Cey. J. Sci. (Bio. Sci.) Vol.30, 2002, 37-54

CLIMATE OF SINHARAJA RAIN FOREST, SRI LANKA: AN ATTEMPT TO UNDERSTAND THE EL-NIÑO AND LA-NIÑA EVENTS

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ABSTRACT

To understand the dynamics of tropical forest ecosystems, it is necessary to analyze their climate over a long term. For this reason, time plots were prepared for three climatic parameters (rainfall, maximum and minimum temperatures and the number of dry days) of the time series (1984 – 2000) in Sinharaja MAB Reserve, in south west of Sri Lanka. Annual, seasonal and monthly scales of these parameters were studied to find out the differences between El-Niño and non El-Niño years. Two out of three El-Niño events showed a wet season irradiance in May confirming similar observations recorded through out the tropics.

Key words

El-Niño, Climatic change, Wet season irradiance, Sinharaja

INTRODUCTION

Climate defined as the average weather over a long period (Houghton *et. al.*, 1990), is the major determinant of the distribution of forests (Anon., 1991) and it's diversity. It has important ecological implications and is also responsible for some of the differences in species composition, structure, productivity and dynamics found between rain forests (Richards, 1996).

As stated by Richards (1996), the climate of tropical rain forest regions is hot and wet. Sri Lanka has a tropical monsoon climate (Anon., 1991). The average annual rainfall has considerable spatial variations in the island and its distribution is influenced by several factors such as the two monsoon wind regimes, Inter Tropical Convergence Zone (ITCZ), convection, orography and cyclonic wind circulation. The rainfall has marked seasonal variations. Based on this, five distinct seasons within one climatic year can be recognized as follows: i. Convectional - convergent period (March - mid April); ii. the pre-monsoon period (mid April - late May); iii. Southwest monsoon period (late May - late September); iv. the convectional cyclonic period (late September - late November) and v. the North-east monsoon period (November- February) (Anon., 1991).

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According to recent studies (Lazaro *et al.*, 2001), on an annual scale rainfall patterns affect floristic composition and grassland biomass and the seasonal variations of rainfall affect the phenology and growth of forest trees.

Therefore, analysis of various climatic elements like rainfall records over long periods provide information about the rainfall variability and helps one to understand the 'natural' behavior of the vegetation. Consequently, the impact of changes can be identified and effective management strategies can be developed (Lazaro *et al.*, 2001).

During the past few decades, increasing attention of the global community has been focused mainly on climatic changes. El-Niño and La-Niña are two such events, which are the cause of inter-annual climatic variations in the tropics. The atmospheric component, termed Southern Oscillation Phenomenon, refers to the inter-annual changes, normally over a cycle of 3-4 years, in pressure distribution and atmospheric circulation over the tropical belt. In normal years, Southern Oscillation Index (SOI), which refers to the normalized value of the surface air pressure difference between Darwin and Tahiti, provided by the Japan Meteorological Agency (JMA), is strongly positive with high pressure over the Central South Pacific and low pressure over Indonesia and northern Australia. Walsh (1996) has pointed out that El-Niño Southern Oscillation (ENSO) events tend to commence in March to May and last for a year and some time longer. He has further stated that the ENSO events, however vary greatly in strength, geographic impact and the relative timing of the oceanic and atmosphere components. Only the stronger events tend to lead to a significant drought in Malaysia.

During an El-Niño event, temperature increases by 0.5°C to 1°C throughout the tropics (Joseph and Caldero, 1999). They have further stated that, El-Niño events bring drought to Southern Central America, Amazon and parts of West Africa, India and Malaysia. In contrast to El-Niño events, La-Niña events bring cooler temperatures, cloudier conditions and above normal rainfall to the same region. According to the World Meteorological Records, El-Niño conditions have been recently observed in 1986-1987, 1991-1992, 1997 and La-Niña conditions in 1985, 1988, 1993 and in 1998.

Considering the impacts of the El-Niño years, Ropelewski and Halpert (1987) pointed out an ENSO - related summer monsoon precipitation deficiency in northern central Peninsular India and an enhanced ENSO - related winter monsoon precipitation in extreme southern India, Sri Lanka and Minicoy. This is further confirmed by Houghton *et al.*, (1990). They have pointed out that consistent ENSO precipitation signals were clearly visible in the October-November-December period for the South East Asian Region.

The purpose of this paper is to provide a descriptive analysis of the climatic elements of Sinharaja International Man and Biosphere Reserve and World Heritage site for the past seventeen years (1984-2000). In doing so, an attempt would be made to compare the climate of the El- Niño events with that of

La-Niña years as a basis for a future study on the relationship between climate and vegetation related processes. The specific objectives were to document (i) the annual monthly and daily variation in rainfall, (ii) the annual monthly and daily variation in temperature and (iii) the variation in the droughts and dry periods over this 17-year period in the northwestern part of Sinharaja.

GEOGRAPHICAL SETTING

Sinharaja International Man and Biosphere (MAB) Reserve and World Heritage Site (6^0 21 - 6 ^{0} 27 N and 80^0 21 - 80^0 38 E) is located in the wet zone lowlands of Sri Lanka (Fig.1). It spans over the administrative districts of Ratnapura, Galle and Matara. Sinharaja is a large (11,250 ha) patch of mostly primary mixed dipterocarp and lower montane forests extending across an altitudinal range of 210 to 1180 m (Gunatilleke *et al.,* 1996). The topography is one of a series of parallel ridges with intervening valleys (Ashton *et al.,* 1995). The common rock types are khondolites, garnetiferous charnokites and recent and sub recent gravels, sands and clays (Gunatilleke and Gunatilleke, 1981).

