academicJournals

Vol. 6(12), pp. 848-853, December 2014
DOI: 10.5897/IJBC2014.0625
Article Number: D74049649019
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Comparative study of shrub diversity in lower Dachigam Kashmir Himalaya

Arif Yaqoob[1]*, Mohammad Yunus[1] and G. A. Bhat[2]

[1]Department of Environmental Science, BBAU, Lucknow (U.P), India.
[2]Department of Environmental Sciences, University of Kashmir, Srinagar (Jand K), Kashmir, India.

Received 20 August, 2013; Accepted 2 May, 2014

The present study was conducted in two different ecosystems, that is, Site I (village site) and Site II (protected site) in the lower part of Dachigam National Park (Jammu and Kashmir) in all seasons during 2010-2011. Site I is located towards the periphery of the National Park near habitations and is under heavy grazing pressures while Site II is located inside the National Park with mild interferences and is a controlled site. The values of diversity (H=2.228) as well as richness index (R= 0.867) were higher for Site II while dominance index showed higher value at Site I (C = 0.113). The evenness index showed more or less similar values for both sites (Site I = 0.497 and Site II = 0.499). The frequently occurring dominant shrub species during the study period based on importance value index (IVI) were *Plectranthus rugosa, Rosa webbiana, Indigofera heterantha, Cotoneaster nummilaria* and *Daphnae oleoides* at Site I and *Indigofera heterantha*, *Clematis montana, Rosa macrophylla, Clematis grata* and *Rosa brunoni* at Site II. The abundance to frequency ratio (A/F) indicated that most of the species present contagious pattern of distribution.

Key words: Shrub, biodiversity, species, grazing, Dachigam.

INTRODUCTION

High biodiversity is seen as an insurance against the decline in ecosystem services, and should therefore be preserved (Yachi and Loreau, 1999). But, the current decline in biodiversity largely through human activities has given rise to global biodiversity crisis which is a cause of concern at the prospect of a rapidly accelerating loss of species, population, domesticated varieties, erratic rainfall, drying up of water resources, land instability and increased rates of erosion. More than half of the habitable surface of the planet has already been significantly disturbed by the human activity (Hannah and Bowles, 1995) which change overall community structure (Shaforth et al., 2002) and in turn can ultimately affect community and population dynamics. Conservation biologists warn that 25% of all species could become extinct during the next 20 to 30 years and we are on the verge of mass extinction of the species (Wilson, 1985). The cause for the loss of species is numerous but the most important is the loss

*Corresponding author. E-mail: arifmalik33@academicjournals.org.

of natural habitats. Biological diversity implies the variety of living organisms and includes diversity within species, between species and of ecosystems and the ecological processes of which they are a part (Gaston and Spicer, 2004). Spices diversity is considered to be one of the key parameters characterizing ecosystems and a key component of ecosystem functioning (Hutchinson, 1959). Globally, biodiversity is changing at an unprecedented rate as a complex response to several human-induced changes (Vitousek, 1994). Such changes are a cause of concern for ethical, economical, ecological and aesthetic reasons, but they also have a strong potential to alter ecosystem services such as the prevention of soil erosion and maintenance of hydrological cycles, and ecosystem goods, like tourism and recreation. In addition to these services, biodiversity influences many ecosystems properties such as productivity, decomposition rates, nutrient cycling resistance and resilience to perturbations (Loreau et al., 2001). Forests are the primary source to rejuvenate productivity of land through recycling of nutrients, which make physic chemical conditions of the soils favourable for plant growth (Bargali et al., 1998). The natural factors both biotic and abiotic, deforestation, burning of ground vegetation, fodder extraction, livestock grazing, etc, have caused a considerable depletion of wild population of flora and fauna of the forest areas responsible for exploittation of forests (Bargali et al., 1998) and other severe anthroprogenic activities on the ecosystem will lead to removal of vegetation, soil erosion and could subsequently lead to soil and habitat degradation. Thus, the current decline in biodiversity largely through human activities is a serious threat to our ecosystem. The study of floristic features and various environmental factors e.g. physiographic, climate, soil, etc., the community stability and the factors correlation with the vegetation can be reached, which is crucial in terms of forest communities development and rehabilitation (Basiri, 2003). Grazing areas have become less and less productive resulting from over stocking of livestock. Conflicts over the use of land have increased due to increased demand for land by different sectors of the economy.

