

1 Introduction

Nature-based tourism and recreation in protected areas is increasing worldwide (Pickering and Hill, 2007). Tourism has long been considered a "clean industry", without any negative effects on the environment worthy to be mentioned (für Naturschutz, 1997). However, this image is now outdated and with the rise in tourism numbers there follows an inevitable increase in negative environmental impacts (Leung and Marion, 2000; Newsome et al., 2002a; Whinam and Chilcott, 2003; Buckley, 2004). The impacts from recreation and tourism are influenced by factors such as the type of infrastructure provided, the location, type of activities, the behaviour of tourists and the season of use (Liddle, 1997; Cole, 2004). The use of protected areas is often zoned, with some areas highly developed and extensively modified through provision of infrastructure such as sealed roads, car parks, toilets, visitor centers, picnic areas, camping areas and accommodation. In contrast, other zones within the same protected areas may be classified remote (which can be designated as 'wildernesses) where there is limited access, no or few facilities, and only small numbers of visitors (Worboys et al., 2005). The recreational activities differ from place to place, region to region and country to country (Worboys et al., 2005). Picnic is very much popular in Bangladesh as recreation and tourism activity. Picnic includes many activities like walking, gathering, cooking of fresh foods or warming cooked foods within the park by making holes into the soil with the burning of deadwood and fallen litter and finally eating the cooked foods being seated on the forest floor. Overseas, a range of direct and indirect impacts of recreational activities in protected areas on vegetation have been documented in both observational and experimental studies (Liddle, 1997; Leung and Marion, 2000; Newsome et al., 2002a; Buckley, 2004; Cole, 2004; Newsome et al., 2004; Pickering and Hill, 2007). But such studies in Bangladesh have not been conducted so far. In addition, studies on the impacts of specific picnic activities on the forest diversity have not been done so far in the world as well.

There are eight national parks in Bangladesh, of which Madhupur National Park and Bhawal National Park are considered as Sal (*Shorea robusta* C.F. Gaertn.) dominating parks (Alam, 1995). Sal forests are distributed in Bangladesh, India and Nepal (Gautam and Devoe, 2006). There are many studies on the Sal forests of Nepal and India concerned with vegetation analysis of *Shorea* communities (Singh et al., 1995; Pande, 1999; Pandey and Shukla, 1999; Shankar, 2001; Pandey and Shukla, 2003; Timilsina et al., 2007), comparing plantation forests with natural Sal forest vegetation (Shankar et al., 1998; Webb and Sah, 2003) and impact of human disturbances (Sukumar et al., 1992; Murali et al., 1996; Shankar, 2001). Some studies focusing on the enlisting of available plant species are found in Bangladesh (Alam, 1995; Rashid et al., 1995; Jashimuddin et al., 1999; Rashid

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and Mia, 2001; Choudhury et al., 2004).

Bangladesh is one of the world's most densely populated countries and, as a consequence, forests are subject to heavy pressures in terms of both wood production and competing land-uses. Due to the high population density and sharply uneven distribution of lands (60% people are landless) natural resources including the forests are overexploited (World Bank, 2004). The human pressure on Bhawal National Park is the highest in Bangladesh as it is located only 40 km away from Dhaka, the fastest growing mega-city in the world with 12 million populations (density of 20000–100000 per km^2, World Bank, 2008). The surrounding area of this park is also highly populated (density of 2505 per km^2; BBS, 2006). The forest area is reduced day by day for the demands of industrialization and urbanization. Meanwhile, most of the forests have either been clear felled or occupied by encroachers and only the remnants of natural patches exist (Gain, 1998). On an average 1.5 million people visit the Bhawal National Park every year for their picnic activities (official source). Therefore, it is important to know the effects of the different kinds of human impacts on the forest diversity of this park.

Hence this investigation was undertaken, to determine the impacts of picnic activities on the botanical richness, community structure, potentiality of regeneration and vitality of trees. The role of picnic activities on the forest diversity will help to determine the overall status of the Sal forests in this park and give recommendations for future management.