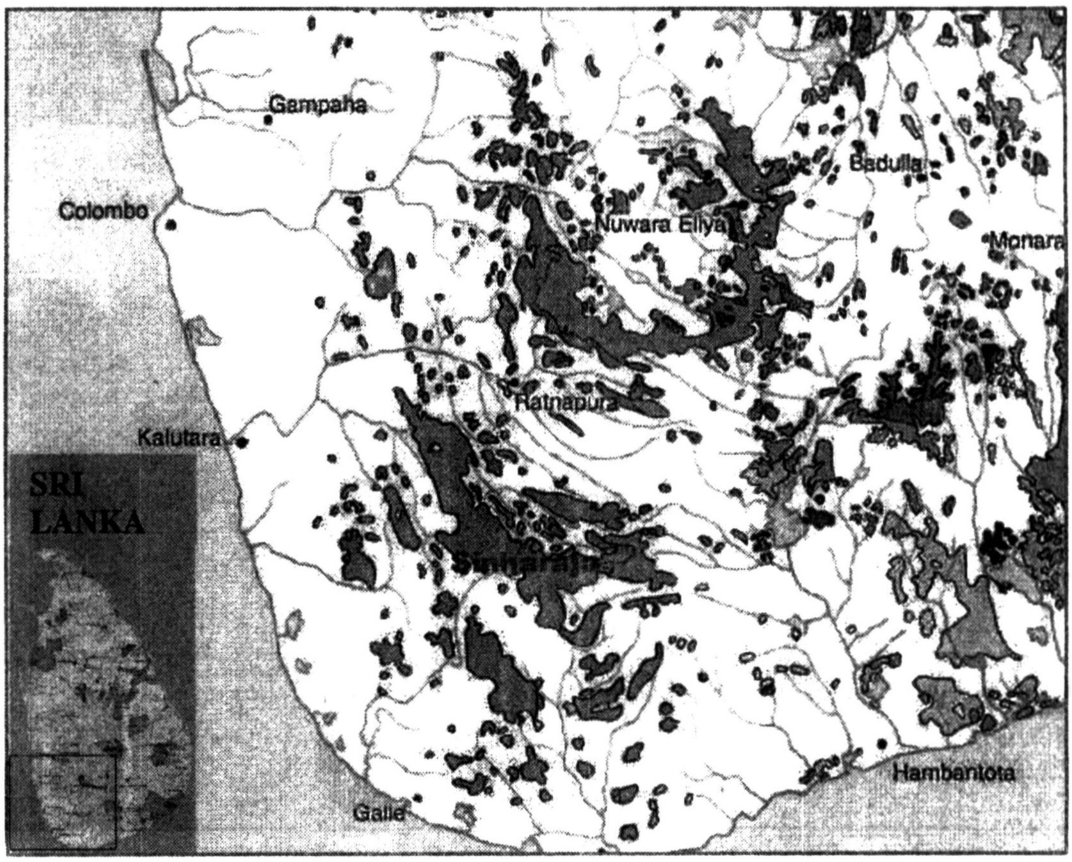

Figure 1. Map showing the forests (shaded areas) in the Southwest of Sri Lanka (Source: Somasekaram *et al.,* 1997).

Sinharaja forest, now recognized as a biologically unique ecosystem because of it's high components of endemic tree species (>60%), is one of the least degraded forest areas in Sri Lanka. Anon., (1991) has described it as a model for optimal and sustainable use of species rich tropical rain forest found in Sri Lanka. It was declared as an International Man and Biosphere Reserve (MAB) and a World Heritage Site by UNESCO in 1978 and 1988, respectively.

The mean annual rainfall recorded for the area ranges from 3,750 - 5,000 mm, mainly from the south west monsoon during May to July and north east monsoon during November to January. The mean annual temperature ranges between 25^0C to 27^0C (Ashton, 1992).

MATERIALS AND METHODS

The field research station in the north-western part of the Sinharaja MAB reserve provides a weather data series long enough for use as an area reference. This part of the forest had been selectively logged during the period of 1972 to 1978. This weather data consists of daily rainfall and daily maximum and minimum temperatures. The days without rain were considered as dry days. All the observations were standardized by setting them along a continuous day numbering system starting with the first day of all observations in 1984 for further analyses.

Using the daily rainfall, daily maximum and minimum temperatures, the mean monthly values for each parameter were calculated and these values were used for further analyses and for constructing time plots.

A climatic diagram was constructed using the system of Walter and Lieth (1960). The temperature scale of the graph from 0^0 to 50^0 C is as large as the rainfall scale from 0 to 100 mm and the rainfall scale above 100 mm is reduced by the factor of 10 (Fig. 2).

As pointed out by Walsh (1996), the mean monthly values give an incomplete and often misleading picture of dry periods, because averages fail to give the true number of dry periods. Therefore, as an alternative to the above, he has suggested that a monthly rainfall data series should be used. In this paper, dry periods were analysed based on the method adopted by Walsh (1996). In this analysis, a dry month is defined as a month receiving less than 100 mm rainfall, when the monthly potential transpiration of lowland tropical forests is at a level leading to soil water deficits and plant water stress (Walsh, 1996).

The Per Humidity Index (PI), which measures the degree of continuity of wetness of the annual rainfall regime, was also calculated. It ascribes positive and negative scores to monthly rainfall means depending on the extent to which they fall below or exceed 100 mm. The annual index value varies from (-) 24 as in deserts, where all monthly means are <50 mm to (+) 24 where all monthly means exceed 200 mm. Tropical rain forest areas have PI values within the range (+) 5 to (+) 24. The PI values were calculated using the following scores (Richards, 1996). A very wet month (>200 mm) = (+) 2; a wet month (100-199 mm) = (+) 1; a dry month (50-99 mm) = (-) 1; a drought month (<50 mm) = (-) 2; the first dry month following a wet month = (-) 0.5 and the first drought month following a wet month = (-) 1.5. Then the monthly scores were summed to obtain the PI values for the year.

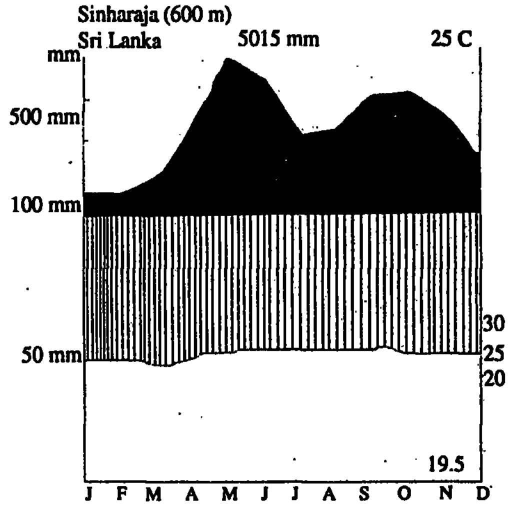

Figure 2. Climatic diagram for Sinharaja rain forest station. The diagram mostly follows the convention of Walter and Leith (1960) and Richards (1996). The station name line also gives the station altitude (m), mean annual temperature (^{0}C) and mean annual rainfall (mm). The means have been calculated for the period 1986-2000. The Per Humidity Index (PI) value is given at the bottom right corner of the graph.

RESULTS

Annual rainfall variations

Over the 17-year period of 1984-2000 the mean annual rainfall at Sinharaja was 5,016 ± 632 mm. It varied from a low of 4087 mm in year 2000 to a high of 5907 mm in 1993 (Table 1a). Over this period, each two, three and five year shifting average for the annual rainfall recorded was 5,023 ± 457 mm, 5,003 ± 319 mm and 4997 ± 234 mm, respectively (Table 1b).

During the 1986/1987 and 1991/1992 El-Niño years annual rainfall (4309, 4253, 4287 and 4522 mm respectively) was below the 17-year average (5016 mm), but in the El-Niño year of 1997 it was 5491 mm, 10% more than the annual mean for the 17 year period. La-Niña years (1985, 1988, 1993 and 1998) where there is above average rainfall either preceding or following an El-Niño year, were also observed during the period of study (Table 1a). Three La–Niña episodes (1988, 1993, 1998) that followed El–Niño years in chronological order had 5576, 5907 and 5363 mm rainfall higher than the 17 year average, but in the 1986/1987 El-Niño event, the year preceding (1985) had a high rainfall of

5851 mm. In all these La-Niña years the values were much higher than the 17-year mean annual rainfall of 5016 mm.