Kashmir Himalaya, due to its rich repository of vegetation has attracted naturalists and botanists for more than two centuries (Dar et al., 2001). The vegetation study of Dachigam has been carried out by Kachroo and Singh (1976) which recognized different vegetation types based on habitat, form and density of dominant species. Although, the vegetation patterns are controlled by such factors as habitat, slope, exposure to sunlight and altitude, besides biotic factors, anthropogenic stresses followed by livestock browsing in shrub lands adversely affected the composition of vegetation, it is therefore important to conserve the vegetation of the study area. Therefore, the present study has been conducted to assess the seasonal variations in phyto-diversity and distribution pattern of shrubs in the studied sites.

METHODOLOGY

Study area

Dachigam National park is located between 34°5'-34° 10' N latitudes and 74°50'-75°10' E longitudes, covers an area of 141 km^2 and is about 22 km away from Srinagar City in Kashmir Valley. The area of Dachigam National Park was an exclusive hunting ground and protected area of the Maharaja of Jammu and Kashmir. But after independence, the area came under the control of forest department and in 1951, it was declared as a Wildlife Sanctuary. In 1981, the area was declared as National Park. The different forest types found in the area are: Temperate Moist Deodar forest, Temperate mixed deciduous forest, Cypress, Alder and blue Pine forest, Popular and Salix forest, Open Scrub forest, Sub open Birch and fir forests, Sub open Scrub and pastures and moist open Scrub. Besides, the area forms a very good habitat of wild birds including Himalayan Monal, Chakur, Patridge, Himalayan griffon, Vulture, Indian Sparrow, Hawk, Asiatic cuckoo, open scrub Swift, Indian pied kingfisher, Golden oriole, Blue magpie, Black Bulbul, Babbler, etc. and wild animals like Kashmir Stag, Leopord, Jackal, Hill fox, Himalayan Black Bear, Snow Leopord, Human langur, Musk deer, Leopord Cat, Himalayan Marmot, Flying Squirrel, Himalayan mouse, etc. The study was carried out at lower Dachigam on seasonal basis in two different ecosystems viz.; site- I (village site falls towards the periphery but inside the official boundary of the park) and site- II (protected site located within the heart of the park) (Map 1).

Vegetation analysis

Numerous field surveys were conducted to study the community composition and other phytosociological characteristics at two selected sites during spring (March-May), summer (June-August), autumn (September-November) and winter (December-February) in 2010-2011. Phytosociological attributes of shrub species were studied by randomly laying 6 quadrats of 5 × 5 m size at each site (Sharma et al., 1983). Specimen of plant species encountered at each site during the study period was collected in flowering/fruiting stages and the specimens were identified at Centre of Plant Taxonomy Department of Botany, University of Kashmir. The plant material was processed using standard herbarium techniques (Rao and Jain, 1977). The vegetation data recorded quantitatively was analyzed for density, frequency and abundance following Curtis and McIntosh (1950). The relative values of these indices were determined using Phillips (1959). These values were summed up to get importance value index (IVI) of individual species (Curtis, 1959). The ratio of abundance to frequency (A/F) for different species was determined by eliciting the distribution pattern (Curtis and Cotton, 1956). Species diversity (H) was computed by using Shanon Wiener Information Index (Shanon-Wiener, 1963). Concentration of dominance was calculated according to Simpson (1949). The species richness or the variety component (R) was determined using Margalef (1958) while species evenness (E) and similarity index (S) both were determined using Pielou (1966) and Sorenson (1948), respectively.

RESULTS

A total of 13 shrub species were reported from site I (village site) and 22 shrub species from site II (protected site) (Tables 1 and 2). Same results were shown by Alhassan et al. (2006). Among all the species, *Plectranthus rugosa* showed highest values of density (35.23),

Map 1. Map of Dachigam National Park, Kashmir India.

Table 1. Community features of shrubs at site I of Dachigam National Park during different periods of study.

