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Research Article

SPECIES RICHNESS, PLANT DIVERSITY AND COMPOSITION WITH RESPECT TO ALTITUDINAL VARIATION IN WESTERN NAYAR WATERSHED, UTTARAKHAND, INDIA

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ABSTRACT

Species richness was observed greater for the herb stratum among all altitudinal ranges followed by shrub and tree stratum. In context of tree species the highest (19) was fond in south facing aspect at lower altitudinal range (700-900m) and lowest (8) was in same aspect at higher altitudinal range (1600-1800m). The diversity of tree, shrub and herb species was varied with the altitudinal ranges. In context of tree layer, the Shannon diversity was recorded maximum (2.85) at upper altitudinal range (1600-1800 m) of south aspect and minimum (1.77) also at upper altitudinal range but in the north facing aspect. . The Margalef diversity was found maximum (6.40) at north facing aspect of upper altitudinal range (1600-1800 m) and minimum (5.02) at middle altitudinal range (1000-1200 m) of north facing aspect.

INTRODUCTION

Indian Himalayan Region represents the unique biological diversity (Dhar *et al.,* 1997, Maikuri *et al*., 2001). It provides a mega biodiversity including 9000 species of angiosperms and hence is considered as the hot spot of biodiversity. About 3470 species are considered exclusively endemic to the Himalayas (Kumar *et al*., 2001). The Himalaya is known as a treasure-house of a wide variety of plants, animals and micro organisms, exhibiting a great diversity in its bioresources. Among different types of forests, the montane forests, due to their unique features including rich biodiversity and prominent ecological services, have always attracted biologists, bio-geographers, ecologists and forest managers (Doumenge *et al.,* 1995).

The forest vegetation of Himalaya has been of major interest to ecologist since long. Structural characteristics of the Himalayan forests have been studied by Champion and Seth (1968), Upreti *et al*., (1985), Bisht and Kusumlata (1993), Singh *et al*., (1994), Baduni and Sharma (1996), Khera *et al*., (2001), Mishra *et al*.,(2004), Jeetram *et al*., (2004), Kumar and Jeetram (2005) and Sagar and Singh (2005). These workers have studied the composition, succession and impact of biotic and abiotic stresses on different forest ecosystems.

The species composition, diversity and regeneration pattern was explored by Uniyal *et al.* (2010) and Pokhriyal *et al.* (2010) in Dewalgarh and Phakot-Pathri rao watershed respectively in different parts of Garhwal Himalaya. Watershed concerned with different configuration of land, water and vegetation in an area which are able to provide basic needs of villagers. This study is an attempt to investigate the species richness, diversity and composition of Western Nayar watershed of Pauri district in Uttarakhand (India).

Study Area

Two villages viz. Ghandalu and Khaira of the Western Nayar Watershed in district Pauri Garhwal has been selected for study. The village Ghandalu (Location' 26°39' to 27^0 21' N latitude; and 78°23'and 79^0 21' E longitude; Altitude: 1700m) lies in micro watershed Kandul in Dwarikhal Block. The village Khaira (Location: 27^0 41' to 28^0 21' N latitude; and 78°23'and 79°21'O" E longitude; Altitude: 900m) lies in micro watershed Bisgaddikhal in Jaiharikhal Block.

MATERIALS AND METHODS

Whole of the study area in the watershed was divided into three altitudinal zones. Two of the altitudinal zones viz. 700-900m and 1000-1200m were adjoing areas of Khaira village. The

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other altitudinal zone 1600-1800m was located in the adjoing areas of Ghandalua village. Data was collected from both north-facing and south-facing aspects.

Surveys were conducted by random sampling by using quadrat method as suggested by Misra (1968) and Kershaw (1973). For the sampling, size and number of the quadrats was determined by species area curve method (Misra, 1968). During the study, quadrats of10x10m for tree layer, 5x5m for shrub layer and 1x1m for herbs were found suitable for the study. Total 16 quadrates of 10x10m size (8 north-facing and 8 south-facing) were laid down for tress in each of the altitudinal zone. Within each of these 10x10m quadrates two quadrats of 5x5m for shrubs and five quadrats of 1x1m size for herbs were laid down.