Table 1A

Variation in the number of rainy days in different years at Sinharaja during the study period (1984-2000).

Years	Annual Rainfall (mm)	Number Rainy of Days			
		1-25 mm	26 - 75 mm	>75 mm	Total
Normal Years					
1984	5693	149	80	0	229
1989	5208	158	47	13	218
1990	4119	149	54	5	208
1994	5003	170	56	10	236
1995	5435	136	71	10	217
1996	4920	155	45	12	212
1999	5241	144	68	8	220
2000	4087	161	37	9	207
La-Niña Years					
1985	5851	154	65	15	234
1988	5576	146	60	15	221
1993	5907	162	51	16	229
1998	5363	145	60	13	218
El-Niño Years					
1986	4309	167	51	5	223
1987	4253	152	46	9	207
1991	4287	160	53	7	220
1992	4522	152	41	11	204
1997	5491	140	57	14	211

Table 1B

Variations of the 2-10 Shifting Averages (SA) of annual rainfall for the study period at Sinharaja.

Year	Annual Rainfall (mm)	Shifting Averages (SA) Year								
		2	3	4	5	6	7	8	9	10
1984	5693									
1985	5851	5772								
1986	4309	5080	5284							
1987	4253	4281	4804	5027						
1988	5576	4915	4713	4997	5136					
1989	5208	5392	5012	4837	5039	5148				
1990	4119	4664	4968	4789	4693	4886	5001			
1991	4287	4203	4538	4798	4689	4625	4800	4912		
1992	4522	4405	4309	4534	4742	4661	4611	4766	4824	
1993	5907	5215	4905	4709	4809	4937	4839	4773	4712	4973
1994	5003	5455	5144	4930	4768	4841	4946	4859	4745	4904
1995	5435	5219	5448	5217	5031	4879	4926	5007	4976	4862
1996	4920	5178	5119	5316	5157	5012	4885	4925	5007	4923
1997	5491	5206	5282	5212	5351	5213	5081	4961	4982	5047
1998	5363	5427	5258	5302	5242	5353	5234	5116	4956	5026
1999	5241	5302	5365	5254	5290	5242	5337	5235	5158	5029
2000	4087	4664	4897	5046	5020	5090	5077	5181	5249	5026
Mean	**5016**	**5023**	**5003**	**4998**	**4998**	**4991**	**4976**	**4973**	**4956**	**4973**
Stdev	**633**	**457**	**319**	**243**	**235**	**228**	**203**	**162**	**177**	**69**

Monthly rainfall variations and per humidity index

Monthly mean values in rainfall during the 17-year study period from 1984 to 2000 varied from a low of 171 mm for February to a high of 695 mm in May (Fig. 3). Two rainfall peaks were observed in May-June and September-October. Monthly rainfall averages have been widely used to give a general indication of the mean, length and timing of any dry season in tropical environments (Walsh, 1996). In that sense, January and February were relatively dry (171-191 mm/month) when compared to all the other months of the year (Figs. 3 & 4).

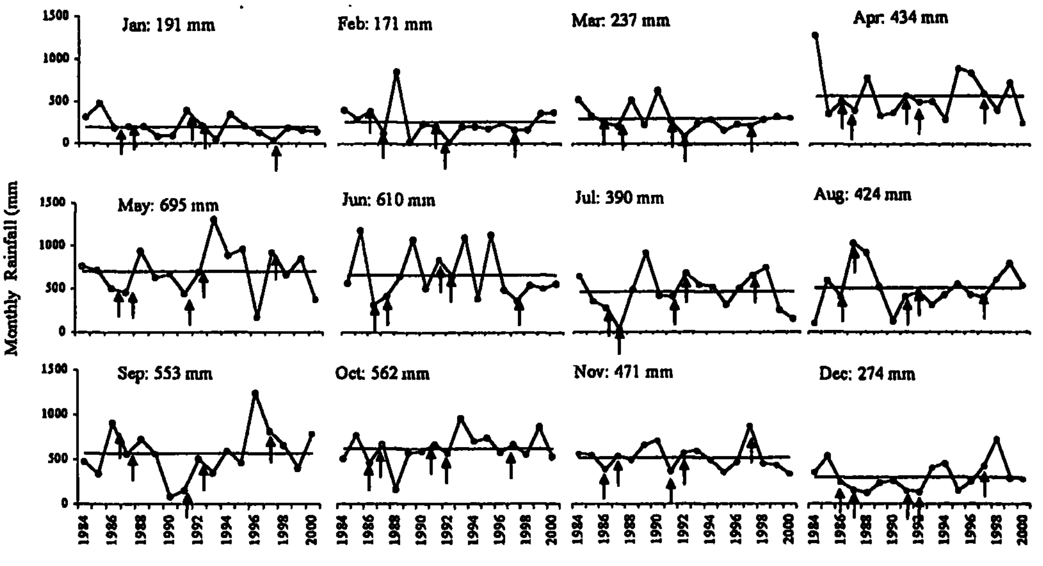

Figure 3. Monthly rainfall variation at Sinharaja forest from 1984 - 2000. The horizontal line and value given alongside each month, indicate the 17 year (1984-2000) mean monthly rainfall for that month. Vertical arrows indicate El-Niño years.

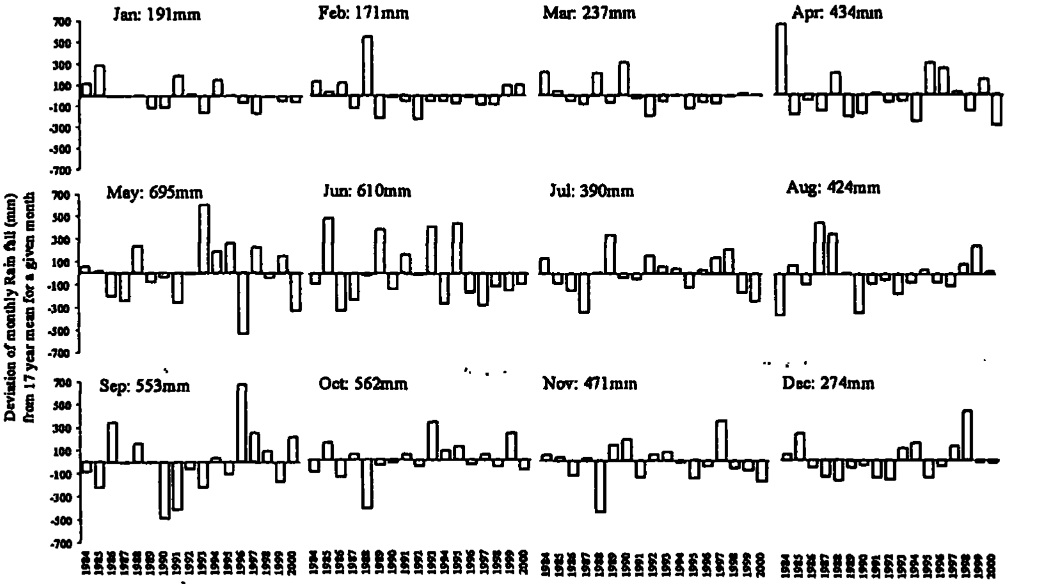

Figure 4. Deviation of monthly rainfall from their mean monthly values (indicated along side each month and the 0 line) at Sinharaja during the study period (1984-2000). (+) and (-) values indicate values greater and less than the monthly means respectively.

