RESEARCH 1(1), January - March, 2015

ISSN 2394–8558 EISSN 2394–8566

Climate Change

Impact of climate change on butterfly diversity in Seshachalam bio reserve forest of Southern Andhra Pradesh

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Publication History
Received: 15 October 2014
Accepted: 03 December 2014
Published: 1 January 2015

Citation
Suryanarayana K, Harinath P, Venkata Ramana SP. Impact of climate change on butterfly diversity in Seshachalam bio reserve forest of Southern Andhra Pradesh. *Climate Change*, 2015, 1(1), 26-39

ABSTRACT

Climate change is universal phenomenon and it influences the seasonality, abundance of the flying jewels "Butterflies". They are known to be highly sensitive to climate change. Seshachalam bio reserve forest is on the richest biodiversity hot spot in India lies between 13^0 38" and 13^0 55"N latitude and 79^0 07" and 79^0 24" E longitudes and spread over two districts Chittoor and Kadapa of Southern Andhra Pradesh. Civilisation of this area leads to enormous increasing of pollution; it effects human population as well as animal population. Vegetation in the study area was deciduous forests with patches of most deciduous and evergreen to semi evergreen forests. In the Eastern Ghats of Southern Andhra Pradesh the highest point is Tirumala hills with 1251m height. Recent studies prove that Butterflies react faster than other groups such as birds. Butterflies have relatively short generation times and are

ectothermic organisms, meaning that their population dynamics may respond to temperature changes more directly and more rapidly. Even the loss of a single species can have cascading effects because organisms are connected through food webs and other interactions. With a suitable climate and vegetation hill region of Eastern Ghats enriched with high number of butterfly population. Earlier 150 species are available on Eastern Ghats in which 75 species were identified in present study area. The typical climate effected the species life cycle, flight times, mating behaviour, essential interactions and ultimately survival. The change of climate and its influences on butterfly species diversity were studied by using structural equation modelling method and also investigated direct and indirect effects of climate variables, host plant richness, habitat diversity on butterfly species richness across the Seshachalam hills.

Key words: Climate change, Seshachalam hills, Butterflies, Eastern Ghats.

1. INTRODUCTION

The diversity of species depends on factors like climate and the topography of the region. They are effective indicators of climate change (Asher *et al*., 2001). India is a large country with different types of physical features and contrasting climate zones from deserts to wet places on earth and from tropical hot deserts to cold alpine regions. Butterflies (Lepidoptera : Rhopalocera) are the lovely and graceful insects provide economic and ecological benefits to the human society, very few studies have been done on the butterfly diversity in Andhra Pradesh. Butterflies are the messengers of the nature not only adding brilliance to their surroundings but also pollinating flowers and revealing the healthiness of our communities. The role of butterflies is important to our natural world their sheer numbers supply a vast food source for predators and they are significant plant pollinators. Butterflies provide the best rapid indicators of habit quality and also they are the sensitive indicators of climate change. Cities constitute a habitat and home for an increasingly large population playing a critical role in maintaining ecological, economic and social wellbeing. The occurrence and diversity of butterflies are considered to be good indicator of the status of any given terrestrial habitat (Kunte 2000). Climatic change cause shifts in geographical distribution of species. Such shifts are considered to be the result of population extinction at equatorial range boundary and pole ward colonization in regions where climatic conditions have become suitable. Seshachalam hills, one of the first Biosphere reserve forests in Andhra Pradesh are located in southern eastern of Chittoor and Kadapa districts. It is spread over 4755.99 km^2 and this reserve forest locates in southern Eastern Ghats and extended from Seshachalam hills of Kadapa district to Tirumala hills of Chittoor district. The faunal composition represents the Deccan peninsular zone of bio-geographic classification of India and the great diversity of geo morphology of vegetation gives rise to multitude of habitats that support wild life. The present study represents that many common endemic and endangered butterflies have extended their distributions in response to the changing climate at Seshachalam bio-reserve forest.

2. MATERIALS AND METHODS

The present study area i.e., Seshachalam bio reserve forest of Southern Andhra Pradesh has rich vegetation. We have chosen Eight different study sites i.e., Tirumala hills, Thalakona hill, ,Balapalli, Mamamdur, jungle Book Lankamalai hill region Kadapa and Belum forest region which is around 350 km. radius during October 2013 to October 2014. We have chosen both plains and hill regions for the study: how climate change affects the butterfly diversity, influences on the habitat, and has its effect on the abundance, diversity and flight variation on the butterflies more than a year. The abundance was studied by using Simpson's Diversity indices.

$D = \Sigma(n/N)^2$

n = total number of organisms of a particular species
N = total number of organisms of all species.
(The values will be between 0 and 1. If the values are near to 0, more diversity, if values are near to 1 then less diversity.)

The present study sites include six hill regions with thick vegetation two plains with dry arid conditions. We have calculated how the climatic changes in these regions are going to affect the butterfly species over 12 months visiting these regions twice in a month throughout the year and how the climatic changes during this season has its influence over butterfly diversity.

