Butterfly Diversity at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province, Southern Thailand

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Received 12 Jul 1999
Accepted 7 Mar 2000

ABSTRACT Butterfly diversity at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province, was investigated by using baited-traps along transects in three types of habitats from June 1997 to May 1998. A total of 147 species involving 77 genera and 9 families (Papilionidae, Pieridae, Danaidae, Satyridae, Amathusiidae, Nymphalidae, Riodinidae, Lycaenidae and Hesperiidae) were captured and identified. Of these, Nymphalidae and Lycaenidae were found to be the dominant families, in contrast to Ridionidae, Hesperiidae and Papilionidae, which were scarce. The largest number of individuals was collected in traps baited with fruit at a waterfall forest site. The monthly diversity was calculated by using the Shannon-Weiner diversity index and the highest diversity was found in February (H=3.20), and the lowest in September (H=1.72). The relationships between physical factors and individuals, total species and number of butterflies per family were determined. There were no significant correlations between humidity, rainfall and temperature, and the total number of individuals or species (P>0.05). The total abundance of Hesperiidae increased with humidity. Total numbers of Amathusiidae and Satyridae were inversely related to rainfall.

KEYWORDS: butterfly diversity, Songkhla Province, wildlife.

INTRODUCTION

Lepidoptera are beneficial as pollinators, silk producers, indicators of environmental quality, and are appreciated for their aesthetic value. The holometabolous life history of butterflies reveals that Lepidoptera are exposed to a wide range of environmental influences, and they are highly sensitive to changes in temperature, humidity and light levels.[1-8]

Increases in human population combined with advances in technology have directly subjected the ecosystems of the world to changes to which many Lepidoptera and other organisms cannot adapt. There is thus a need to develop long term resource management policies for these ecosystems based on an understanding of the ecological processes involved in their maintenance, ensuring a sustained yield of agricultural or forest products for human benefit as well as reservoirs of natural habitat to maintain biological diversity. Associated with this is a need for techniques to monitor changes in populations caused by degradation and regeneration. Butterfly monitoring programs in the tropics must, by necessity, focus on changes in the relative abundance of species. The assumption behind this approach is that data on temporal fluctuations in locally common species will help us assess environmental trends and evaluate the effectiveness of habitat conservation efforts.

MATERIALS AND METHODS

Study area

Ton Nga-Chang Wildlife Sanctuary is a protected area of about 365 km^2 in Songkhla and Satun provinces in southern Thailand. It is located between latitudes 15° 33' N to 16° 23' N and longitudes 99° 33' E to 99° 07' E. The study sites are at 260 m above mean sea level in tropical rain forest.

Sampling and Identification

Field surveys for tropical butterflies were conducted from June 1997 through May 1998 by using line transect and Pollard's transect baited traps[5]. The plant community in this area is the lower hillside and valley. The dominant species of ground vegetation were *Etlingera littoralis*, *Zingiber zerumber*, *Amomum villosum*, *Alpinia* spp., *Costus speciosus*, *Schumannianthus dichotomus*, *Ixora* spp., *Psychotria rhinocerotis,* etc. The height of the lower canopy was approximately 15.5 m and contained the trees

Castanopsis sp., *Lithocarpus* sp., *Orophea cuneiformis*, *O. enterocarpa*, *Rinorea sclerocarpa*, *Croton argyratus*, *Baringtonia pendular,* etc. The upper canopy was approximately 30-40 m in height and contained *Pometia pinnata*, *Shorea assamica* var. *globifera*, *Millettia atropurpurea, Dipterocarpus hasseltii,* etc. The study sites were classified into 3 groups by the tree density : dense forest (DF), secondary forest (SF) and waterfall forest (WF). All trees with a diameter at breast height greater than or equal to 23.6 cm were counted. DF had > 7.6 trees per 25 m^2 ; SF had 4.6-7.6 trees per 25 m^2 and WF had < 4.6 trees per 25 m^2. The vegetation found in DF was similar to that in SF, but seemed more dense and lush. WF was the forest area near the waterfall with sandy loam and sandstone outcrops, and was an edge habitat.