Of the 204 months over the study period (1984-2000), five months (two months each of January and February and one of July), which had less than 50 mm monthly rain, were observed as drought months. There were seven months (four in the months of January, February and March, and three in August and September), where the monthly rainfall was between 50-100 mm. As shown in Table 2, 33 months were wet and the remaining 158 months were very wet exceeding 200 mm rain per month. In three months of June and one each of May and September during this period the rainfall exceeded 1000 mm per month.

Table 2

Number of months over the study period (1984-2000) falling within a given rainfall category, in the Sinharaja forest reserve. Numbers in parenthesis indicate the number of months falling within the El-Niño year.

Month	Monthly rainfall (mm)													
	<49	50-99	100-199	200-299	300-399	400-499	500 599	600-699	700 799	800-899	900-999	1000-1099	1100-1999	>1200
Jan	2 (1)	2	8 (2)	1 (1)	3 (1)	1								
Feb	2 (1)	1 (1)	8 (2)	5 (1)	1									
Mar		1 (1)	7 (3)	6 (1)		2	1							
Apr			1	4	5 (3)	2 (2)	1	3			1			
May			1	1		3 (3)		4 (1)	2	2	3 (1)			1
Jun					4 (3)	4	4 (1)		1 (1)		1	2	1	
Jul	1 (1)		1	4 (1)	2 (1)	4	3 (2)	1	1					
Aug		2		2 (1)	7 (3)	2	1	1	1	1 (1)				
Sep		1	1 (1)	1	3	2 (1)	3 (1)	1	2	2 (2)				1
Oct			1		2 (1)	1	5 (1)	5 (3)	2	1				
Nov				1	4 (2)	6 (1)	4 (1)	1	1 (1)					
Dec			5 (3)	6 (1)	3 (1)	2		1						
Total Number of Months	**5**	**7**	**33**	**31**	**34**	**29**	**22**	**17**	**10**	**6**	**5**	**2**	**1**	**2**

Periodic rainfall variations

The rainfall received during the periods of January-April, May, June-August, September and October-December, of each year over the duration of the study, is given in Fig. 5. Out of the three El-Niño events, 1986/1987 and 1991/1992 had rainfall less than the averages for January-April, May, June-August (one year only), September (one year only) and October-December periods. In September 1986/1987, the rainfall observed was relatively high while it was below the average in 1991/1992. On the other hand during 1997, the rainfall measured was high in all seasons except January to April and June to August periods.

In most years during the study period, January to March, received between 100-300 mm rain while it was about 500 - 700 mm during April to June and 500-700 mm in September to October (Table 2).

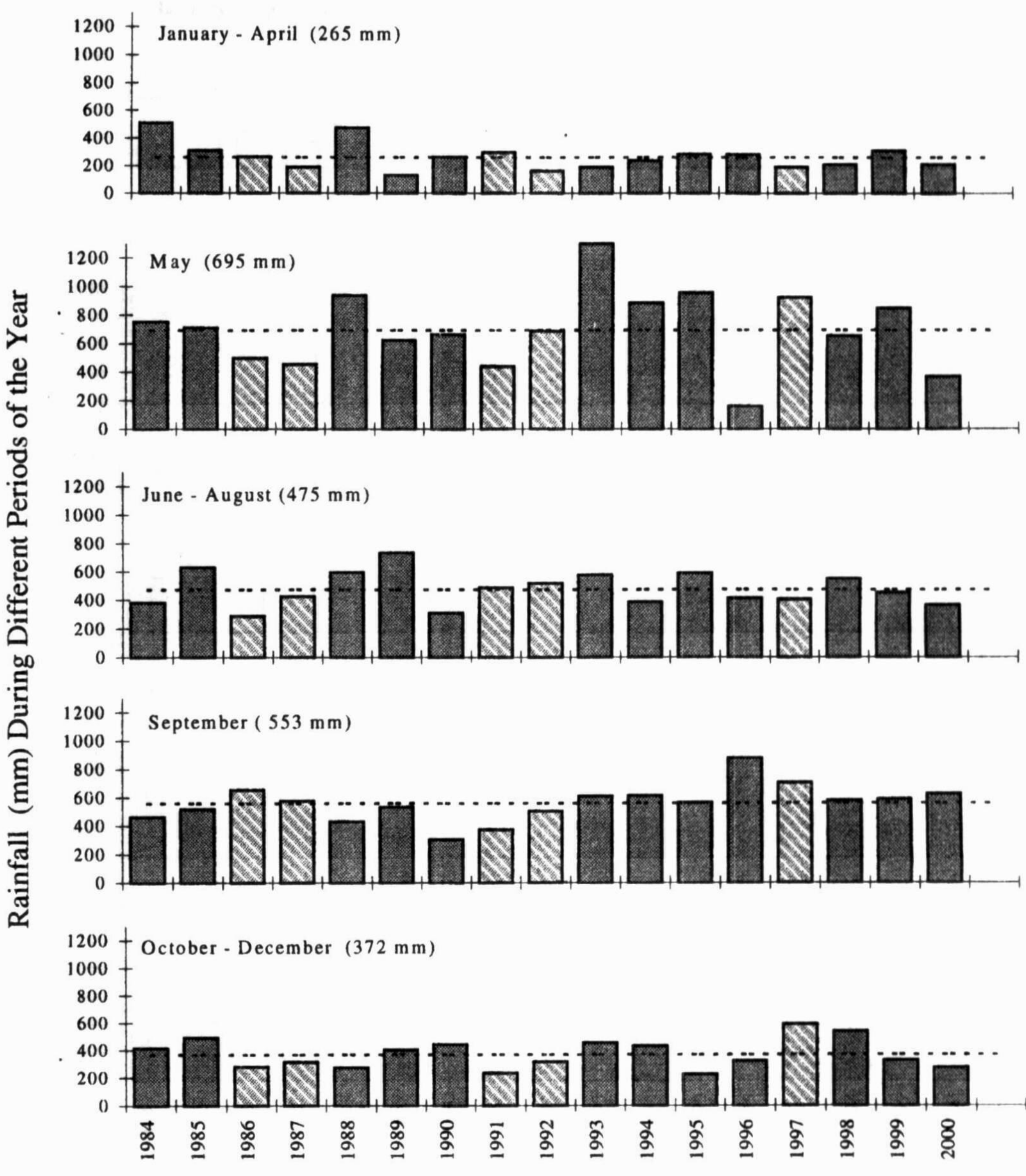

Figure 5. Monthly rainfall in five periods (January-April, May, Jun-August, September and October-December) each year recorded at the Sinharaja field station during the study period (1984-2000). Light coloured bars indicate the El-Niño years.