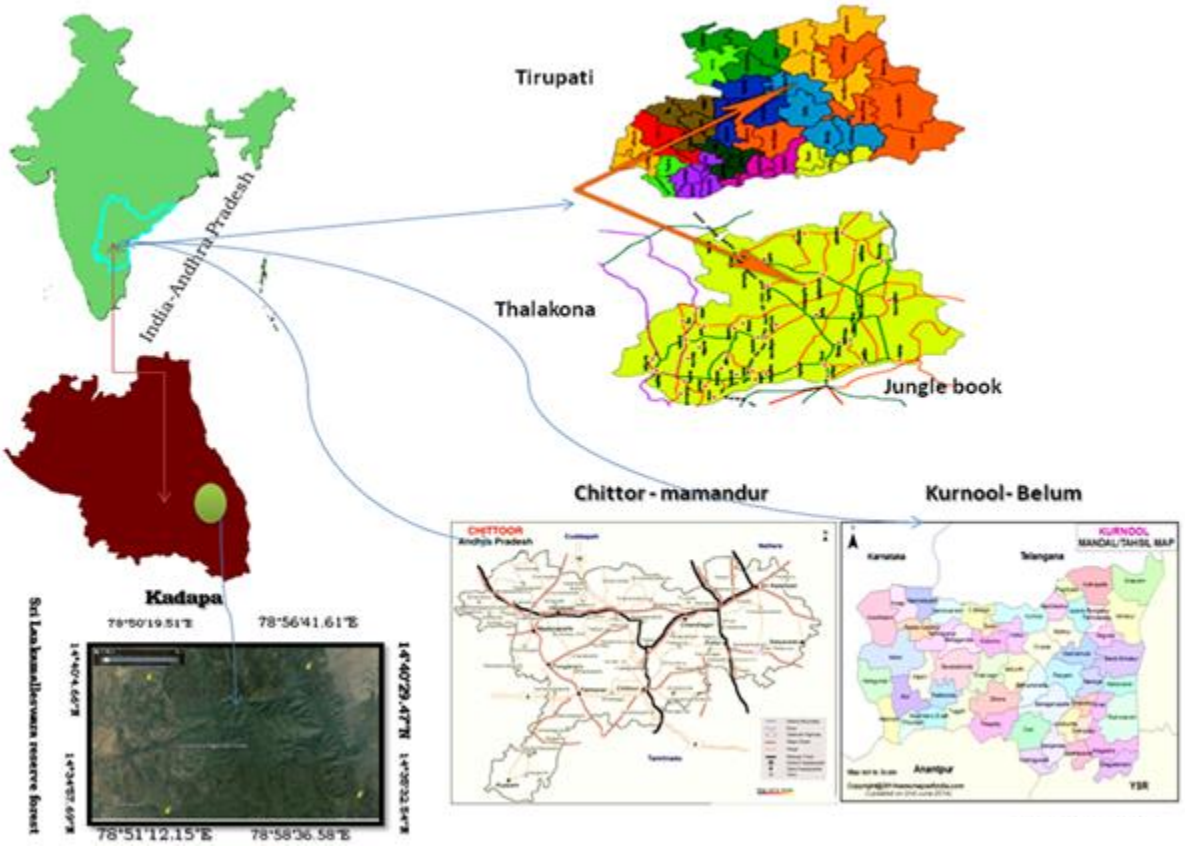

Figure 1a
Study area map

3. RESULTS AND DISCUSSION

During the course of study the climate variations, relative abundance and diversity of the butterfly species in all these study sites were investigated. Visiting these areas twice in a month enables us to identity the species type and their abundance in these sites their diversity of the species. Kadapa and Belum regions are recorded very few species when compared with rich vegetation habitats like Tirumala, Thalakona, Jungle book, Mamundur, Balapalli, Lankamalla (Table-1). Climate variance in plain regions Kadapa and Belum shows greater influence on host plants of butterfly species, it leads to decreasing of the number of particular species whether it is directly or indirectly. These plain regions have high temperature in summer seasons which are affecting the host plants and also the butterfly species survival. Butterflies are known to be highly sensitive to climate change (Parmesan *et al* 1999) and recent studies prove that they react faster than other groups such as birds (Devictor *et al* 2012).The mean annual temperature of earth has swung up and down by several degrees Celsius over the past million years. A warming trend began around 1850, lasting until the 1940s,when temperatures began to cool again, followed by a levelling off of temperature in the 1950 and a further drop during the 1960s. After that, the average surface temperature increased. The past two decades have been the warmest since global temperatures have been monitored (Hensen, J., *et al* 2005). Many species, which have been formerly confined to southern Britain, have shown a significant extension to their range margin of 37km. over a 21 year study period, nearly 2km. per year (Hickling *et al* 2006). The other study sites Tirumala, Thalakona, Jungle book, Mamundur, Balapalli and Lankamalla are having thick vegetation throughout year and has recorded higher number of availability of species which may be due to the availability of abundance of host plants in these regions. Maximum numbers of butterflies were recorded during rainy season it might be due to the presence of sufficient host plants and favourable climate conditions. The least number of butterflies were collected during summer season when the adequacy of the host plants and unfavourable conditions. (Fig 2, Fig 3 & Fig 4) There is a negative correlation between temperature and butterfly species we could observe the decrease in the number of species in plains and increasing in the number of hill regions due to the climate change effect affecting directly. Rainfall is also one of the climate parameter it influence growth of vegetation as well as butterfly host plants. We observe less rainfall in Belum and kadapa plain regions when compare to other study