2 Materials and methods

2.1 Study site

The study was conducted at Bhawal National Park of Bangladesh (Fig. 1), which is locally known for Bhawal Sal (*Shorea robusta* C.F. Gaertn.) forest or Rajendrapur Gajari (Sal) forest. The study area is located in 40 km north from the capital city Dhaka (24°01′N, 90°20′E). It has been kept under IUCN management category as a protected landscape. Before this park was officially declared as national park in 1982 under the Bangladesh Wildlife Act, coppicing was introduced to manage these forests in 1925 and 'taungya' was initiated to plant other tree species along with Sal in 1938. During the independence war these forests were hugely destroyed in 1971. Since then no management practices have been implemented except planting of some ornamental plants near forest roads for aesthetic purposes. Though no felling activities have been allowed after the declaration of the national park a number of human activities like illegal logging, cutting of regeneration, fuel wood collection, litter sweeping and soil disturbance are still common. In course of time Sal associates have been almost disappeared. Therefore, the park can be considered as semi-natural forests. The area of this national park is about 5000 hm^2 according to government master plan. The Dhaka-Mymensingh high way divides the park in two parts: east and west. The adjacent eastern part from the high way is administered by 'Araishoprasad bit' (bit: small administrative unit), which is used as 'picnic spots'; whereas the adjacent western part is administered by the 'Bishoyakuribari bit', which is treated as 'wilderness area' compared to the eastern part. In the eastern side a lot of infrastructures were constructed like rest houses, cottages, parking areas, picnic spots, residential areas for the forest staff, mosque, children parks, lakes, carpeting roads, shops, tea stalls, benches and sun sheds. In total there are 50 'picnic spots' in this park which are used all the year round by the people for cooking, eating, playing and gathering. From October to February these spots remain fully occupied by different picnic parties keeping hugely crowded. Especially in the weekend (Friday and Saturday) these 50 spots are not sufficient at all to accommodate all picnic parties. The adjacent area of each picnic spot is used as picnic spot temporarily as well. From this consideration the study area was classified into three categories on the basis of the frequency of picnic activities taken place. The intensity of picnic activities was estimated qualitatively by observing the area and on the basis of the official map of the park (Table 1). The wilderness area was considered as non-used (N), the adjacent areas of picnic spots as occasionally used (O) and the picnic spots as frequently used (F) areas.

Fig. 1 Map of the study area

The present feature of the forest area is actually honeycombed with habitations and rice fields. The topography is characterized by low hills, which rise 3.0–4.5 m above the surrounding paddy fields locally known as 'chalas' which are intersected by numerous depressions or 'baids'. The dominant tree species is Sal (*Shorea robusta*) in this national park (Sarker and Huq, 1985). The soil belongs to the bio-ecological

Table 1 Disturbance level in different stands

Stand	Elements of disturbance [a]	Severity	Distance from the picnic spot (m)	Nature	LC [b] (%)	Other anthropogenic disturbances [c]
N	H, C, Hm	Very high	0–50	Protected	10–20	L, RD, SD, LS
O	H, C, Hm	Medium-High	100–200	Protected	1–5	L, RD, SD, LS
F	Hm	Medium	200–1000	Protected	0	L, RD, SD, LS

Note: [a]H, digging holes for cooking; C, cleaning of forest floor to be seated and to eat; Hm, human trampling. [b]LC, litter coverage of forest floor. [c]L, logging; RD, regeneration destruction; SD, soil disturbance; LS, litter sweeping.

zone of Madhupur Sal Tract (Nishat et al., 2002) and this tract represents highly oxidized reddish brown clay containing ferruginous nodules and manganese spots. According to Richards and Hassan (1988) the soils are moderately to strongly acidic in reaction. The soils are characterized by a low organic matter and a low fertility (Alam, 1995). Following Thornthwaite's principles this region is included in the humid region (Ismail and Mia, 1973). The annual rainfall ranges from 2030–2290 mm and the annual temperature ranges from 10–34°C. The humidity varies between 60% and 86%, the duration of sunshine ranges from 5–9 h and average maximum wind speed is 16 km·h^{-1}.