Minimum and maximum monthly rainfall

The minimum monthly rainfall during the study period ranged between 2-33 mm shown by a month of January, February and July and 65-75 mm in March, August and September (Table 2). In all other months minimum rainfall exceeded 100 mm. The maximum monthly rainfall values ranged between 310-474 mm in January/ February to between 1091-1300 mm in June, September and May, and in the remaining months between 503-871 mm.

According to the results of this study, different periods within an El-Niño event, respond differently. In Sri Lanka during an El-Niño year, the south west monsoon brings less rain (referred to as wet season irradiance), but the north east monsoon brings more rain, and the periods between them, that is, before the south west monsoon and after the north east monsoon are said to be drier. Our Sinharaja data were examined in the light of these observations and to some extent was in agreement with them (Fig. 5).

Daily rainfall variations

Month-wise variations in daily rainfall from their respective daily mean values were examined. The widest variation was observed in the months of May to July and September and the least in January-March. In 1986-1987 low rainfall was recorded in May to June and it was very low in July. On the other hand, it was slightly higher than the mean during August to September period. Unusually low daily rainfall conditions were observed in May (1996/97), August (1990), September (1990) and December (1992).

The total number of rainy days per year varied from 204 (1992) to 236 (1994) with a mean of 218 days per year (Table 1) during the study period. Rainfall per day (total amount of rainfall of a given month divided by the number of rainy days of that particular month) was low in January (12 mm per day) and it was high in May (27 mm per day). In June, September and October it was 24 mm per day (Fig. 6).

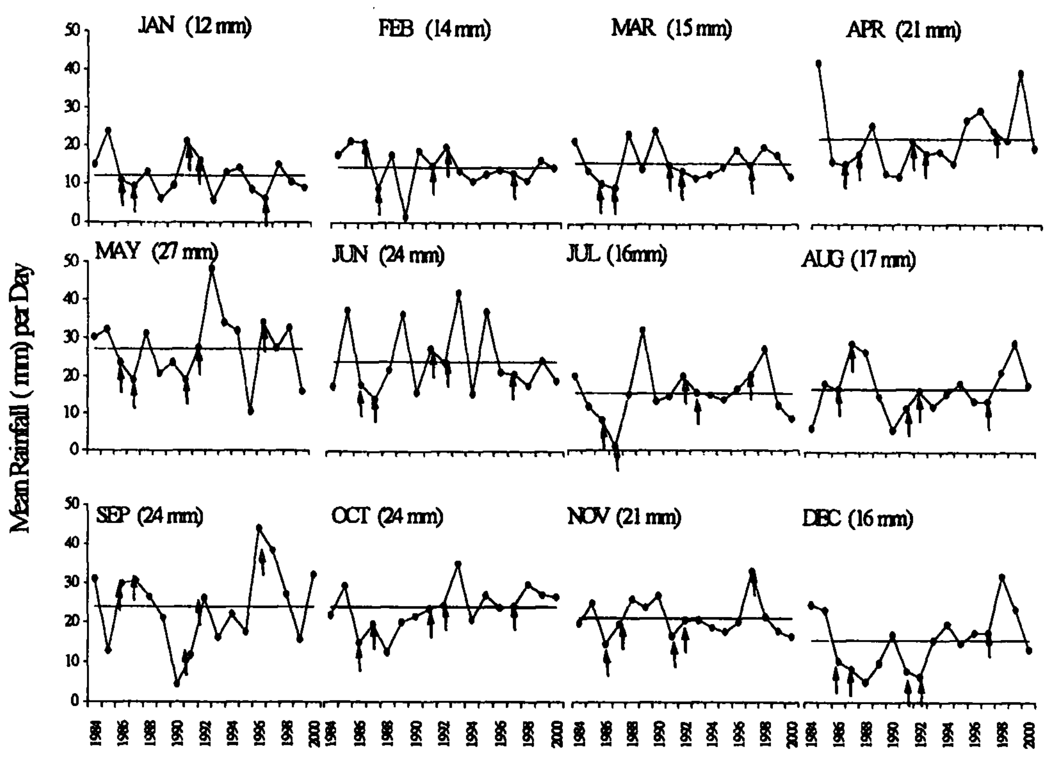

Figure 6. Mean rainfall per day (total monthly rainfall / number of rainy days of that month) for each month recorded in Sinharaja field station during the study period (1984-2000). Horizontal line indicates the 17-year average in rainfall for each month and the value is given in parenthesis. Vertical arrows indicate the El-Niño years.

Drought and dry periods

Over the study period (1984-2000), the months with the highest number of dry days (16 days) were January and February, while it was least 5-6 days in May and June (Fig. 7). December (13 days) and March (14 days) were also dry compared to the remaining months of the year. The total number of dry days/month varied from 0 (June 1984 and 1990, September 1986 and October 1994) to 27 (January 1997). The results shown in Figs. 8 and 9 indicate that during the El-Niño years of 1986-1987 and 1991-1992, the number of dry days recorded per year was high but in 1997 it was relatively low.

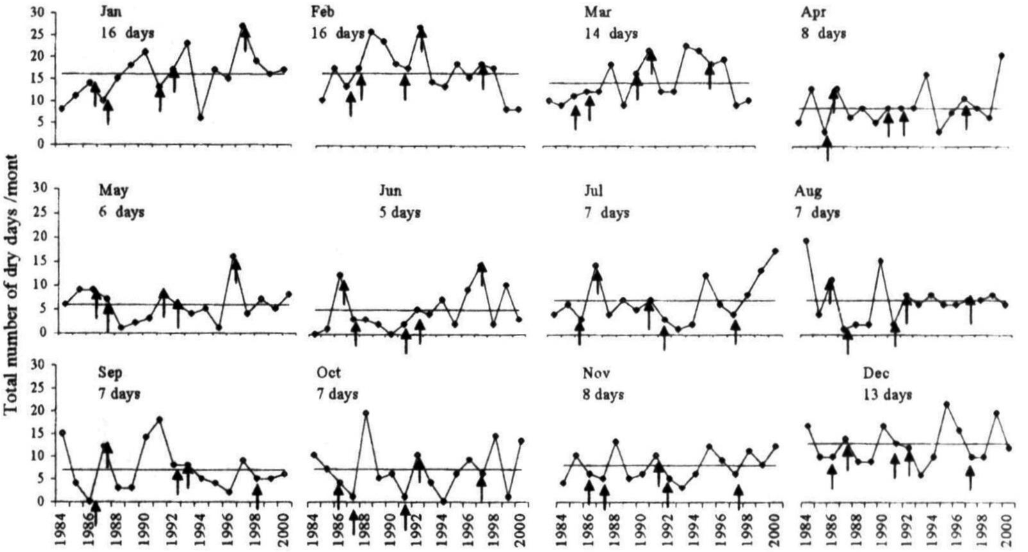

Figure 7. Total number of dry days each month at Sinharaja forest during the study period (1984-2000). Vertical arrows indicate the El-Niño years.