Traps were arranged along 5 line transects. Two transects were in DF, two others were in SF, and one transect was in WF. The 2.5 km of transects were walked once a month and Pollard's transect walking technique was modified to include both captures with a hand net and hanging baited-trap[5]. Attempts were made to catch every butterfly seen. Sampling stations were established at fixed distances along the transect. The cylindrical hanging baited-traps, baited with fermented pineapples and bananas, were hung approximately 3 m from the ground. At each trapping site, a 15-minute visual survey was conducted within a 10-m radius of the trap after the traps had been emptied.

Date, location, time, species, number of individuals, and weather conditions were recorded. Data from netting and trap records were combined in assessments of species richness and relative abundance at each trap site. We calculated butterfly species diversity by the Shannon-Weiner index,[9] and performed an analysis of abiotic factors associated with the total number of individuals, total species and individual number of butterflies in each family using the Spearman rank correlation. Butterfly nomenclature follows Lekagul *et al*,[10] and Pinratana.[11-16] Voucher specimens are deposited in the collection of diurnal Lepidoptera at the Natural History Museum of Prince of Songkla University, Hat Yai, Songkhla Province.

The Shannon-Weiner index (H) is calculated as

$$H = -\sum_{i=1}^{N} P_i \log_e P_i$$

where H = species diversity index
P_i = the proportion of individuals in the i^{th} species
N = total number of species
i = species 1, 2, 3,..., N

Results

Diversity of butterfly at Ton Nga-Chang Wildlife Sanctuary

Butterflies found from June 1997 to May 1998 comprised 9 families. All species found in each family, from both hand netting and hanging traps, are shown in the Appendix. Table 1 shows a summary of species and families caught in each habitat, including for each habitat the total number of species recorded, total trapped, number of exclusive species (not found in other habitats) and number of individuals. The total species recorded in DF, SF and WF were 71, 75 and 74, respectively. Nymphalids were found in all sites. In contrast, Papilionidae and Ridionidae were rare, represented by only one individual at the DF and the WF site. The most abundant and commonly found family was Nymphalidae (Table 1) with *Euthalia dirtea* (Fabricius) (Fig 1 a,b) as the dominant species (Table 2). Another important family of butterfly was Lycaenidae (Table 1) which were frequently found though not in high numbers, while Ridionidae (Table 1) were rarely found. *Narathura democritus* (Fabricius) (Fig 1 c) and *Eurema blanda* (Boisduval) (Fig 1 d), representing the Lycaenidae and Pieridae, were found in high numbers in this study. Table 2 shows the most abundant butterfly species found at each trap site and the months of their occurrence. February, July and December were the richest months in terms of species, while March, April and September were the poorest in species. The cumulative numbers of species identified for each site are shown in Fig 2.

Species diversity index

Regular transect counts on fixed sites were used to establish monthly diversity indices. Fig 3 shows the values of the index calculated by the Shannon-Weiner equation. The maximum diversity was observed in February (H=3.2) and the lowest in September (H=1.72).

Effects of physical factors on numbers of individuals and species

The Spearman rank correlation between physical factors (humidity, rainfall and temperature) and total individuals number shows that none of the physical factors was significantly related to the number of individuals and the number of species of butterflies caught per month (Table 3). Regarding each family of Lepidoptera, humidity is the only physical factor significantly positively correlated with the numbers

Table 1. A summary of the individuals and species numbers of butterflies in each habitat at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province.