2.2 Sampling and data analysis

In total 40 plots were selected randomly near 40 picnic spots out of a total of 50, which were considered as frequently used (F) areas. Another 40 plots were selected within a minimum distance of 100 m from each plot of the F-areas, which were classified as occasionally used (O) areas. From the wilderness area 40 plots with a minimum distance of 100 m from each other in any directions were selected randomly, which were called non-used (N) areas. However, due to the presence of depressions in the honey comb like huge gaps or bare land without forest cover it was not possible to establish the plots in a regular distance in the N-areas. The area of each circular plot was 300 m^2 with 9.77 m radius. Within the 300-m^2 plot a subplot of 100 m^2 area (r = 5.64 m) was considered for the inventory of large seedlings (< 5 cm DBH and > 30 cm height) and another subplot of 12.6 m^2 area (r = 2 m) for small seedlings (the seedlings of < 30 cm height according to Sagar and Singh, 2005). The whole area (300 m^2) was considered for measuring mature trees (> 10 cm DBH), saplings (5–10 cm DBH), climbers and herbs. The percentage of forest floor occupied by different species of herbs (≥ 1% of forest floor) was approximated. With this exception each stem was counted as an individual. Regeneration included small seedlings, large seedlings and saplings. The regeneration was categorized in relation to the occurrence of the seedling categories as good (small seedlings >> large seedlings >> saplings), fair (small seedlings > large seedlings > saplings), poor (small seedlings < large seedlings < saplings), very poor (general absence of individuals in one or two stages) and nil (absence of regeneration in all stages). The vitality of each tree was assessed on the basis of the parameters crown percentage of total height, crown development, trunk shape, root damage, bark damage, insect infestation and pathogen infection (Table 2).

The relative values of frequency, density and basal area for each single tree species were used to calculate the importance value index (IVI) plot wise according to Phillips (1959) and Curtis (1959):

$$\text{IVI} = \text{relative frequency} + \text{relative density} + \text{relative basal area} \quad (1)$$

The similarity index (SI, community coefficient) among different areas was calculated according to Sorenson (1948):

$$\text{SI} = 2C/(A+B) \quad (2)$$

Table 2 Classification of tree vitality

Class	Indication
VC-1 (very high vitality)	a) vigorous crowns with a length of 55% or more of the total height, well developed; b) trunk straight, insect free, disease free, damage or injury free; c) no damage or injury in root system; d) bark intact; e) leaf vigorous, no infestation or infection of pests
VC-2 (high vitality)	a) moderately vigorous crowns with a length from 30%–55% of total height, medium developed; b) trunk nearly straight; c) few roots were damaged or injured; d) bark almost intact; e) initial infestation or infection caused by insects or disease
VC-3 (low vitality)	a) fair to poor crowns with a length from 10%–30% of total height, weakly developed; b) trunk little bit wavy shaped; c) many roots were damaged or injured; d) some portions of trunk were debarked; e) advanced infestation or infection caused by insects or disease
VC-4 (very low vitality)	a) very short, less than 10% of the total height; sometimes merely a tuft at top of tree or dieback occurred or crownless; b) trunk fully wavy shaped; c) root system almost destroyed; d) most of the portion of the trunk was debarked; e) foliage or trunk was severely infested or infected by insects or disease

where C is the number of species common to both forests, a the number of species in forest A, and b the number of species in forest B (compare 2).

The Shannon-Wiener diversity index (Shannon and Wiener, 1963) was calculated from the following formula given by Magurran (1988):

$$\bar{H} = -\sum_{i=1}^{s} p_i \ln p_i \qquad (3)$$

where p_i is the proportion of the ith species and the number of all individuals of all species N (n_i/N) (compare 3).

Evenness was calculated by Pielou's index (Pielou, 1966) from the formula given by Magurran (1988):

$$E = \bar{H} / \ln S \qquad (4)$$

where $\bar{H}$ is the Shannon-Wiener diversity index and S the number of species

Simpson's index (Simpson, 1949) measured the concentration of dominance (CD):

$$\text{CD} = -\sum_{i=1}^{s} (p_i)^2 \qquad (5)$$

where p_i is the same as for the Shannon-Wiener information function (compare 5).

Species area curves were produced from the total number of floral species found at different sample sizes. Data were analyzed by an analysis of variance (ANOVA) and linear regression analysis to find out the relation between the degree of disturbance and the stem density, basal area, diversity index, concentration of dominance and evenness. All statistical analyses were done using the SPSS package (SPSS, 2006).