RESULTS

Species Richness and Plant Diversity

Species richness was observed greater for the herb stratum among all altitudinal ranges followed by shrub and tree stratum. In context of tree species the highest (19) was fond in south facing aspect at lower altitudinal range (700-900m) and lowest (8) was in same aspect at higher altitudinal range (1600-1800m). Maximum (33) number of shrub species richness was found in both the aspect at the altitudinal range of 1600-1800m. Herb species richness (41) was encountered again at high altitudinal range as for shrub species richness at 1600-1800m altitude (table 1).

The diversity of tree, shrub and herb species was varied with the altitudinal ranges. In context of tree layer, the Shannon diversity was recorded maximum (2.85) at upper altitudinal range (1600-1800 m) of south aspect and minimum (1.77) also at upper altitudinal range but in the north facing aspect. The Simpson diversity of tree layer ranged 0.08 – 0.31 among all altitudinal ranges. The highest Margalef diversity (5.77) was observed at south facing aspect of upper altitudinal range (1600-1800 m) and lowest (2.90) at north facing aspect of the same altitudinal range. As far as the shrub layer was concerned, the Shannon diversity was found highest (3.46) in north facing aspect for upper altitudinal range (1600-1800m) and lowest (3.04) at middle altitudinal range (1000-1200 m) of south facing aspect. The Simpson diversity was recorded maximum (1.40) in the lower altitudinal range (700-900m) of north facing aspect and minimum (0.04) middle altitudinal range (1000-1200 m) of the both north and south facing aspect. The Margalef diversity of the shrub layer was ranged 4.92 – 6.88 in all studied altitudinal ranges. In the herb layer of the studied watershed, the highest Shannon diversity was recorded for north aspect of lower altitudinal range (700-900 m) as 3.48 while, lowest (3.26) at upper altitudinal range (1600-1800 m) of south facing aspect. The Simpson diversity of herb layer was ranged 0.03 – 0.58 in all studied altitudinal ranges. The Margalef diversity was found maximum (6.40) at north facing aspect of upper altitudinal range (1600-1800 m) and minimum (5.02) at middle altitudinal range (1000-1200 m) of north facing aspect (table - 2)

Species Composition

The tree species composition among all three altitudinal ranges is represents in table 3. The species mentioned in the table are on the basis of their density values as compare to other species recorded. In the lower altitudinal range (700-900 m), *Pinus roxburghii* (1.50) was observed as most dominant tree species followed by *Pyrus pashia* (1.30), *Mallotus philippensis* (0.90), *Grewia optiva* (0.80) and *Ficus religiosa* (0.60) in the north aspect. In the south aspect *Pinus roxburghii, Lagerstroemia parviflora* and *Syzygium cumini* was only the species which dominantly distributed. In the middle altitude (1000-1200 m) at north facing aspect, *Ficus roxburghii*was recorded dominant tree species with density of 2.60/ 100 m^2 followed by *Butea monosperma* (0.90), *Cassia fistula* (0.80), *Ficus palmate* (0.80) and *Ficus religiosa* (0.60). In the south aspect, *Bauhinia purpurea* (0.80), *Ficus religiosa* (0.40) and *Cassia fistula* (0.80) were recorded dominant tree species. For upper altitude (1600-1800 m), *Quercus leucotrichophora* (4.60), *Pinus roxburghii* (3.90), *Pyrus pashia* (1.00) and *Rhododendron arboretum* (0.50) was observed dominant tree species of north facing aspect. *Quercus leucotrichophora* (2.90), *Pinus roxburghii* (2.60), *Rhododendron arboreum* (1.50) and *Bauhinia purpurea* (0.80) was found major tree species in the south facing aspect