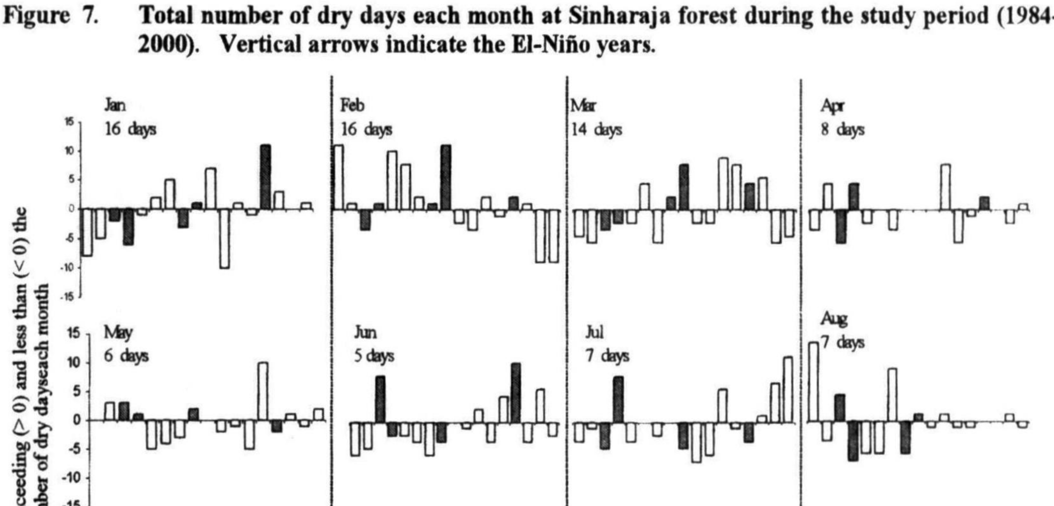

Figure 8. Variation in total number of dry days each month from their mean monthly values (indicated as 0) at Sinharaja during the study period (1984-2000). Striped bars indicate the El-Niño years.

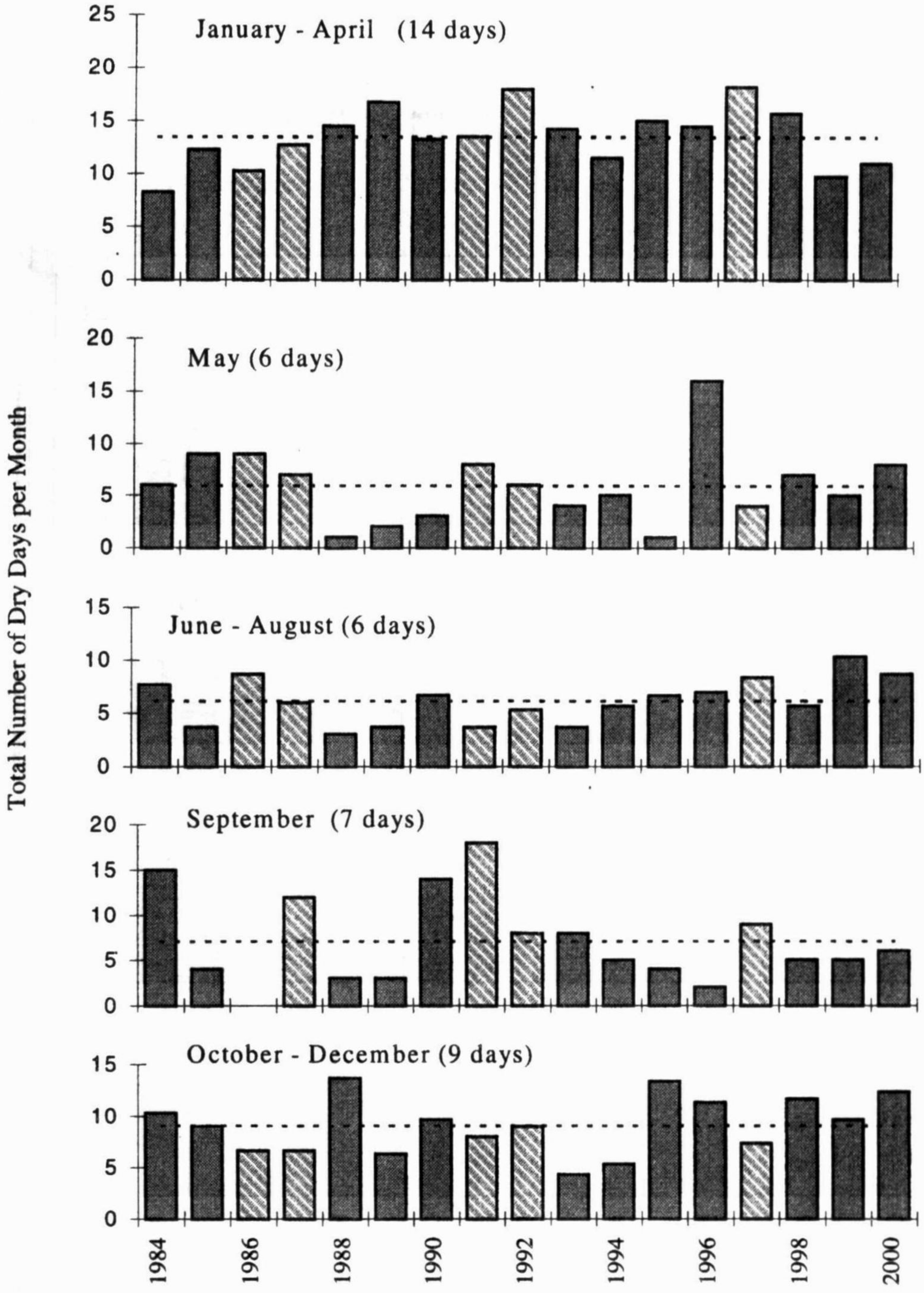

Figure 9. Total number of dry days per month in five periods (January-April, May, June-August, September and October-December) recorded each year at the Sinharaja Field Station. Average values for each period are indicated by the dotted lines and the exact values are given in the parenthesis. El-Niño years (1986, 1987, 1991, 1992 and 1997) are indicated by the lighter coloured bars.

As shown in Fig. 12, the mean number of dry days per year varied between 90-130 (with a mean of 113 per year) for the study period. The highest total was observed in 1997 (133 days per year) and the least (89 days per year) was observed in 1994.