3 Results

3.1 Species richness and diversity

The inventory on the 3.6-hm^2 tropical wet deciduous forest yielded a total of 43 plant species. Species richness was biggest (41) in the N-areas followed by O-areas (27) and F-areas (11). Out of 43 species recorded in the whole area, 22 were represented in the tree group, 10 in the shrubs group, 6 in the climbers group and 5 in the herbs group (Table 3). Species-area curves indicated that the number of sampling plots sufficiently captured the array of plant species available at this site (Fig. 2). The number of mature tree species was 13 in the whole area. The highest number of mature tree species was found in the N-areas (12) followed by O-areas (6) and F-areas (3). Only Sal (*Shorea robusta*) was common to all three areas (Table 4). Considering all plants together the highest similarity index was observed between N-O areas (0.74) followed by O-F areas (0.53) and F-N areas (0.42). Diversity index was highest in the N-areas followed by O-areas and F-areas for all plant groups (mature tree, sapling, seedling, shrub and herb). On the contrary, dominance index was highest in the F-areas followed by O-areas and N-areas. Except the category of large seedlings all other tree groups (mature tree, sapling and small seedling) exhibited the highest evenness in the F-areas followed by O-areas and N-areas (Table 5).

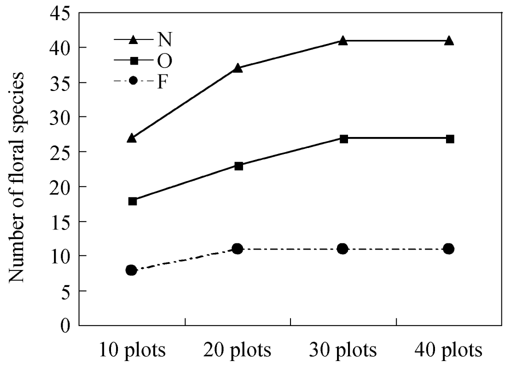

Fig. 2 Species richness-area curves for all three picnic categories (N, O, F)

3.2 Composition, community structure and tree vitality

The important value index of the mature tree showed that the whole study area is highly dominated by Sal

Table 3 Similarity index of floral species for all three picnic categories (N, O, F)

Plant groups	Species richness				Species overlapping			Similarity index		
	N	O	F	All	N-O	O-F	F-N	N-O	O-F	F-N
Mature tree	12	6	3	13	5	1	3	0.56	0.22	0.40
Sapling	10	6	3	10	6	3	5	0.75	0.67	0.77
Large seedling	17	6	2	18	5	2	2	0.43	0.50	0.21
Small seedling	12	8	4	12	8	4	4	0.80	0.67	0.50
Tree	20	15	7	22	13	6	7	0.74	0.55	0.52
Shrub	10	6	1	10	6	1	1	0.75	0.29	0.18
Climber	6	5	2	6	5	2	2	0.91	0.57	0.50
Herb	5	1	0	5	1	0	0	0.33	0.00	0.00
Total	41	27	11	43	25	10	11	0.74	0.53	0.42

Table 4 Density, basal area and important value index (IVI) of the enlisted mature tree species all three picnic categories (N, O, F)

Botanical name	Local name	Density (individuals·hm^{-2})			Basal area (m^2·hm^{-2})			IVI		
		N	O	F	N	O	F	N	O	F
Adina cordifolia (Roxb.) Hook. f. ex Brandis	Haldu	0.8	–	–	0.01	–	–	2.2	0.0	0.0
Albizia lebbek (L) Benth.	Koroi	3.3	2.5	–	0.08	0.13	–	9.1	9.2	0.0
Bridelia retusa (L) A. Juss.	Katakhai	–	0.8	–	–	0.01	–	0.0	2.9	0.0
Careya arborea Roxb.	Gadhila	1.7	–	–	0.04	–	–	4.5	0.0	0.0
Cassia fistula L.	Sonalu	1.7	–	0.8	0.03	–	0.02	4.5	0.0	3.2
Dillenia pentagyna Roxb.	Ajuli	1.7	–	–	0.03	–	–	4.4	0.0	0.0
Eugenia jambolana Lam.	Jam	2.5	–	3.3	0.07	–	0.06	6.8	0.0	9.7
Ficus benghalensis L.	Bot	0.8	–	–	0.04	–	–	2.4	0.0	0.0
Lannea coromandelica (Houtt.) Merr.	Jiga	0.8	0.8	–	0.02	0.02	–	2.3	2.9	0.0
Miliusa roxburghiana (Wall. Ex Griff.) Hk.f.&Th.	Bongajari	0.8	0.8	–	0.03	0.03	–	2.3	3.0	0.0
Miliusa velutina (Dunal) Hk.f.&Thoms.	Gandhigajari	0.8	0.8	–	0.02	0.08	–	2.2	3.3	0.0
Shorea robusta C.F. Gaertn.	Sal	725.8	745.0	728.3	18.03	16.28	14.62	257.0	278.7	287.2
Zanthoxylum rhetsa (Roxb.) DC.	Bajna	0.8	–	–	0.02	–	–	2.3	0.0	0.0