areas. Based on the climate parameters i.e., rainfall and temperature, the State is broadly divided into 6 distinct Agro-Climatic Zones. The agriculture planning for each zone is supported with the research and recommendations of a Regional Agriculture Research Station of ANGRAU set up within the particular zone. In an attempt to plan the agricultural operations in much more focused way, these 6 agro climatic zones have been divided into 322 farming situations, which are unique in terms of micro-environment and need specific practices under each situation. In the State, South-West and North-East Monsoons are the two important periodic winds, which are the important sources of the rain. South-West Monsoon (66%) is spread over the period from June to September and North-East Monsoon (24%) (From October to December), the normal annual rainfall of the State is 940mm. Major portion (66%) of rainfall is contributed by South-West Monsoon (June-Sept) followed by (24%) North- East Monsoon (Oct- Dec), the rest 10% of the rainfall is received during the winter and summer months. In our study we also observe the flight mode of butterflies, their life cycles duration and mating behaviour. In which nearly 75 species (Table-3) were observed and recorded their abundance and seasonality in our study area (Table 3 & Fig 4). Among them Nymphalidae, and Pieridae are reported at greater number (Fig: 4) where as Papilionidae, Lycaenidae, Hesperiidae, and Satyridae reported the least number. In which 17 species of hill regions and 37 species of plain regions were reported as rare when compared with the others. The recorded butterflies and their abundance were categorized in hill and plain regions respectively as very rare (VR) 22,37 species; Rare (R) 14 , 22 species, Less common (LC) 13,10 species, common (C) 19, 4 species, Very common (VC) 7, 2 species (Fig: 6). The species diversity was more at plain regions i.e. Kadapa and Belum regions when compared with Tirumala, Thalakona, and Jungle book, Mamumdur, Balapalli and Lankamalla Family Nymphalidae shows less diversity in all study areas (0.0729, 0.0625) and Hesperiidae family shows more diversity (0.0049, 0.0049) (Table-2).

The diversity of butterfly species depends upon not only the availability of food plants but also on the climate and topographic features of the study area.