Family	Dense Forest (DF)				Secondary Forest (SF)				Waterfall Forest (WF)				Total
	S	T	E	N	S	T	E	N	S	T	E	N	
Papilionidae	1	1	-	**1**	3	3	-	**3**	14	7	11	**28**	32
Nymphalidae	19	15	7	**80**	19	16	6	**100**	15	15	4	**105**	285
Danaidae	2	2	-	**3**	6	-	4	**11**	11	9	7	**82**	96
Amathusiidae	6	4	3	**23**	8	8	3	**22**	7	7	2	**14**	59
Satyridae	10	7	4	**28**	10	9	2	**41**	8	7	3	**31**	100
Pieridae	5	5	2	**27**	4	3	1	**28**	7	7	3	**42**	97
Ridionidae	3	2	1	**7**	2	2	-	**7**	1	1	1	**1**	15
Lycaenidae	20	15	8	**58**	19	17	7	**65**	4	4	-	**13**	136
Hasperiidae	5	5	5	**5**	4	3	3	**7**	7	5	6	**9**	21
Total	71	56	30	**232**	75	61	26	**284**	74	62	37	**325**	841

S=total number of species recorded, T= total number of trapped species, E= total number of exclusive species, N= total number of individuals.

Table 2. Most common butterflies caught in traps and nets by habitat and the months of occurrence at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province.

Overall Rank	Species	Numbers collected (traps/nets) by habitat				Months of Occurrence											
		DF	SF	WF	Total	J	F	M	A	M	J	J	A	S	O	N	D
1	*Euthalia dirtea* (Fabricius)	30 / -	38 / -	28 / 17	113	3	8			3		9	8	**42**	7	10	23
2	*Eurema blanda* (Boisduval)	20 / -	11 / -	15 / -	46	3	8			5	3	**16**	3		3		5
3	*Euthalia dunya* Doubleday	18 / -	11 / -	4 / -	33		6	3	1	3		5		**10**	2		3
4	*Faunis canens* HÜbner	13 / -	10 / -	5 / 2	30	7	**10**	3			4				1	2	3
5	*Narathura democritus* (Fabricius)	1 / -	20 / -	- / -	27		3			2	**9**	**9**	2		2		
5	*Melanitis leda* (Linnaeus)	9 / -	8 / -	10 / -	27	2	**8**	3	4		1	5	2	1		1	
7	*Euploea mulciber* (Cramer)	2 / -	- / -	16 / 7	25		1			**7**	5	3	6				3
7	*Euthalia teuta* (Doubleday)	3 / -	6 / -	16 / -	25		**8**		6	3					3		5
9	*Appias albina* (Boisduval)	2 / -	12 / -	10 / -	24	1					3	**11**				2	7
10	*Drupadia theda* (Felder)	12 / -	8 / -	3 / -	23						7	5			3		**8**

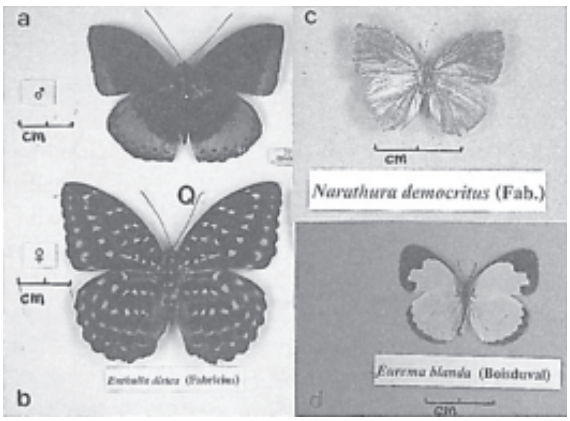

Fig 1. Showing upperside of a) male : *Euthalia dirtea* (Fabricius) b) female: *Euthalia dirtea* (Fabricius) c) *Narathura democritus* (Fabricius) d) *Eurema blanda* (Boisduval)

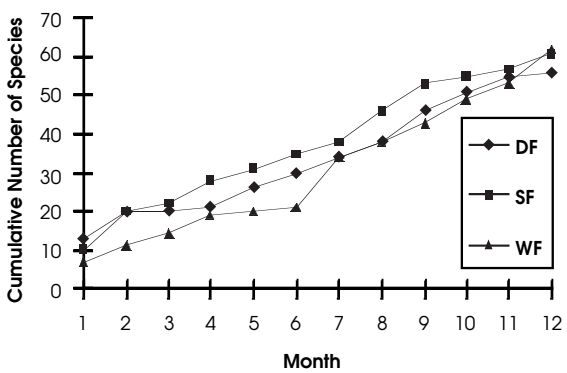

Fig 2. Cumulative numbers of butterfly species recorded in dense forest (DF), secondary forest (SF) and waterfall forest (WF) sites at Ton Nga-Chang Wildlife Sanctuary.