Table 4 shows the composition of major dominant shrub species found in all altitudinal ranges. In the lower altitudinal range, *Lantana camara* (1.90), *Berberis asiatica* (0.90), *Berberis aristata* (0.80), *Ziziphus mauritiana* (0.80) and *Eupatorium adenophorum* (0.70) was found dominant shrub species at north facing aspect. As far as south facing aspect of lower altitudinal range was concerned, the major dominant shrub species was observed as *Lantana camara* (1.50), *Berberis asiatica* (0.90), *Berberis aristata* (0.90), *Nepeta govaniana* (0.90), *Woodfordia fruticosa* (0.90), *Saxifraga diversifolia* (0.80) and *Rubus foloilosus* (0.60). The middle altitudinal range (1000-1200 m), again *Lantana camara* (1.70) was found most dominant shrub species at north facing aspect followed by *Ziziphus mauritiana* (1.20), *Eupatorium adenophorum* (0.90), *Rubus paniculatus* (0.80) and *Artemisia japonica* (0.60). The south facing aspect of this altitudinal range, major dominated shrub species was as *Lantana camara* (1.10), *Berberis aristata* (1.00), *Selinum tenuifolium* (0.90), *Ziziphus mauritiana* (0.90) and *Eupatorium adenophorum* (0.80). In context of upper altitudinal range (1600-1800 m) of the studied watershed, the main dominant shrub species at north facing aspect, *Phyllanthus parvifolius* (0.80) was found dominant shrub species followed by *Aster albescens* (0.80), *Bergenia ciliata* (0.80), *Hypericum elodeoides* (0.70), *Desmodium podocarpum* (0.70) and *Myrsine Africana* (0.60). The south aspect of this altitudinal range showed dominancy of *Deutzia compacta* (1.90), *Rosa macrophylla* (0.90), *Sarococca soligna* (0.80), *Cotoneaster microphyllus* (0.70) and *Digitaria ciliaris* (0.60).

The composition of herb species observed in all altitudinal ranges of studied watershed is represented by table 5. The lower altitudinal range (700-900 m) of north facing aspect showed, *Bidens pilosa* (0.70), *Crotalaria medicaginea* (0.70), *Heteropogon contortus* (0.60), *Blumea fistulosa* (0.60) and *Aerva sanguinolenta* (0.60) the dominant herb species. While, in the south aspect of this altitudinal range the recorded dominant herb species were *Brachiaria villosa* (1.70), *Chloris dolichostachya* (1.00), *Blumea fistulosa* (0.80), *Chrysopogon fulvus* (0.70) and *Desmodium microphyllum* (0.60). The middle

altitudinal range (1000-1200 m) of north aspect *Artemisia nilagirica* (0.80), and *Artemisia roxburghiana* (0.60), *Justicia quinqueangularis* (0.60) . In the south aspect, major dominant herb species were recorded as *Aerva sanguinolenta* (0.90), *Rumex hastatus* (0.90), *Saccharum spontaneum* (0.90), *Leucas cephalotes* (0.80), *Oxalis corniculata* (0.80) and *Boenninghausenia albiflora* (0.70) and *Chenopodium album* (0.60). In the upper altitude (1600-1800 m) at north facing aspect, *Dioscorea belophylla* (1.20) was observed dominant herb species followed by *Thalictrum secundum* (0.80), *Arisaema concinnum* (0.70), *Fragaria nubicola* (0.60) and *Gonatanthus pumilus* (0.50). South facing aspect of this altitudinal ranges showed major dominant herb species as *Androsace lanuginose* (0.70), *Fragaria nubicola* (0.40) and *Boenninghausenia albiflora* (0.30).

Table 1 Species Richness of tree, shrub and herb along altitudinal ranges in studied watershed.

Altitudinal Range	North Facing Aspect			South Facing Aspect		
	Tree	Shrub	Herb	Tree	Shrub	Herb
700-900m	17	30	40	19	28	34
1000-1200m	16	32	29	15	29	30
1600-1800m	12	33	41	8	33	35

Table 2 Species diversity indices of tree, shrub and herb along altitudinal ranges in studied watershed.

Altitudinal Range	North Facing Aspect			South Facing Aspect		
	Shannon	Simpson	Margalef	Shannon	Simpson	Margalef
			Tree stratum			
700-900m	2.70	0.09	4.31	2.58	0.09	3.80
1000-1200m	2.50	0.08	3.94	2.29	0.14	3.29
1600-1800m	1.77	0.31	2.90	2.85	0.27	5.77
			Shrub stratum			
700-900m	2.83	1.40	4.92	3.25	0.58	5.31
1000-1200m	3.19	0.04	6.58	3.04	0.04	5.18
1600-1800m	3.46	0.30	6.88	3.22	0.40	5.11
			Herb Stratum			
700-900m	3.48	0.03	6.27	3.45	0.58	5.31
1000-1200m	3.24	0.05	5.02	3.41	0.03	5.18
1600-1800m	3.41	0.03	6.40	3.26	0.38	5.49

Table 3 Altitudinal composition of tree stratum on the basis of density /100 m^2 in studied Western Nayar Watershed.