Figure 1b
Study sites

Figure 1c
Thalakona hill region

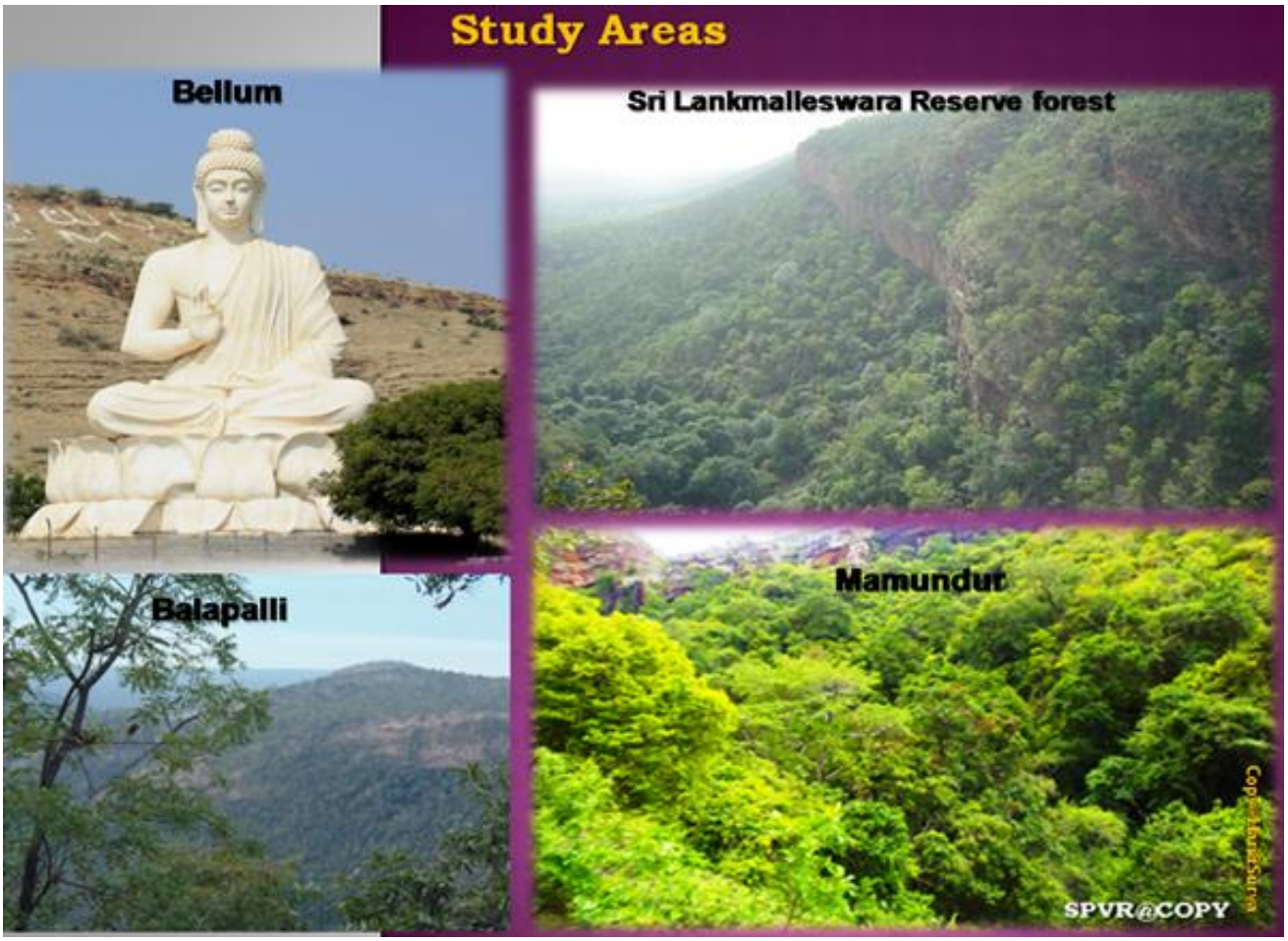

Figure 1d
Study areas

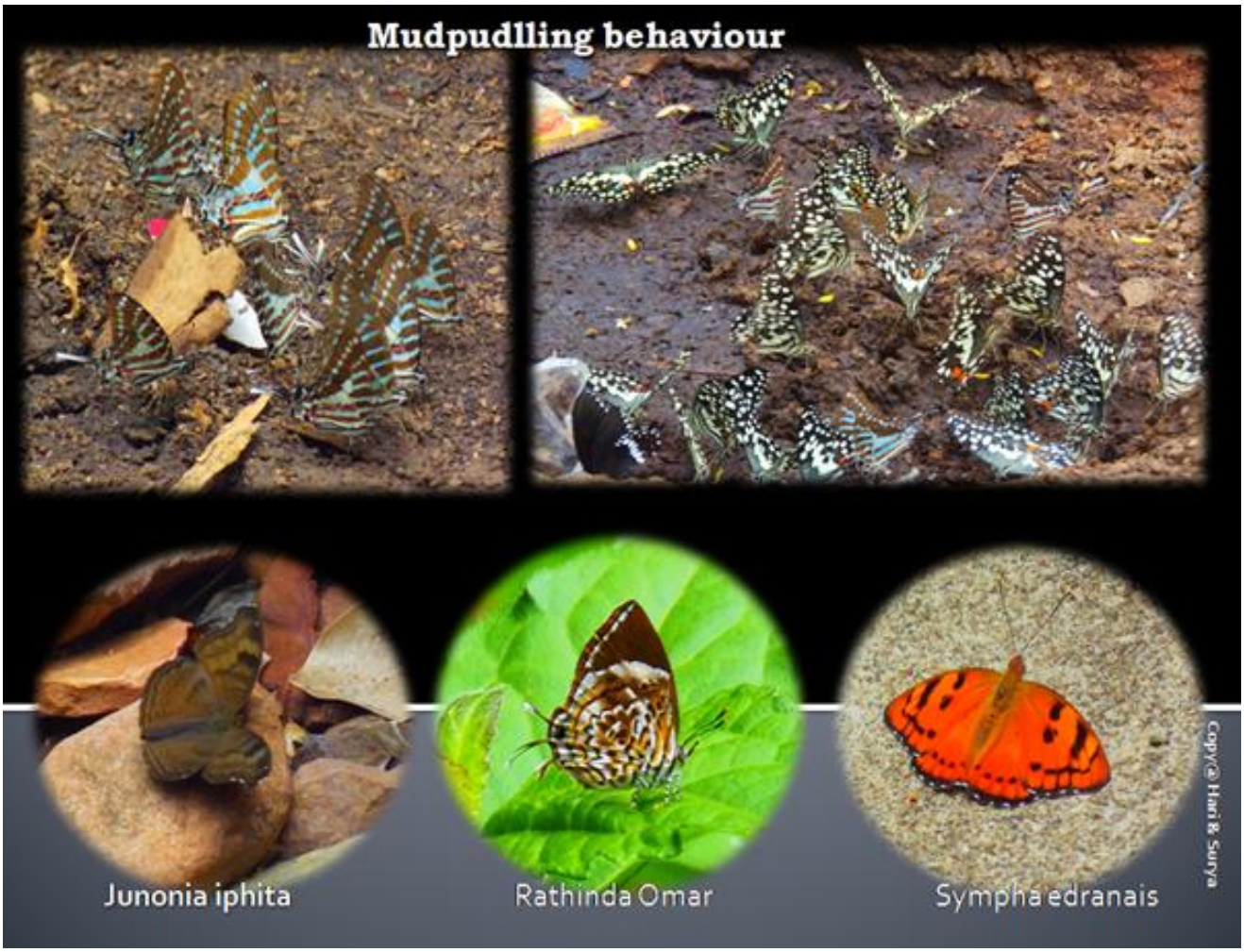

Figure 1e
Mudpudlling behaviour

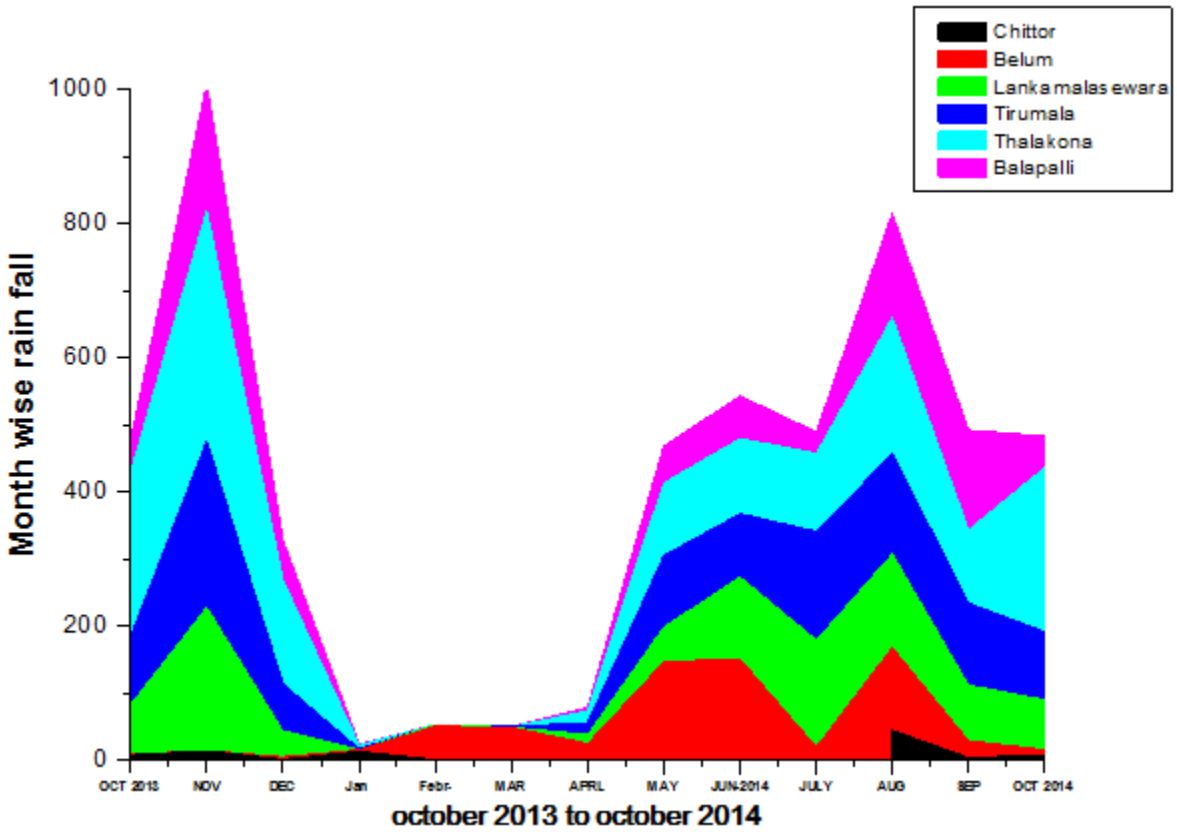

Figure 2