Table 5 Diversity indices for all three picnic categories according to different components of the Sal forests

Plant groups	Diversity index			Dominance index			Evenness		
	N	O	F	N	O	F	N	O	F
Mature tree	0.15	0.06	0.04	0.96	0.98	0.99	0.06	0.03	0.03
Sapling	0.67	0.28	0.14	0.75	0.90	0.95	0.29	0.16	0.13
Large seedling	0.41	0.15	0.09	0.87	0.95	0.96	0.14	0.09	0.13
Small seedling	1.20	1.10	0.82	0.53	0.54	0.59	0.48	0.53	0.59
Shrub	1.14	1.01	0.00	0.50	0.50	1.00	0.50	0.57	–
Climber	1.63	0.98	0.47	0.22	0.51	0.70	0.91	0.61	0.68
Herb	0.92	0.00	–	0.51	1.00	–	0.57	–	–

(*Shorea robusta*). The dominance of Sal was the highest in the F-areas (IVI = 287.2) followed by O-areas (IVI = 278.7) and N-areas (IVI = 257) compared among the three areas (Table 4). There was no significant differences in density (individuals·hm^{-2}) of the mature trees among the three areas, but the density of saplings, large seedlings, small seedlings, shrubs, climbers and herbs were significantly the highest in the N-areas followed by O-areas and F-areas. The basal area of the mature trees was significantly the highest in the N-areas followed by O-areas and F-areas also (Table 6). *Randia dumetorum* was the dominant shrub in the O-areas and it is the only species found in F-areas, whereas *Clerodendrum serratum* was the dominant species followed by *R. dumetorum* in the N-areas (Table 7). Among the climber species, *Pothos scandens* was the dominant species in all three areas (Table 8). Considering the average area of forest floor occupied by herbs the overall abundance of herbs was the most frequent in the N-areas, whereas occasional in the O-areas and absent in the F-areas (Table 9). Only *Cyperus rotundus* was common to both N and O-areas.

Out of the 20 tree species in the N-areas 18 were found to be regenerating, whereas 15 species out of 15 in the O-areas and 7 species out of 7 in the F-areas (Table 10). Seven species (35% of total tree species) exhibited good regeneration in the N-areas, whereas one species (7%) in the O-areas. Seven species out of seven in the F-areas showed very poor regeneration (100%).

Except in the N-areas the diameter distribution of the mature trees in all areas showed a reverse J-shaped pattern (Fig. 3), and an approximately normal distribution of tree height in the three areas (Fig. 4). The proportion of comparatively larger trees in terms of diameter and tree height increased from F-areas to O-areas and O-areas to N-areas. The vitality class-4 (very low vitality) had the highest proportion considering the stem number within the O- (33.9%) and F-areas (61.7%), whereas only 13.7% of all trees were classified with a very low vitality in the N-areas. The proportion of the vital class-1 (very high vitality) was 14.7%, 9.1% and 1.3% within the N-, O- and F-areas respectively (Fig. 5).

Table 6 Mean values (Mean±SD) of the densities (individuals·hm^{-2}) and basal area (m^2·hm^{-2}) for all three picnic categories (N, O, F) according to different components of the Sal forests

Parameter	Flora	N	O	F	ANOVA	
					F	*p*
Density (individuals·hm^{-2})	Mature tree	741.7±109.1a	750.8±154.3a	732.5±141.3a	0.18	0.835
	Sapling	240.8±116.1a	253.3±100.9b	176.7±90.0c	6.4	0.002
	Est. seedling	4552.5±1321.8a	1450.0±572.4b	140.0±243.7c	288.7	0.000
	Ephemeral	1790.5±1015.4a	795.8±697.9b	318.3±434.0c	39.7	0.000
	Shrub	1305.8±298.8a	264.2±112.1b	46.7±73.5c	506.9	0.000
	Climber	63.3±45.2a	37.5±33.9b	18.3c	15.8	0.000
Basal area (m^2·hm^{-2})	Mature tree	18.4±2.9a	16.5±5.0b	14.7±4.1c	8.3	0.000