S/N	Species	D	RD	A	RA	F	RF	A/F	IVI	R.IVI
1	*Berberis lycium*	4.54	5.07	7.85	6.35	54.71	8.16	0.143	19.59	6.53
2	*Cotoneaster nummilaria*	7.68	8.57	7.89	6.38	97.85	14.61	0.08	29.56	9.86
3	*Daphnae oleoides*	6.67	7.44	9.03	7.31	72.62	10.84	0.124	25.59	8.53
4	*D. mucronata*	1.91	2.13	5.75	4.65	33	4.92	0.174	11.72	3.91
5	*Indigofera heterantha*	12.49	13.94	13.85	11.21	89.37	13.34	0.154	38.49	12.83
6	*Lonicera quinqueloculari*s	1.16	1.29	2.33	1.88	50	7.46	0.0466	10.63	3.54
7	*Parrotiopsis jacquemontiana*	0.16	0.17	1	0.81	16	2.38	0.0625	3.36	1.12
8	*Plectranthus rugosa*	35.23	39.34	35.62	28.84	97.87	14.61	0.363	82.79	27.59
9	*Rosa macrophylla*	1.5	1.67	9	7.28	16	2.38	0.562	11.33	3.78
10	*R. webbiana*	15.8	17.64	18.21	14.74	87.25	13.02	0.208	45.4	15.13
11	*Rhamnus purpureus*	0.33	0.36	2	1.62	16	2.38	0.125	4.36	1.45
12	*Spirea canscens*	0.33	0.36	2	1.62	16	2.38	0.125	4.36	1.45
13	*Ziziphus jujuba*	1.74	1.94	8.95	7.24	23.28	3.47	0.384	12.65	4.21
	Total	89.54	100	123.48	100	669.95	100	2.5511	300	100

Where D=density; RD=relative density; F=frequency; RF=relative frequency; A=Abundance; RA=relative abundance; IVI=importance value index; RIVI=relative importance value index.

abundance (35.62) and frequency (97.87%) at site I while at site II, *Indigofera heterantha* showed highest density values (65.54) as well as frequency values (100%) and *Clematis montana* showed highest abundance values (19.91). Out of the total shrub species encountered at both sites during different seasons, 16 species were highly dominant based on importance value index (IVI). Dominant species based on IVI during all seasons at site I were *P. rugosa* (82.79), *Rosa webbiana* (45.40), *I. heterantha* (38.49), *Cotoneaster nummilaria* (29.56), *Daphnae oleoides* (25.59), *Berberis lyceum* (19.59), *Zyzephus jajuba* (12.65) whereas at site II dominant species recorded were *I. heterantha* (56.73), *C.s montana* (29.61), *Rosa macrophylla* (23.69), *Clematis grata* (22.39), *Rosa brunoni* (20.06), *Jasminum officinale* (14.63), *B. lyceum* (13.97) and *Rubus niveus* (12.09). Different diversity indices recorded at both sites are presented in Table 3. The perusal of the data revealed that diversity index (H),

Table 2. Community features of shrubs at site II of Dachigam National Park during different periods of the study.

S/N	Species	D	RD	A	RA	F	RF	A/F	IVI	R.IVI
1	*Berberis lycium*	5.55	3.38	8.09	4.98	63	5.61	0.128	13.97	4.65
2	*Cotoneaster nummilaria*	2.5	1.54	3.3	2.04	49.6	4.42	0.066	8	2.66
3	*C. insignis*	1.87	1.14	4.45	2.74	41.5	3.69	0.107	7.57	2.52
4	*C. accuminatus*	1.16	0.71	3.5	2.15	33	2.94	0.106	5.8	1.93
5	*Clematis grata*	11.05	6.79	14.91	9.19	72	6.41	0.207	22.39	7.47
6	*C. montana*	18.59	11.42	19.91	12.27	66.5	5.92	0.299	29.61	9.87
7	*Crataegus songerica*	0.36	0.21	2	1.23	16	1.42	0.125	2.86	0.95
8	*Indigofera heterantha*	65.54	40.28	12.23	7.54	100	8.91	0.122	56.73	18.92
9	*Jasminum humile*	1.38	0.85	3.77	2.33	33	2.94	0.114	6.12	2.04
10	*J. officinale*	6.55	4.02	9.23	5.69	55.31	4.92	0.166	14.63	4.87
11	*Lonicera quinquelocularis*	3.12	1.91	4.74	2.93	58	5.16	0.081	10	3.33
12	*L. aspersifolia*	1.83	1.12	3.63	2.23	50	4.45	0.081	7.8	2.6
13	*Rosa webbiana*	8.59	5.27	10.52	6.48	69.8	6.22	0.15	17.97	5.99
14	*R. macrophylla*	12.05	7.41	15.2	9.37	77.64	6.91	0.195	23.69	7.89
15	*R. brunoni*	9.75	5.99	12.6	7.76	70.75	6.31	0.178	20.06	6.69
16	*Rubus niveus*	3.79	2.32	9.63	5.93	43.2	3.84	0.222	12.09	4.03
17	*R. fruticosa*	1.74	1.06	4.16	2.57	41.5	3.69	0.101	7.32	2.45
18	*R. ellipticus*	1.66	1.02	3.33	2.05	50	4.45	0.0666	7.52	2.51
19	*R. ulmifolia*	2.16	1.32	6.5	4.01	33	2.94	0.1969	8.27	2.76
20	*Spirea canscens*	0.83	0.52	2.5	1.54	33	2.94	0.075	5	1.66
21	*Sorbaria tomentosa*	0.33	0.21	1	0.61	33	2.94	0.0303	3.76	1.25
22	*Spastiun junceum*	2.33	1.43	7	4.32	33	2.94	0.212	8.69	2.89
	Total	**162.73**	**100**	**162.2**	**100**	**1122.8**	**100**	**3.0288**	**300**	**100**