Monthly rain fall data particular of the study sites

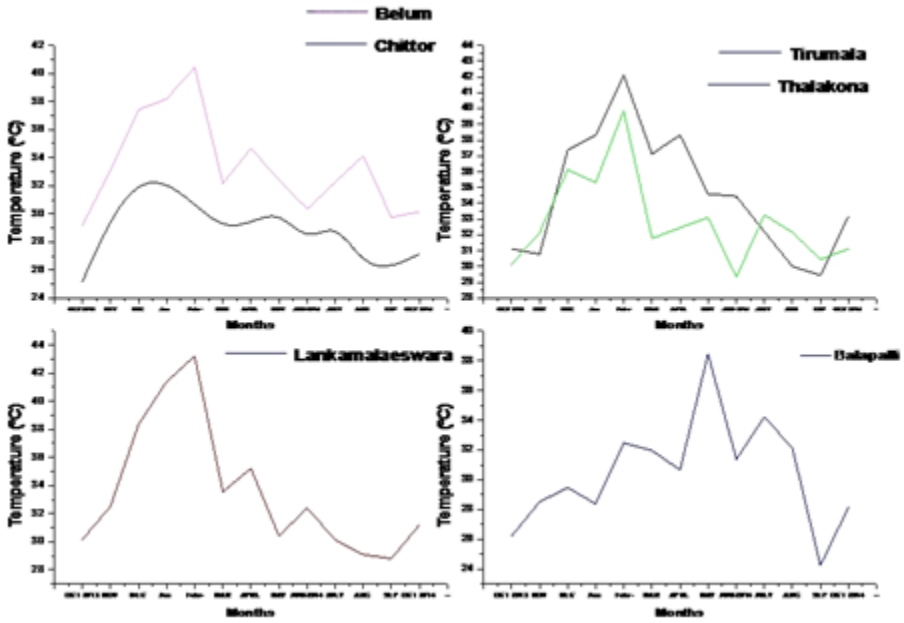

Figure 3
Weather data of Tirumala hills, Thalakona hills, Balapalli, Sri Lankamaleswara hill region Kadapa and Belum forest regions (Oct.2013-Oct. 2014)