Means within columns followed by the same letter or letters (a–c) are not significantly different (p <0.05) by LSD

4 Discussion

The Bhawal National Park dominated by Sal appears poor in plant species richness (43 plant species: 22 trees, 10 shrubs, 6 climbers and 5 herbs) comparing to other Sal forest regions of the world. Rahman et al. (2008) (unpublished data) counted 134 species (70 trees, 15 shrubs, 26 climbers and 23 herbs) from the Madupur National Park, which is also dominated by Sal and located in the same agroecological zone. Webb and Sah (2003) enlisted 159 species (49 trees, 45 shrubs, 16 climbers and 42 herbs) from the Central Terai, whereas Timilsina et al. (2007) counted 131 species (28 trees, 10 shrubs, 6 climbers and 87 herbs) from the western Terai of Nepal. Pandey and Shukla (2003) found 208 species (93 trees, 50 shrubs, 34 climbers and 31 herbs) in the eastern Terai, and Shankar (2001) examined 87 species (≥ 10 cm DBH) in the Darjiling Terai of India. Swamy et al. (2000) listed 82 species (48 trees, 10 shrubs, 8 climbers and 16 herbs) from a low elevated (250–400 m altitude) and moist deciduous forest in the Western Ghat of India. The species richness of mature trees (> 10 cm DBH) was low when compared with the range across the tropics, 20 species per hm^2 in Varzea forest of Rio Xingu, Brazil (Campbell et al., 1992) to as high as 307 species per hm^2 in Amazonian Ecuador (Valencia et al., 1994). Compared to various moist tropical forests in the neighbouring countries of Bangladesh (Chandrashekara and Ramakrishnan, 1994; Ganesh et al., 1996; Parthasarathy and Karthikeyan, 1997; Kadavul and Parthasarathy, 1999), this study site represents the lowest forest diversity according to species

Table 7 Density (individuals·hm^{-2}) of shrubs in all three picnic categories (N, O, F)

Botanical name	Local name	N	O	F
Ageratum sp.	Fulkhari	52.5	5.0	–
Ardisia humilis Vahl.	Bonjam	9.2	2.5	–
Clerodendrum serratum (L.) Moon.	Bhite	890.0	21.7	–
Dalbergia spinosa Roxb.	Anantakata	39.2	47.5	–
Glycosmis pentaphylla (Retz.) DC.	Mouhati	20.0	9.2	–
Holarrhena antidysenterica Wall. Ex A. DC.	Kuteshwar	19.2	–	–
Lantana Camara L.	Lantena	30.0	–	–
Mimosa pudica L.	Lojjaboti	16.7	–	–
Randia dumetorum Lamk.	Monkata	215.8	178.3	46.7
Urena lobata L.	Ghaghra	13.3	–	–

Table 8 Density (N·hm^{-2}) of climbers in all three picnic categories (N, O, F)

Botanical name	Local name	N	O	F
Asparagus racemosus Willd.	Shotomuli	5.8	–	–
Ficus scandens Roxb.	Dumurlata	4.2	1.7	–
Pothos scandens L.	Kalalata	20.8	25.8	15.0
Smilax macrophylla Roxb.	Kumarilata	15.8	3.3	–
Spatholobus roxburghii Benth.	Mongolilata	5.8	0.8	–
Unknown	Nangollata	10.8	5.8	3.3

Table 9 Abundance of herbs in all three picnic categories (N, O, F)

Botanical name	Local name	N	O	F
Adhatoda vasica Nees.	Bashok	Rare	Absent	Absent
Curcuma zedoaria (Christm.) Roscoe	Shoti	Occasional	Absent	Absent
Cyperus rotundus L.	Mutha	Frequent	Occasional	Absent
Nicotiana plumbaginifolia Viv.	Bontamak	Rare	Absent	Absent
Oplismenus aemulus (R.Br.) Roem. & Schult.	Basket	Occasional	Absent	Absent
Total		Frequent	Occasional	Absent

Absent = 0, Rare = 0.01%–0.1%, Occasional = 0.1%–1%, Frequent = 1%–10% and Abundant ≥ 10% of the forest floor of whole sample areas.