S.N.	Tree Species	700-900 m.		1000-1200 m.		1600-1800 m.	
		North	South	North	South	North	South
1	*Bauhinia purpurea*	-	-	-	0.80	-	-
2	*Boehmeria rugulosa*	-	-	-	-	0.10	0.80
3	*Butea monosperma*	-	-	0.90	-	-	-
4	*Cassia fistula*	-	-	0.80	0.30	-	-
5	*Engelhardtia spicata*	-	-	-	-	0.30	1.00
6	*Ficus palmate*	-	-	0.80	-	-	-
7	*Ficus roxburghii*	-	-	2.60	-	-	-
8	*Ficus religiosa*	0.60	-	0.60	0.40	-	-
9	*Grewia optiva*	0.80	-			-	-
10	*Lagerstroemia parviflora*	-	0.90	-	-	-	-
11	*Machilus odoratissima*	-	-	-	-	0.30	0.90
12	*Mallotus philippensis*	0.90	-	-	-	-	-
13	*Pinus roxburghii*	1.50	1.10			3.90	2.60
14	*Pyrus pashia*	1.30	-	-	-	1.00	-
15	*Quercus leucotrichophora*	-	-	-	-	4.60	2.90
16	*Rhododendron arboretum*	-	-	-	-	0.50	1.50
17	*Syzygium cumini*	-	1.30	-	-	-	-

Table 4 Altitudinal composition of shrub stratum on the basis of density /10 m^2 in studied Western Nayar Watershed.

S.N.	Shrub Species	700-900 m.		1000-1200 m.		1600-1800 m.	
		North	South	North	South	North	South
1	*Abutilon persicum*	0.70	-	-	-	-	-
2	*Artemisia japonica*	-	0.80	0.60	-	-	-
3	*Artemisia roxburghiana*	-	-	-	-	0.30	0.70
4	*Asparagus racemosus*	-	-	-	0.60	-	0.80
5	*Aster albescens*	-	-	-	-	0.80	0.80
6	*Berberis aristata*	0.80	-	0.50	1.00	0.30	0.30
7	*Berberis asiatica*	0.90	0.90	0.40	-	-	-
8	*Berberis lyceum*	-	0.90	0.30	0.70	-	-
9	*Berchemia edgeworthii*	-	-	0.50	-		
10	*Bergenia ciliata*	-	-	-	-	0.80	0.40
11	*Boerhavia diffusa*	-	-	-	-	-	0.70
12	*Caryopteris foetida*	-	-	0.50	-	-	-
13	*Colebrookia oppositifolia*	-	-	0.40	0.60	0.20	-
14	*Cotoneaster microphyllus*	-	-	-	-	0.40	0.70
15	*Cryptolepsis buchanaii*	-	-	-	-	0.50	0.40
16	*Datura innoxia*	-	-	-	0.60	-	-
17	*Desmodium laxum*	-	-	-	0.50	0.60	-
18	*Desmodium podocarpum*	-	-	-	-	0.70	-
19	*Deutzia compacta*	-	-	-	-	0.40	1.90
20	*Digitaria ciliaris*	-	-	-	-	0.40	0.60
21	*Euphorbia royleana*	0.70	-	-	-	-	-
22	*Eupatorium adenophorum*	0.70	-	0.90	0.80	-	-
23	*Hypericum elodeoides*	-	-	-	-	0.70	0.30
24	*Indigofera dosua*	-	0.60	-	-	-	-
25	*Indigofera heterantha*	-	-	-	-	0.40	0.50
26	*Inula cappa*	0.40	0.60	-	-	-	-
27	*Lantana camara*	1.90	1.50	1.70	1.10	-	-
28	*Leea asiatica*	0.60	-	-	-	-	-
29	*Myrsine africana*	-	-	-	-	0.60	-
30	*Phyllanthus parvifolius*	-	-	-	-	0.80	-
31	*Prinsipia utilis*	-	-	-	-	0.40	0.40
32	*Nepeta govaniana*	-	0.90	-	-	-	-
33	*Rhus parviflora*	-	-	-	-	0.50	0.40
34	*Rosa macrophylla*	-	-	-	-	-	0.90
35	*Rubus ellipticus*	-	-	-	-	0.40	0.30
36	*Rubus foloilosus*	-	0.60	-	0.60	0.50	0.40
37	*Rubus paniculatus*	-	-	0.80	0.50	0.30	-
38	*Sarococca soligna*	-	-	-	-	0.50	0.80
39	*Saxifraga diversifolia*	-	0.80	-	-	-	-
40	*Selinum tenuifolium*	-	-	0.10	0.90	-	-
41	*Woodfordia fruticosa*	0.40	0.90	0.60	-	-	-
42	*Ziziphus mauritiana*	0.80	0.80	1.20	0.90	-	-