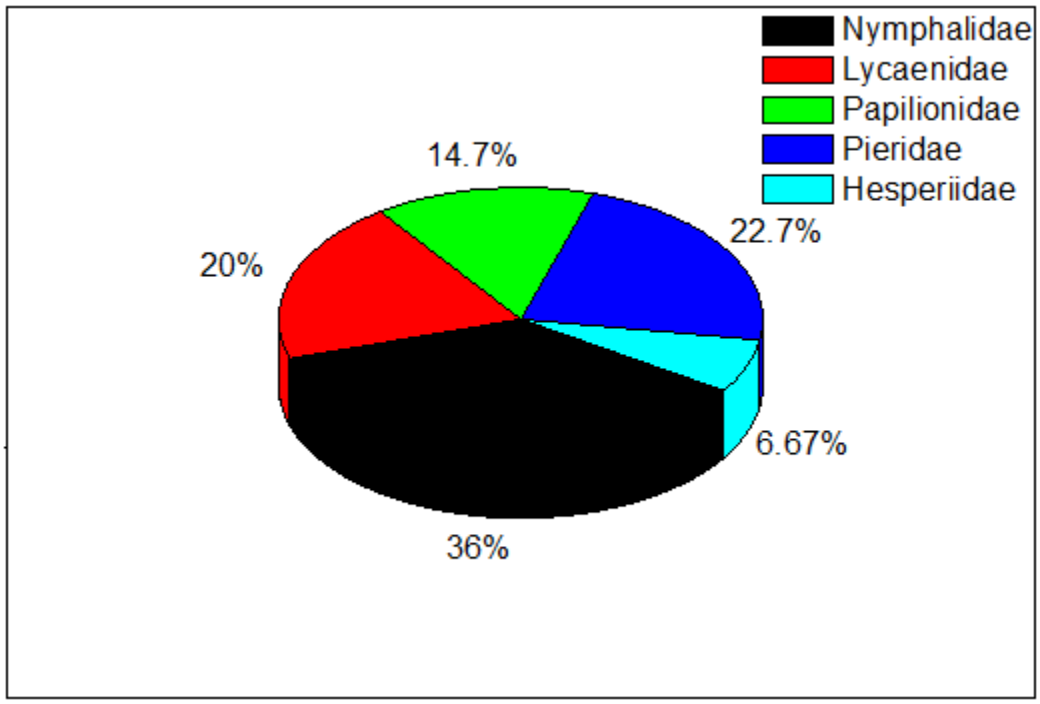

Figure 4
Diversity of butterflies in Seshachalam Bio Reserve forest during Oct. 2013 to Oct 2014

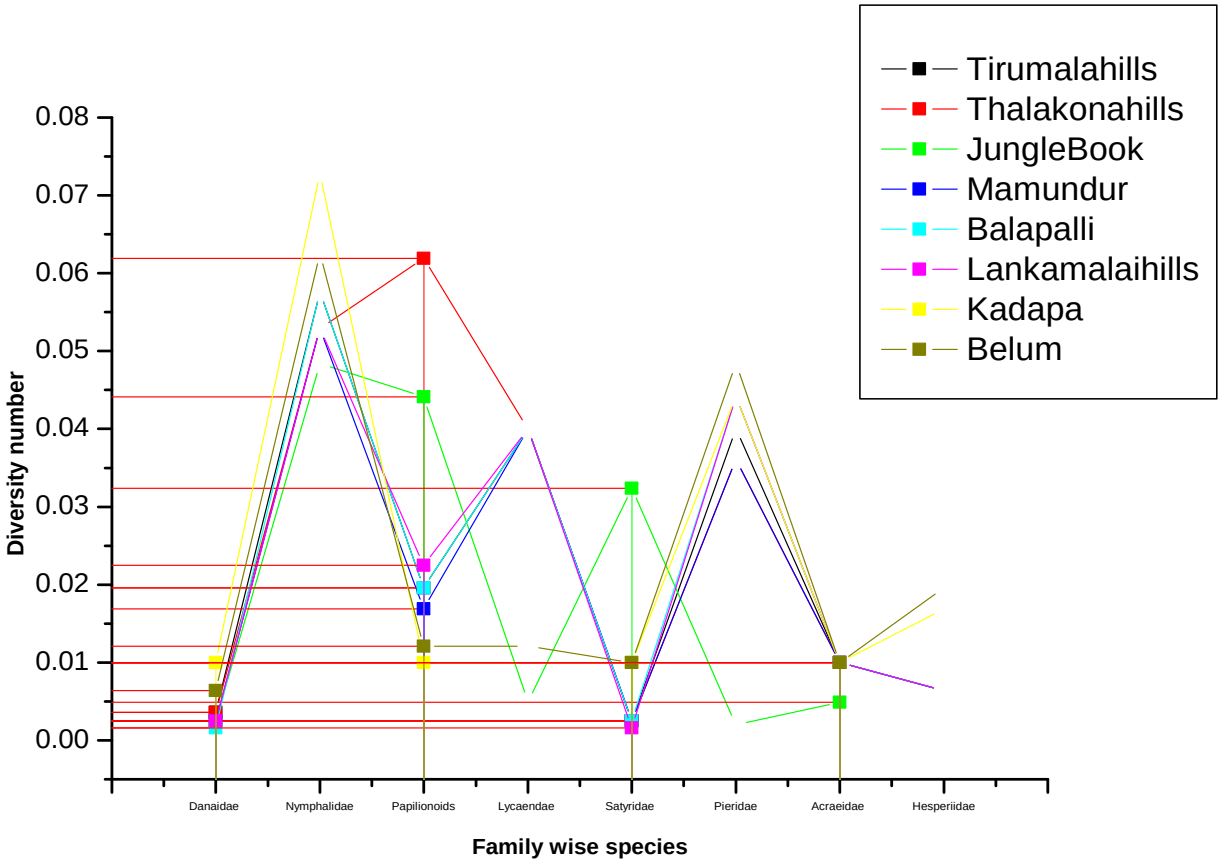

Figure 5
Diversity indices of butterfly species at different study sites during October 2013 to October 2014