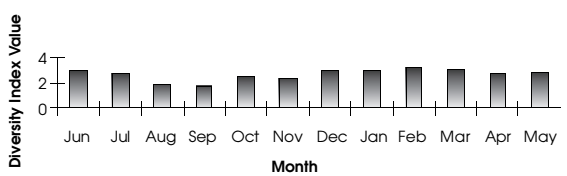

Fig 3. Species diversity index of butterfly calculated by Shannon-Weiner equation from June 1997-May 1998.

Table 3. Correlation Coefficient (r_s) of Spearman rank correlation and Probability (P) between physical factors and total number of individuals, species, and individual numbers in each family caught per month.

Physical factor r_s - value	Humidity (%)	Rainfall (mm)	Temperature (°C)
Total individuals	-0.08 (P=0.80)	-0.30 (P=0.35)	-0.23 (P=0.47)
Species	-0.28 (P=0.38)	-0.40 (P=0.20)	-0.26 (P=0.42)
Individual numbers in			
Papillionidae	0.12 (P=0.72)	-0.10 (P=0.75)	-0.35 (P=0.27)
Nymphalidae	0.25 (P=0.44)	0.03 (P=0.93)	-0.13 (P=0.68)
Danaidae	-0.06 (P=0.86)	0.34 (P=0.28)	0.10 (P=0.75)
Amathusiidae	-0.46 (P=0.14)	**-0.59 (P=0.04)***	-0.19 (P=0.55)
Satyridae	-0.51 (P=0.09)	**-0.59 (P=0.04)***	-0.09 (P=0.78)
Pieridae	-0.05 (P=0.89)	-0.08 (P=0.79)	-0.38 (P=0.22)
Riodinidae	-0.07 (P=0.82)	-0.15 (P=0.64)	-0.34 (P=0.28)
Lycaenidae	0.02 (P=0.96)	-0.04 (P=0.99)	-0.34 (P=0.28)
Hesperiidae	**0.62 (P=0.03)***	0.21 (P=0.51)	-0.35 (P=0.26)

* significant level at 0.05.

of butterflies in Hesperiidae (r_s= 0.62, P<0.05, Table 3). Rainfall was also significantly negatively correlated with the individual numbers of amathusid butterflies (r_s= -0.59, P<0.05, Table 3) and satyrids (r_s= -0.59, P<0.05, Table 3). However, there was no evidence of a correlation between temperature and butterfly numbers of each family (Table 3).

Discussion

Data collection

Many studies[6,17] have recorded vertical stratification of insects in rain forest, with greatest abundance in the canopy. This could result in under-representation of canopy-feeding species in ground-based surveys. De Vries[18] considered that Nymphalidae in neotropical rain forests showed species stratification when feeding, but these data were based on evidence from baited traps, and did not consider whether stratification is maintained at all times. However, a study[19] in Australian rain forest butterflies did not show species stratification as adults, and they concluded that butterflies could be adequately surveyed without access to the canopy. In particular, no evidence has been found for a specialist canopy fauna different from that observed near the ground.

Diversity of butterflies at Ton Nga-Chang Wildlife Sanctuary

The diversity of butterflies found at Ton Nga-Chang Wildlife Sanctuary during June 1997 - May 1998 was high. The total of 147 species collected by hand net and hanging traps can be classified into 9 families and 77 genera. The butterfly families with