Where D=density; RD=relative density; F=frequency; RF=relative frequency; A=abundance; RA=relative abundance; IVI=importance value index; RIVI=relative importance value index.

Table 3. Spatial variation in diversity, richness, evenness, dominance and similarity indices of shrubs at different study sites.

Indices / Sites	Diversity(H')	Dominance (C)	Richness (R)	Evenness(E)	Similarity index
I	-1.4635553	0.234732295	0.490918016	-0.44057404	37.5
II	-2.228731579	0.078809577	0.867850098	0.499779292	

evenness index and richness index maximum value were obtained at site II (H=2.228, E=0.499 and R=0.867) than site I (H=1.463, E=0.440 and R=0.490). However, dominance index revealed an inverse trend to that of Shannon diversity with lowest values reported at site II (C =0.078) and highest at site I (C=0.234). Same were the findings of Kharkwal et al. (2004). The abundance to frequency ratio (A/F) indicated that most of the species at site I performed contagious pattern of distribution except *Lonicera quinquelocularis* showing random distribution while as at site II *Sorbaria tomentosa* showed slightly random distribution and the rest of the species showed a contagious type of distribution. The results are in consonance with the findings of Shadangi and Nath (2005).

DISCUSSION

Species diversity is considered to be one of the key parameters characterizing ecosystem and a major component of ecosystem functioning (Hutchenson, 1959). Species diversity, considered to be an outcome of the evolution of species in a biogeographic region is often a synthetic measure of the structure, complexity and stability of the ecosystem (Hubble and Foster, 1983). Species diversity is also important for the stability and proper functioning of ecosystems (Schlapfer et al., 1999), however, with increasing disturbance in the vegetation, the plant species diversity, richness and evenness are significantly reduced (Dar and Kaul, 1987). Diversity is a combination of two

factors: the number of species present, referred to as species richness and the distribution of individuals among species, referred to as species evenness or equability. Species diversity therefore, refers to the variation that exists among the different life forms. In the present study, general structure of vegetation depicts that the species number was greater at site II (22) than at site I (13). The reason for maximum number of species at site I could be due to more availability of soil moisture and other environmental factors present in this area due to more vegetation cover (Alhassan et al., 2006). Comparatively, results of Shannon diversity at both sites fall within the range of the study carried out by Kiss et al. (2004).The species diversity was lower at site I (1.463) than site II (2.228) owing to adverse climatic conditions at this site (Shadangi and Nath, 2005) or lower rate of evolution and diversification of communities (Fischer, 1960). However, highest species diversity at site II might be due to the moderate level of grazing or anthropogenic disturbances and invasion of new species (Connell, 1978). Several studies mentioned similar results pertaining to the present study emphasizing moderate level of grazing promoted species diversity (Rikhari et al., 1993). However, others like Lubchenco (1978) considered it as a positive force that might increase species diversity in the community by preventing competitive exclusion by dominant species. The highest values of dominance index at site I (0.234) and lowest values (0.078) at site II having inverse relationship with diversity index (H) were also reported by Kharkwal et al. (2004). The lower value of dominance at controlled forest site showed that dominance of shrub layer is shared by many species. The Pielou's indices at both sites were 0.440 (site I) and 0.499 (site II), indicating low dominance and more or regular distribution of shrub species at both sites. Lower richness values (0. 490) at site I could be due to dry environmental conditions and also to slow growth rate, and maximum value (0.867) at site II could be due to favourable climatic conditions (Abdullah et al, 2009).