Table 10 Classification of the natural regeneration at all three picnic categories (N, O, F)

Classification	N	O	F
Good	7 (35%)	1 (7%)	–
Fair	1 (5%)	–	–
Poor	1 (5%)	1 (7%)	–
Very poor	9 (45%)	10 (67%)	7 (100%)
Nil	2 (10%)	3 (20%)	–
Total	20 (100%)	15 (100%)	7 (100%)

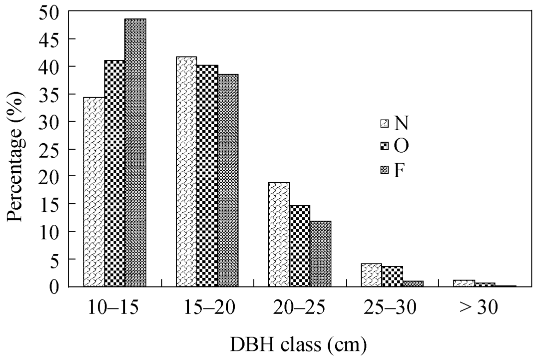

Fig. 3 Diameter distributions of the mature trees in all three picnic categories (N, O, F)

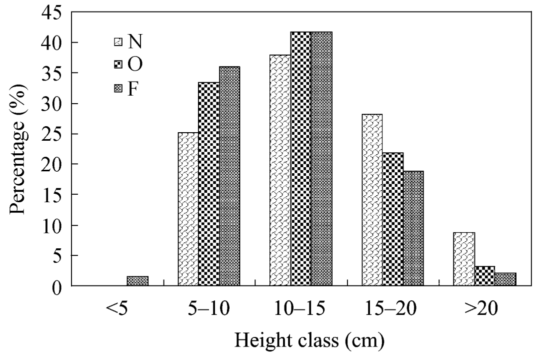

Fig. 4 Tree height distribution in all three picnic categories (N, O, F)

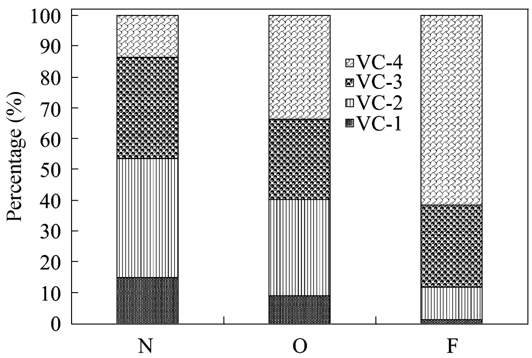

Fig. 5 distribution of the vitality classes of the mature trees in all three picnic categories (N, O, F)

richness. The diameter and height distributions indicated that the park is scarce of old and merchant timbering trees as Sal may be 45 m tall and 8 m girth (Troup, 1986). On the other hand, the Sal forests in this region are supposed to be mixed natural forests with a total share of 75% to 25% by Sal (*Shorea robusta*) and the rest by other deciduous species like *Adina cordifolia*, *Albizia procera*, *Bombax ceiba*, *Butea monosperma*, *Lagerstroemia parviflora*, *Dillenia pentagyna*, *Garuga pinnata*, *Hymenodictyon orixensis*, *Semecarpus anacardium*, *Miliusa velutina*, and *Schleichera oleosa* (Ismail and Mia, 1973). The relative abundance of Sal ranged from 98% to 99% among the three study sites in our study which indicates that most of the associates of Sal have been almost lost. The impacts of tourism and other human disturbances on this park are very much severe due to its location (40 km away from the center of the capital). Tremendous human pressure caused the decrease of the species richness and the relative proportion of natural Sal associates by increasing the relative proportion of Sal in this forest. The outside area of this park is highly populated and other disturbances like logging, regeneration cutting, litter sweeping and animal grazing are severely prominent here along with tourism. It is comparatively difficult for the illegal loggers to sell Sal timber on the local market due to vigilance of the law enforcing agencies and the easy identification of the species compared to other species. The natural associated species of Sal grow often in the homesteads too, but Sal is the only species which grows in the forest. Rapid urbanization and industrialization in that area may be other causes of being species-poor forest.