the highest number of species are Nymphalidae and Lycaenidae. These are large groups of Lepidoptera and include many common species which can be seen nearly anywhere. For Nymphalidae, *Euthalia dirtea* (Fabricius) is the most abundant species, which was found at all sites. September was the period of peak emergence of adults. Lycaenidae, a group of small, delicate and often brightly colored butterflies, were found most often at the SF site. *Narathura democritus* (Fabricius), a member of this family, was most frequently found in June and July at the SF site because it often flew in the open sunshine. In contrast, Danaidae were not found in baited traps at the SF site. There was no obvious reason for this, but, the abundance of this species may also depend on the distribution of its host plants. Ridionidae were rarely found, because this family has few species. Butterflies at other families (Papilionidae, Satyridae, Pieridae, Amathusiidae and Hesperiidae), were usually common but there were also uncommon and rare species.[10] The occurrence of rare species may provide important information for conservation, but a more accurate and rapid assessment of the condition of the habitat may be obtained by monitoring a carefully selected group of locally common species.

Examination of the cumulative number of species over time shows that sampling was probably sufficiently intensive to describe adequately the butterfly fauna at each site, but as the curves (Fig 2) do not clearly level off, it is likely that the true number of species present is higher than the number recorded. Each site possessed a diverse fauna with several species from each family, the exceptions being Papilionidae and Danaidae at the DF site, Ridionidae at the SF and WF sites. The most butterfly species were at the WF site. Perhaps they came to obtain water or salts near the waterfall.[20]

Species diversity index

The monthly species index value was maximum in February. From our observations, this may be due to the timing of flowering in some tree species (such as Leguminosae) during that part of the year. Some species of butterflies are highly seasonal. They were likely to have emerged as adults during this time. On the other hand, the monthly species index value was minimum in September. This could have been the result of forest fires all over Indonesia in 1997 during the study period. These fires occurred over a wide area for a long time, and had a major effect on atmospheric conditions in many countries in this region, especially in the southern Peninsular Thailand. Consequently, these fires may have influenced the present-day diversity. Furthermore, the butterflies may have survived in imago stages such as larvae, so we could not collect them in the adult form.

Effects of physical factors on numbers of individuals and species

None of the physical factors measured was significantly related to the total number of individuals or the species numbers of butterflies. This result is in contrast with those of Moss and Pollard[21] and Pollard *et al,*[22] which may reflect the differences between the tropical and temperate climate patterns. They reported significant effects of weather: rainfall and humidity were negatively correlated with the numbers of individuals and species of butterflies.[22-23] Some field studies of tropical butterflies indicate that periods of very heavy rain may result in increased mortality of adults,[9] thus causing their numbers to decrease. Our study showed a similar pattern in the families Satyridae and Amathusiidae. In contrast, individual numbers of Hesperiidae increased with high humidity. It is possible that the immature stages of Hesperiidae usually reside in blotch mines, and that the leaf is often folded and becomes a shelter from rain.[24] Thus, Hesperiidae show a positive correlation with humidity. Otherwise, butterflies are most active as adults in sunny weather[9,25-28] when conditions are suitable for mating and oviposition.

Butterfly populations increased significantly during the period of high temperature and low precipitation. Temperature effects the growth of food plants[23], and therefore should be positively correlated with the numbers of individuals and species. In our study, however, correlations with temperature were not significant, probably because the temperature in the tropics is rather constant. Also, the average temperature in each month may have differred from the real temperature during the survey periods.

Temperature may affect butterfly populations in several ways. High temperature may enhance courtship behavior, oviposition and larval development. High temperature weather may even promote outbreaks in some species. On the other hand, larval development may be adversely affected if the humidity of the soil remains low. Finally, the family–weather correlations are weak; because of the large number of tests carried out at the 0.05 probability level, it is expected that some (1 in 20) will be "significant" by chance alone. Overall, weather variations in the wet tropics are not great enough to produce many measurable effects on butterfly numbers.

The study period was relatively short for an analysis of trends which may affect their conservation status. Longer term monitoring is needed to identify significant changes in biological diversity, permitting the timely adjustment of management activities to reverse or prevent undesired trends.

Acknowledgements

We would like to thank Mr Pinit Suwanno, chief of Ton Nga-Chang Wildlife Sanctuary, for permitting us to work and collect butterflies. Further thanks are due to anonymous referees who made comments that led to considerable improvement of the text.

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