Temperature

Out of the five seasons (January-April, May, June-August, September and October-December) the highest maximum temperature was recoded in May (28.9^0 C), and next highest in the period January-April (28.2^0 C) (Figs.10 & 11).

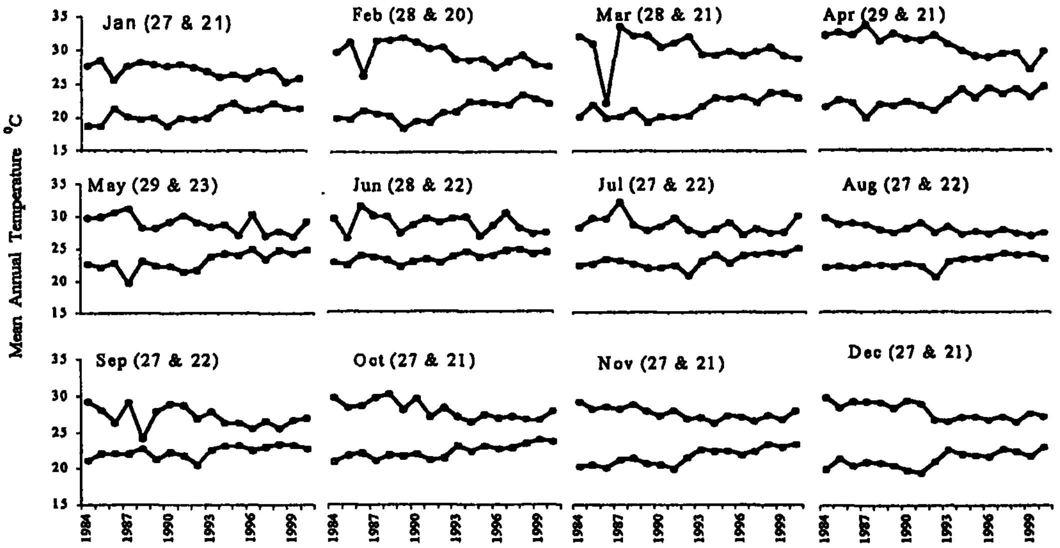

Figure 10. Monthly maximum (upper) and monthly minimum (lower) temperature of Sinharaja forest during the study period (1984-2000).

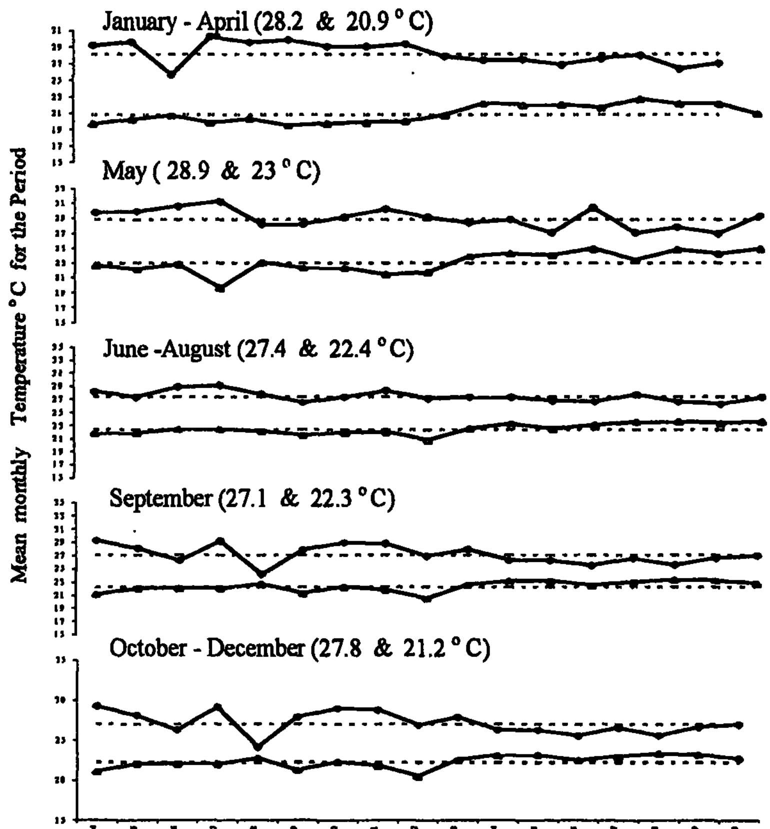

Figure 11. Mean monthly maximum (upper) and minimum (lower) temperatures recorded in Sinharaja for each period of the year from 1984-2000. The respective means for each period over the 17 years are indicated by the dotted lines and the numerical values are given in parenthesis.

Mean annual minimum and maximum temperatures for the study period were 22 and 28^0 C respectively (Fig. 12). Highest monthly temperatures were observed in April (25.3^0 C), May (25.9^0 C) and January (25.1^0 C) and it was least in December (23.8^{0}C) (Fig. 11). Over the study period (1984-2000), the difference between the mean maximum and mean minimum temperature was seen to decrease in the site sampled.

No specific trend was observed in temperature variations in El-Niño compared to those of the normal years.

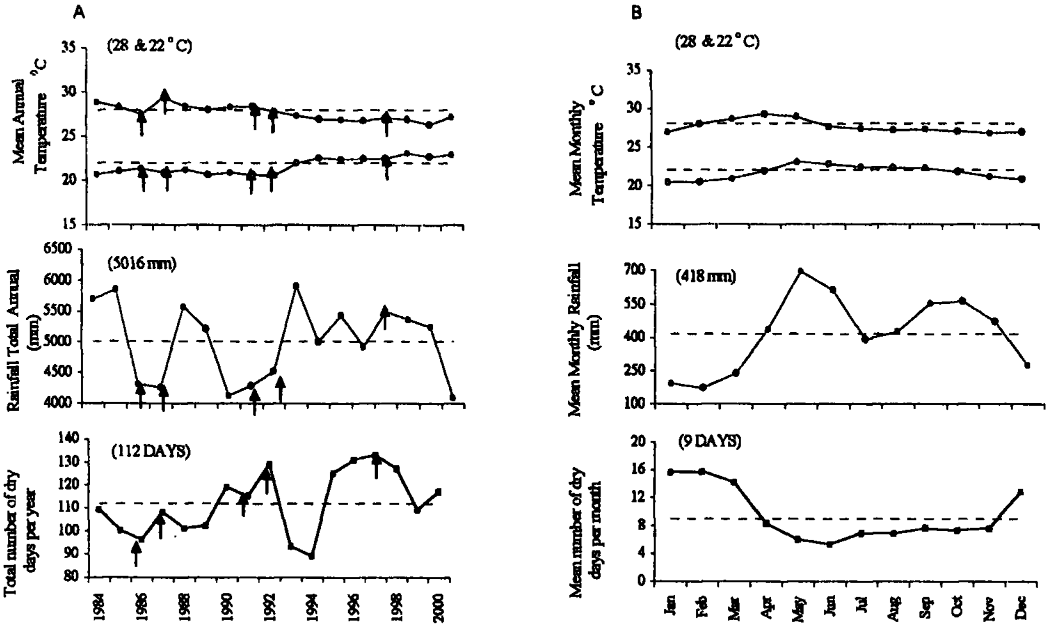

Figure 12. Variation of mean annual (A), mean monthly (B) maximum (upper) and minimum (lower) temperatures, annual rainfall and total number of dry days per year in Sinharaja during the study period (1984 - 2000). Average value for each parameter is indicated by a dotted line and the numerical value is given in parenthesis. El-Niño years are indicated by the vertical arrows.