Nevertheless, the anthropogenic disturbances are similar in the whole study area but the intensity of picnic activities varies from one site to another. Within the study area the species richness of all plant groups tended to be decreasing from the wilderness area to the picnic spots. At the same time the vegetation composition and cover also differed between the plots at the roadside compared to the more undisturbed areas at some distance. The proportion of bare ground increased with the decrease of naturalness (Johnston and Johnston, 2004). The density of plant groups except the number of the mature trees increased with the distance from the picnic spot to the wilderness area as well. Picnic spots are not a congenial habitat for natural regeneration of Sal associates due to the continuous human movements. Small seedlings of Sal associates could not attain the size of large seedlings, saplings and mature trees. But Sal was able to compete with its continuing regeneration even within picnic spots because of the strong coppicing characteristics (Suoheimo, 1999). The intensity of picnic activities decreased the vitality of the mature trees. People damage the bark and branches unnecessarily just for fun. The disturbances by man on the forest floor in passing by have a negative impact on the vegetation (Hill and Pickering, 2006). With the increasing distance from the road the level of humus, nutrient supply, pH values and electrical conductivity may increase (Johnston and Johnston, 2004). On the other hand the picnic activities cause strong compactness to the soil (Buckley and Pannell, 1990; Pickering and Buckley, 2003; Donaldson and Bennet, 2004; Worboys et al., 2005). The construction of infrastructures near to picnic spots may degrade the soils including erosion, sedimentation and pollutant runoff at picnic spots (Buckley and Pannell, 1990; Spellerberg, 1998; Newsome et al., 2002a). Compaction can reduce the growth rate of trees by reducing the size or extent of root systems and the number of fine roots. As a consequence the oxygen uptake of roots is reduced, thereby decreasing the absorption of water and nutrients as well as impeding water movement through soils. Extensive soil compaction may significantly reduce a site's capability for timber productivity through degraded reforestation potential, rate of tree growth, and stand health in the long term. Direct damages to the roots of trees occurred due to activities in digging holes for cooking and disposing of human or other waste (Newsome et al., 2002b; Phillips and Newsome, 2002; Smith and Newsome, 2002; Bridle and Kirkpatrick, 2003).

The most obvious impacts on the vegetation are caused by camping and walking including the effects on the vegetation being crushed, sheared off, and uprooted (Stone and Elioff, 2000; Newsome et al., 2002a). These impacts may result in changes to the vegetation including loss of height, biomass, reproductive structures (e.g. flowers, fruits), reduction in cover, damage to seedlings and change in species composition (Whinam and Chilcott, 1999; Growcock, 2005; Hill and Pickering, 2006). Moreover, the litter coverage increased with the decrease of picnic activities. The maintenance of the soil organic pool in tropical ecosystems is achieved by the high and rapid circulation of nutrients through the fall and decomposition of litter (Ola-Adams and Egunjobi, 1992). The litter on the forest floor acts as an input-output system of nutrients (Das and Ramakrishnan, 1985). It is particularly important in the nutrient budget of tropical forest ecosystems on nutrient-poor soils, where vegetation depends on recycling of nutrients contained in the plant detritus (Singh, 1968).

All the man-made impacts observed during the study have direct and indirect effects on the species composition and species richness of trees, ground vegetation and climbers. That is why the Sal-dominated national park appears poor in plant species richness compared to other Sal forests. The tourist activities very much represent "a double edged sword" for the socio-environmental movement, in that it is an activity which is both reviled and revered. It has become a focus of criticism for its impacts and a focus of promotion for achieving sustainable development" (Mowforth and Munt, 1998). Tourism will therefore have a specific position in policies aimed at the conservation of biodiversity as the level of acceptance in the general public is of great importance. Conservation measures will be more "sustainable" if they are widely accepted and supported, and especially if large parts of the society are directly aware of the benefits they derive from the protection of biodiversity for themselves. The implementation of biodiversity conservation activities for the Bhawal National Park is challenging for being the nearest park with picnic facilities from the mega-populated capital. But obviously the impacts can be minimized to some extent. Park managers should have legislative requirements to manage recreation in ways that mitigate impacts and ensure that activities are ecologically sustainable. Recreation management should consider areas where particular picnic activities are allowed to be conducted and areas where the focus should be on a limitation in number and size of the picnic parties. The number of picnic parties should not exceed the number of picnic spots and a balanced number of occasionally used picnic spots may lead to near to wilderness areas. However, further comprehensive research activities are needed to measure and monitor the impact of tourists on soil characteristics and plants to understand the role of these damages for ecosystem processes.

Nevertheless, it is very difficult to control negative human impacts in the context of an overpopulated region and the rising demands for recreational purposes. There is an urgent need for public awareness programmes for visitors to increase the understanding for the vulnerability of the environment and the importance for the maintenance of forest biodiversity.

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