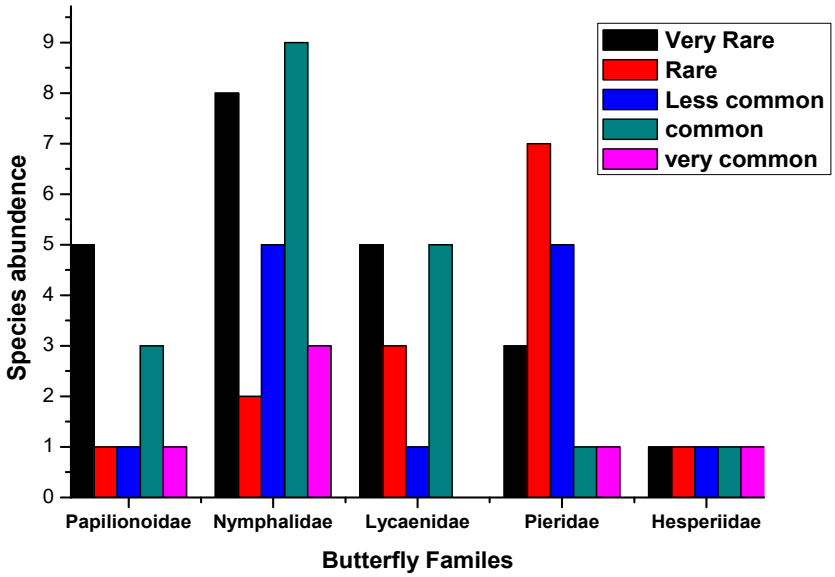

Figure 6

Relative abundance of butterfly species in the vegetation's of Plain and hill Regions of Seshachalam Bio Reserve forest during Oct. 2013 to Oct 2014

Table 1

Population of butterfly species at different study sites during October 2013 to October 2014

Family	Tirumala hills	Thalakona hills	Jungle Book	Mamundur	Balapalli	Lankamaleswara hills	Kadapa	Belum
Danaidae	5	5	4	4	3	4	4	3
Nymphalidae	18	17	16	16	17	17	10	9
Papilionoids	11	10	11	9	10	11	4	4
Lycaendae	15	15	15	14	14	15	4	4
Satyridae	4	4	5	4	4	3	1	1
Pieridae	15	14	13	13	15	16	8	8
Acraeidae	1	1	1	1	1	1	1	1
Hesperiidae	6	6	5	6	6	6	5	5
Total	75	72	70	67	70	73	37	35

Table 2

Diversity indices of butterfly species at different study sites during October 2013 to October 2014

Family	Tirumala hills	Thalakona hills	Jungle Book	Mamundur	Balapalli	Lankamalai hills	Kadapa	Belum
Danaidae	0.0036	0.0036	0.0025	0.0025	0.0016	0.0025	0.01	0.0064
Nymphalidae	0.0576	0.0529	0.0484	0.0529	0.0576	0.0529	0.0729	0.0625
Papilionoids	0.0196	0.0169	0.0225	0.0169	0.0196	0.0225	0.01	0.0121
Lycaendae	0.04	0.04	0.0441	0.04	0.04	0.04	0.01	0.0121
Satyridae	0.0025	0.0025	0.0049	0.0025	0.0025	0.0016	0.0004	0.0004
Pieridae	0.04	0.0361	0.0324	0.0361	0.0441	0.0441	0.0441	0.0484
Acraeidae	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0004
Hesperiidae	0.0064	0.0064	0.0049	0.0064	0.0064	0.0064	0.0169	0.0196

Table 3

Relative abundance and seasonality of butterfly species in the vegetations of Plain and hill regions of Seshachalam bio reserve forest of Southern Andhra Pradesh during October 2013 to October 2014

Scientific Name	**Common Name**	**Season by months**	**Relative Abundance**	
			Hill regions	**Plain regions**
Family: Nymphalidae				
1. *Danaus chrysippus chrysippus*	Plain tiger	1-12	* * * * *	***
2. *D. limniace leopardus*	Blue tiger	10-4	* * * *	***
3. *D. plexippus*	Common tiger	3-10	*	*
4. *Vanessa indica*	The Paller	4-5	*	*
5. *Euthalia garuda*	The baron	5-8	*	*
6. *Erites falcipennis*	Common Cyclops	9-3	*	*
7. *Melanitis leda ismene*	Common evening	9-5	* * * *	**
8. *Mycalesis visala subdita*	Tamil brush brown	1-3	*	*
9. *Ariadne merione merione*	Common castor	1-12	* * * *	**