Species grow together in a particular environment because they have similar requirements for existence in terms of environmental factors such as light, temperature, water and soil nutrients and drainage etc. or they may also share the ability to tolerate the activities of animals and humans such as grazing, burning, cutting or trampling (Wood et al., 1994). It is generally argued that each individual species depends on some set of other species for its continued existence and the species have co-evolved in the ecosystem on which they depend (Paine, 1966). The loss of natural associations may be the probable reason for supporting low number of species (Walker, 1992). Ecological success, good power of regeneration and ecological amplitude of a species is governed by high IVI. Highest value of density and IVI by *P. rugosa* and *R. webbiana* indicate their dominance due to environmental suitability and ability of the species to survive grazing may be due to non-palatability or prickly nature, that is, adaption against herbivory or maximum utilization of available resource by that species (Kukshal et al., 2009). Difference in the species composition from site to site is mostly due to microenvironmental changes (Mishra et al., 1997). Abundance and frequency ratio (A/F) ratio were in consonance with the study of Shadangi and Nath (2005), Greig-Smith (1957) etc., which reveals that most of the species were contagiously distributed whereas as regular distribution was reported almost negligible during present study. Dominance of contagious distribution may be due to the fact that the majority of species reproduce vegetatively in addition to their sexuality. Odum (1971) described that in natural conditions, contagious distribution is the most common type of distribution and is performed due to small but significant variation in environmental conditions while random distribution is found only in very uniform environment. The Sorensen's similarity index shows that lower degree of similarity between sites I and II may be due to the different habitat conditions, non adjacent location or varied biotic interference at these sites.

Conclusion

The study concluded that with increasing disturbance in the forest vegetation, the plant species diversity, richness and evenness are significantly reduced and increase in shrub diversity and evenness at protected site may be due to less competition and availability of more space and nutrients or due to less or controlled biotic stresses. There is an urgent need to improve the vegetation cover at site I which could be achieved through regular monitoring of livestock grazing and biotic interference in addition to providing alternate grazing sites for livestock that will certainly tend to regenerate the vegetation of such threatened areas. However, increasing human activities like fuel fodder collection, harvesting of medicinal herbs, burning of ground vegetation inside the national park needs prime and immediate attention for sustainability. It is further recommended that species with low IVI need to be restored on priority basis by providing protection which ultimately help in regeneration process to maintain diversity in the selected sites.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Abdullah MB, Sanusi SS, Abdul SD, Sawa FBJ (2009). An Assessment of the Herbaceous Species Vegetation of Yankari Game Reserve, Bauchi, Nigeria. Am-Eur. J. Agric. Environ. Sci. 6(1):20-25.