DISCUSSION

Forest diversity is mostly influenced by topography, soil characteristics, climate, altitude, soil moisture, geographical location and intensity of biotic factors of the area (Joshi and Johari, 1985; Kharakwal *et al*., 2004). The species diversity is regulated by long term factors like community stability and evolutionary time as heterogeneity of both micro and macro

climate affects the diversification among different communities (Verma *et al*., 2004).

Table 5 Altitudinal composition of herb stratum on the basis of density /100 m^2 in studied Western Nayar Watershed

S.N	Herb species	700-900 m.		1000-1200 m.		1600-1800 m.	
		North	South	North	South	North	South
1	*Achyranthes aspera*	0.30	0.60	0.50	-	-	0.20
2	*Aerva sanguinolenta*	0.60	0.50	-	0.90	0.20	-
3	*Andropogon munroi*	0.20	0.60	-	-	-	-
4	*Androsace lanuginose*	-	-	-	-	0.20	0.70
5	*Arisaema concinnum*	-	-	-	-	0.70	-
6	*Artemisia nilagirica*	-	-	0.80	-	-	-
7	*Artemisia roxburghiana*	-	-	0.60	-	-	-
8	*Bidens pilosa*	0.70	-	-	-	-	-
9	*Blumea fistulosa*	0.60	0.80	-	-	-	-
10	*Boenning hausenia albiflora*	0.40	-	-	0.70	0.30	0.30
11	*Boerhavia diffusa*	0.50	-	0.50	-	-	-
12	*Brachiaria villosa*	-	1.70			-	-
13	*Chenopodium album*	-	-	-	0.60	-	-
14	*Chloris dolichostachya*	0.50	1.00			-	-
15	*Chrysopogon gryllus*	0.50	0.10	-	0.60	-	-
16	*Clematis gouriana*	-	-	0.50	-	-	-
17	*Crotalaria medicaginea*	0.70	-	-	-	-	-
18	*Chrysopogon fulvus*	-	0.70	-	-	-	-
19	*Cynodon dactylon*	-	0.50	-	-	-	-
20	*Cyperus niveus*	-	-	-	0.70	-	-
21	*Desmodium dichotomum*	-	-	-	0.60	-	-
22	*Desmodium microphyllum*	-	0.60	0.10	0.10	-	-
23	*Dioscorea belophylla*	-	-	-	-	1.20	0.20
24	*Erigeron sublyratus*	-	-	0.50	-	-	-
25	*Euphorbia chamaesyce*	0.50	0.10	-	0.50	-	-
26	*Euphorbia peplus*	0.50	-	-	-	-	-
27	*Filago hurdwarica*	-	-	-	0.70	-	-
28	*Fragaria nubicola*	-	-	0.50	-	0.60	0.40
29	*Gonatanthus pumilus*	-	-	-	-	0.50	0.10
30	*Heteropogon contortus*	0.60	0.10	0.10	0.40	-	-
31	*Justicia quinqueangularis*	-	-	0.60	-	-	-
32	*Lathyrus sphaericus*	-	-	-	0.50	-	-
33	*Leucas cephalotes*	0.30	0.30	0.30	0.80	-	-
34	*Lindenbergia macrostachya*	-	-	0.60	-	-	-
35	*Oxalis corniculata*	-	-	-	0.80	-	-
36	*Portulaca oleracca*	-	-	0.60	-	-	-
37	*Ranunculus diffuses*	-	-	-	-	0.50	0.10
38	*Rumex hastatus*	-	-	-	0.90	-	-
39	*Saccharum spontaneum*	-	-	0.20	0.90	-	-
40	*Salvia lanata*	-	-	-	0.70	-	-
41	*Setaria intermedia*	-	-	-	0.80	-	-
42	*Thalictrum secundum*	-	-	-	-	0.80	-
43	*Tridax procumbens*	-	-	0.60	-	-	-
44	*Vervascum thapsus*	0.20	0.70	0.50	-	-	-
45	*Youngia japonica*	-	-	-	0.50	-	-