10. *Elymnias hypermnestra*	Common palm fly	9-3	*	*
11. *E. nais*	The baronet	6-10	* * * *	**
12. *Hypolimnas bolina*	Great egg fly	6-10	* * * *	**
13. *H. misippus*	Danaid egg fly	7-3	* * * *	**
14. *Junonia almanac*	Peacock pansy	7-12	* * * *	***
15. *J. hierta*	Yellow pansy	6-12	* * *	*
16. *J. lemonias*	Lemon pansy	1-12	* * * * *	****
17. *J. orithyia*	Blue pansy	7-12	* * *	**
18. *J. iphita*	Chocolate pansy	6-12	* * *	**
19. *Neptis hylas*	Common sailer	10-4	* * *	**
20. *Phalanta phalantha*	Common leopard	1-12	* * * *	***
21. Melanitis phedima	Dark evening brown	9-11	**	*
22. *Eyuploea core core*	Common crow	1-12	* * * *	**
23. *Cynthia erota*	The Devil	9-11	*	*
24. *Atella alcippe*	The Camel	2-4	*	*
25. *Acraea terpsicore*	Tawny coster	1-12	* * * * *	***
26. *Charaxes solon*	Black Rajah	10-4	***	*
27. *Byblia ilithyia*	The Joker	3-7	* *	*
Family: Lycaenidae				
28. *Rathinda omor*	Monkey puzzle	1-12	* * * *	***
29. *Castalius rosimon*	Common pierrot	1-12	* * * **	****
30. *Castalius caleta*	Common Comb	4-9	***	**
31. *Tarucus nara*	The Hill Rock	2-5	*	*
32. *Euchrysops cnejus*	Gram blue	1-12	* * * *	**
33. *Everes lacturnus syntala*	Indian cupid	6-10	* * * *	**
34. *Jamides celeno aelianus*	Common cerulean	1-12	* * * *	**
35. *Rapala airbus sorya*	Indian red flash	5-7	* *	*
36. *Spindasis vulcanus vulcanus*	The silverline	6-10	* * * *	**
37. *Talicada nyseus*	Red pierrot	4-6	* *	*
38. *Lycaenesthes emolus*	The wind mill	3-5	*	*
39. *Rapala jarbus*	Indian Red glass	4-7	* *	*
40. *Curetis thetis*	Oak blue	7-9	*	*
41. *Pratapa deva*	Common cool	12-3	*	*
42. *Apharitis vulcanus*	Common silver line	8-10	*	*
Family: Papilionidae				
43. *P. crino*	Common banded	5-8	*	*

	peacock			
44. *G. doson*	Common jay	5-10	*	*
45. *Pathysa nomius nomius*	Spot sword tail	6-7	* *	*
46. *Pachliopta aristolochiae*	Common rose	1-12	* * * *	****
47. *P. hector*	Cromson rose	1-12	* * * **	*****
48. *Papilio polymnestor*	Blue Mormon	10-3	* **	**
49. *P. polytes polytes*	Common mormon	5-8	*	*
50. *P. memnon*	Common merun	3-5	*	*
51. *P. liomedon*	The black tail	1-3	*	*
52. *Graphium agamemnon*	Tailed jay	1-12	* * * *	***
53. *Princeps demoleus*	Lime butterfly	3-11	* * * *	***
Family: Pieridae				
54. *Eurema brigitta*	Small grass yellow	1-12	* ***	**
55. *Appias pandione*	Spot puffin	7-2	* *	*
56. *A. albina darada*	Common albatross	12-4	* *	*
57. *Catopsilia crocale crocale*	Common emigrant	1-12	* * *	**
58. *C. c. Pomona*	Lemon emigrant	6-10	* *	*
59. *C. pyranthe*	Molted emigrant	1-12	* * *	**
60. *Colotis danae danae*	Crimson tip	1-12	* * *	**
61. *C. eucharis eucharis*	Plain orange tip	1-12	* *	*
62. *C. fausta*	Large salmon arab	6-11	* *	*
63. *C. amata*	The Rose tip	8-12	**	*
64. *Cepora nerissa nerissa*	Common gull	1-12	*	*
65. *Delias eucharis*	Common jezebel	9-12	* *	**
66. *Eurema hecabe simulate*	Common grass yellow	1-12	*	*
67. *Leptosia nina nina*	The psyche	9-4	*	*
68. *Valeria valeria anais*	Common wanderer	1-4	* * *	**
69. *Eurema blanda*	Three spot grass yellow	9-4	* * ***	*****
70. *Anaphaeis aurota*	The pioneer	1-12	* * *	***
Family: Hesperiidae				
71. *Caprona agama*	Spotted angle	9-4	* * *	**
72. *Pelopidas mathias mathias*	Small branded swift	1-12	* * * *	***
73. *Hasora alexis*	Common banded Awl	2-8	* *	*
74. *H. nexis*	The Red dot	4-5	*	*
75. *Borbo cinnara*	Rice swift	1-12	* * * * *	****

***very rare **rare ***less common ****common *****very common**

ACKNOWLEDGEMENT

The first author K. Suryanarayana greatly acknowledge to DST, New Delhi for financial assistance through INSPIRE Programme along with the research supervisor Dr. S.P. Venkata Ramana. Sincere thanks to A.P forest department for giving permission to periodical survey in the field areas and also grateful to weather report centre Tirupati for their support.

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