Alhassan AB, Chiroma AM, Kundiri AM (2006). Properties and

classification of soils of Kajimaram oasis of Northeast Nigeria. Int. J. Agric. Biol. 8:256-261.
Bargali K, Bargali SS, Singh RP (1998). Ecological relationship of Bidens biternata and Galingsonga ciliata in open and closed habitats. Ind. J. Ecol., 25(2):107-113.
Basiri R (2003). Ecolgogical study on Quercus libani site by analyzing environmental features in Marivan. Ph. D Thesis University of Tarbiat Modarres.
Connell JH (1978). Diversity in tropical forests and coral reefs. Science, 1999:1302-1310.
Curtis JT, Cotton G (1956). Plant Ecology Workbook: Laboratory Field Reference Manual. Burgess Publishing Co., Minnesota. p.193.
Curtis JT, McIntosh RP (1950). The interrelation of certain analysis and systematic phytosociological characters. Ecology 31:434-455.
Curtis JT (1959). The vegetation of Wisconsin: An ordination of plant communities. University of Wisconsin Press Madison, Wisconsin. p.657.
Dar GH, Bhagat RC, Khan MA (2001). Biodiversity of Kashmir Himalaya. Valley Book House, Srinagar, J & K, India.
Fischer AG (1960). Latitudinal variation in organic diversity. Evolution 14:64-81.
Gaston KJ, Spicer JL (2004). Biodiversity: an introduction. 2nd ed. Oxford, Blackwell Science. p.191.
Greig-Smith P (1957). Quantitative plant ecology, 2nd ed. Butterworth, London.
Hannah L, Bowels I (1995). Global priorities. Biol. Sci. 45:122-132.
Hubble SP, Foster RB (1983). Diversity of canopy trees in a neo-tropical forest and implications to conservation. Tropical Rain Forest: Ecol. Manage., (Sutton L, T. C.) pp. 25-41
Hutchinson GE (1959). Homage to Santa Rosalia, or why are there so many kinds of animals? Am. Nat. 93:145–159.
Kachroo P, Singh G (1976). Forest flora of Srinagar and plants of neighbourhood. Bishen Singh Mahendra Pal Singh, Dehradun, India
Kharkwal GP, Mehrotra RYS, Pangtey YPS (2004). Comparative study of herb layer diversity in pine forest stands at different altitudes of central Himalaya. Appl. Ecol. Environ. Res. 2(2):15-24.
Kiss T, Sipos G, Bodis K, Barta K (2004). Community composition, species diversity, and secondary succession in grazed and ungrazed alpine meadows of the west Himalaya, India. Int. J. Field work Stud. 2:1.
Kukshal S, Nautiyal BP, Anthwal A, Sharma A, Bhat AB (2009). Phytosociological investigation and life form pattern of grazing landsunder pine canopy in temperate zone, Northwest Himalaya, India. Res. J. Bot. 4:55-69.
Loreau M, Naeem S, Inchausti P (eds). (2002). Biodiversity and ecosystem functioning. Oxford, University Press. p.294.
Lubchenco JL (1978). Plant species diversity in a marine inter-tidal community: importance of herbivore food preference and algae competative abilities. Am. Nat. 112:23-29.
Margalef R (1963). On certain unifying principles in Ecology. Am. Nat. 97:357-374.
Mishra D, Mishra TK, Banerjee SK (1997). Comparative phytosociological and soil physic-chemical aspects between managed and unmanaged lateritic land. Ann. For. 5(1):16-25.
Odum EP (1971). Fundamentals of Ecology. Saunders Co., Philadelphia.
Paine RT (1966). Food-web complexity and species diversity. Am. Nat. 100:65-75.
Phillips EA (1959). Methods of vegetation study. Henry Holt and Co. Inc; New York. p.318.
Pielou EC (1966). Species diversity and pattern diversity in the study of ecological succession. J. Theor. Biol. 10:370-383.
Rikhari HC, Negi GCS, Ram J, Singh SP (1993). Human-induced secondary succession in alpine meadow of Central Himalaya, India. Art. Alp. Res. 25:8-14.
Schlapfer F, Schmid B, Seidl I (1999). Expert estimates about effects of biodiversity on ecosystem processes and services. Oikos, 84:346-352.
Shadangi DK, Nath V (2005). Impact of seasons on ground flora under plantation and natural forest in Amarkantak. Ind. For. 131(2):240-250.
Shaforth PB, Stromberg JC, Patten DT (2002). Riparian vegetation response to altered disturbance and stress regimes. Ecol. Appl. 12:107-123.
Sharma SK, Georga M, Prasad KG (1983). Forest vegetation survey and classification with special reference to South India. 1. Vegetation survey and quadrate analysis. Ind. For. 109(6):384-394.
Simpson EH (1949). Measurement of diversity. Nature 163:688.
Vitousek PM (1994). Beyond global warming: ecology and global change. Ecology 75:1861-1876.
Walker BH (1992). Biodiversity and ecological redundancy. Conserv. Biol. 6:18-23.
Wilson EO (1985). The biological diversity crisis. Bio-science 35:700-7006.
Wood J, Low AB, Donaldson JS, Rebelo AG (1994). Threats to Plant Species Diversity through Urbanization and Habitat Fragmentation in the Cape Metropolitan Area, South AfricaIn: Huntely BJ (Ed.) Strelitzia 1, Botanical diversity in South Africa. Proceedings of a Conference on the Conservation and Utilization of Southern African Botanical Diversity. Cape Town, September 1993. Pretoria: National Botanical Institute. pp: 259-274.
Yachi S, Loreau M (1999). Biodiversity and ecosystem productivity in a fluctuating environment: The insurance Hypothesis. Proc. Nat. Acad. Sci., USA. 96:1463-1468.