Shannon diversity index (H') and concentration of dominance (CD) were found inversely proportional to each other which have also been suggested by Magurran (1988) and Pande *et al*., (2002).

In the present study, the species richness was found higher at lower and middle altitudinal ranges for tree layer but for shrub and herb layer it was higher at middle and upper altitudinal ranges. Singh *et al.* (2015) observed higher species richness and diversity in low elevation-high disturbance forests of Central Himalaya along anthropogenic disturbance gradients may be due to forest types and elevation. Uniyal *et al.,* (2010) observed maximum tree (17) shrub (53) and herb (83) species richness in the moderately disturbed stand in *Quercus leucotrichophora* forest of Dewalgarh watershed in Garhwal Himalaya which is similar to present study results.

Shannon diversity for tree reported by Sharma *et al.,* (2010) in a temperate forest of Garhwal Himalaya ranged between 0.41 – 1.81 are also similar to present findings. These values are similar to the reported values (1.34 – 2.22) by Giri *et al.,* (2008) in a mixed banj (*Quercus leucotrichophora*) and tilonj (*Quercus floribunda*) forest in Kumaum Himalaya. Simpson dominance index was recorded as reversed of Shannon diversity which is a general trend i.e. where dominance is higher diversity will be lower**.** Shannon diversity of shrub layer ranged from 2.83 – 3.46 among allaltitudinalranges**.** Highest diversity was found in the moderately disturbed stand of middle elevational range of south-facing aspect. Similar trend for shrub Shannon diversity was reported by Uniyal *et al.,* (2010) as highest (2.75) in moderately disturbed stands followed by undisturbed stand (2.72) and highly disturbed stand (2.49).In case of herb species, Shannon diversity index ranged from 3.24 to 3.48 among all altitudinal ranges. These values are more or less similar to the reported herb Shannon diversity by Uniyal *et al.,* (2010) but found similar with the reported values for different forests by many workers (Singh and Singh, 1986 and Pande *et al*., 2002).

The Simpson's index values ranged from 0.04 to 1.40 for shrubs and 0.03 to 0.58 for herbs in the present study. For

shrubs, these values are more or less similar to the findings of Bhatt *et al*., (2003) who reported Simpson value of (0.18 to 0.71). Kumar *et al*., (2004a, 2005b) reported Simpson index of 0.13 to 0.15 for shrubs and 0.05 to 0.10 for herb layer in different sub-tropical forests in Garhwal Himalaya. Margalef index of species richness for trees layer ranged from 2.90 to 5.77 among all studied altitudes. Maximum Margalef value for shrub was 5.02 at north aspect of lower altitude (700-900 m) and for herbs it was maximum (6.40) at upper altitude (1600-1800 m.). Jeetram *et al.*, (2004) also reported tree richness (3.4), shrub richness (9.4) and herb richness (2.0) for six forest types of Uttarakhand. Chauhan *et al*., (2008) reported Margalef index of 9.88 for planted and 23.8 for natural forest in Dudwa National Park which is much higher to the values of present study.

CONCLUSION

Present study in relation to species richness, diversity and composition indicate that there may be necessary requirement of existence of different species assemblage for a good established forest ecosystem. Altitudinal variance of the study reveals the distribution and composition of different tree, shrub and herb layer. Shrub and herb species richness was recorded greater in the upper altitudinal range while for tree layer lower and middle altitudinal ranges favors the high tree species richness. Some species are restricted to a specific altitude which may be have limited or low seed dispersal for their good distribution nearby altitudes. Study further may indicate a great variety of species richness, diversity and their composition. In the conclusion, research work also may be suggested for some species which were restricted to a limited extent.

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