DISCUSSION

Overall climate

Richards (1996) stated that, the climate of tropical lowland rain forests can be divided in to three classes namely, super wet, wet and wet seasonal based on the Per Humidity (PI) value. For Sinharaja, the PI value is 19.5, which suggests that Sinharaja belongs to the wet localities. Similar conditions were observed in Danum valley is in Borneo where the PI values was 19.5.

The present study revealed trends similar to the climatic patterns observed by previous studies conducted by Ashton (1992). The mean annual rainfall of Sinharaja was 5016 mm with two major rainfall peaks in May-June and September-October without a marked dry period. This observation is confirmed by the Walter climatic diagram of southwestern part of the island as given by Ashton (1992).

The high rainfall in the southwestern part of the island is in part due to the topography of the island. The central hills that rise above 2000 m intercept the moisture-laden monsoon winds, specially on steeper flanks, bringing high rainfall (Anon., 1991) to the southwestern part of the island. The amount of rainfall recorded was low during the northeast monsoon period, because of the rain shadow of the island's central mountain. This difference in rainfall variability is very important as a factor, which alters the level of solar radiation, amount of sunshine and light received by the forest and also leaching potential of the rain forest soils (Richards, 1996).

There was no clear pattern of dry or drought months during the study period. As stated by Richards (1996), this is a common feature of tropical wet localities where PI lies between 10-19.5. In Sinharaja, three dry months (rainfall <100 mm), three drought months (rainfall <50 mm) and two consecutive drought months were recorded from 1984-2000.

The total number of dry days per month was high in January–February, when the mean monthly rainfall was very low (Fig. 3). This observation suggests that, in these drier months, much of the total monthly rainfall often fell on just a few days leaving the rest of the month dry. This is also true for the period December-March when their frequency of consecutive dry days was higher.

The closing up between maximum and minimum temperatures may be due to the increasing cooling effect of the area. At the time when the first observations were taken, the study area had been exposed due to selective logging. After seventeen years, the area is much more shady and cooler as a result of the gradual canopy closure following natural regeneration. The temperature recording station was located in the forest but close to a large opening which was used as an office *cum* vehicle maintenance workshop area. The central area is still maintained as an open area, but trees in the peripheral areas of the gap are growing and the forest canopy is closing up. This could account for the gradually decreasing difference observed between the mean annual minimum and maximum temperatures during the more recent years.

Impacts of El-Niño and La-Niña events

Many recent researchers have attributed the El-Niño and La-Niña events for the unusual wet or dry years in parts of the tropics (Richards, 1996). Houghton *et al.*, (1990) has pointed out that the consistent ENSO precipitation signals were clearly visible in October-November-December period for the South East Asian region. But, results of the present study did not strongly agree with this observation. However, out of three El-Niño events, 1986 and 1997 showed high amount of rainfall during the month of September. This may be because, only the stronger El-Niño events tend to bring variations in rainfall patterns to the Indo- Malayan Region (Walsh, 1996) and these strong El-Niño events seldom occur less than six to seven years apart although the weak El-Niño events occur every three to four years.

During an El-Niño year, either unusual dry conditions arise during the wet season (wet season irradiance) or unusual rains occur in the dry season or both these effects can occur (Joseph and Caldero, 1999). The analysis of the present study confirmed the wet season irradiance during the past seventeen year period at Sinharaja MAB reserve. Out of two rain peaks (May-June, September-October) observed at the study site, in all three El-Niño events relatively low rainfall was observed in May. In the 1986-1987 El-Niño event, this reduction of rainfall was continued until July. Similar conditions were also observed in Eastern Borneo, Sumatra and the Malay Peninsula (Yasuda *et al.*, 1999). The positive anomalies in of the sea surface temperature of the eastern Pacific in the El-Niño episode causes greater atmospheric convection there and induces an anomalous easterly flow of air from the western Pacific. This tends to subdue the trade winds that are the major source of orographic rainfall (Yasuda *et al.*, 1999). Joseph and Calderon (1999) recorded that the wet season irradiance is a very important ecological change, which plays a major role throughout the tropics. They have further observed a co-occurrence of an elevated community level fruit production and high irradiance in Cameroon during the 1992 El-Niño event and in French, Guyana, and southeastern Peru, during the 1997 El-Niño event. Similar patterns of fruit production have been observed elsewhere in the tropics. In addition to the above, Harrison and Sakai (1999) recorded that the General Flowering (i.e. a community flowering/fruiting episode in which a large proportion of the individuals belonging to varied taxonomic groups show flowering following several years of little or no reproductive activity) episodes often coincide with El - Niño years and high irradiance in the Dipterocarp forests of Malaysia. We have also observed the same phenomena of flowering and fruiting of Beraliyas in Sinharaja MAB reserve.

The contribution of consecutive dry days to the total number was also higher in all El-Niño years in the December to March period indicating the prolonged dry condition in the area. This was very significant in 1997 El-Niño year. The studies conducted in tropical areas by Harrison and Sakai (1999) recorded an unusually severe drought in 1997 and it was the strongest El-Niño year for the past 32 years (Nakagawa, 2000).

In summary, the results of the present study show strong deviations in all three climatic parameters from the average climate of the study area. Except rainfall, temperature and dry days did not show a clear pattern of variation. Wet season irradiance or a reduction of rainfall during the southwest monsoon period was observed in two out of three El-Niño years. As pointed out by Richards (1996) those variations such as extremes of drought, wind or continuously saturated conditions are more important than the average climate of a given area. On the other hand there is also an uncertainty about the relative roles played by climatic means (of rainfall, temperature and dry season length) and extremes (droughts and fire, tropical cyclones, unusual cold weather) in influencing the nature and distribution of tropical rain forest vegetation types (Walsh, 1996).

Therefore, this study hopefully provides a basis to understand the climate and its influence on vegetation in the Sinharaja rain forest in Sri Lanka.

ACKNOWLEDGEMENTS

Work on this project at Sinharaja was made possible by the generous financial aid given by the USAID research grant (DPE-5542-G-55-4073-00) through Harvard University, U. S. A. and the John D. and Catherine T. MacArthur Foundation which is gratefully acknowledged.

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