NAT. HIST. BULL. SIAM SOC. 49: 177–188, 2001

PHYSICAL EFFECTS ON BUTTERFLY DIVERSITY AT TON NGA CHANG WILDLIFE SANCTUARY, SOUTHERN THAILAND

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ABSTRACT

Fifty-three genera and 98 species of butterflies (Lepidoptera) were collected at Ton Nga Chang Wildlife Sanctuary, Songkhla Province, from September 1999 to August 2000. The specimens were collected with aerial nets and hanging baited-traps along transects. Nymphalidae and Satyridae were the best represented families. The most abundant species was *Melanitis leda leda* (Linnaeus) (Satyridae). The highest diversity was found in April (Shannon-Weiner index, $H = 3.41$), and the lowest in November ($H = 1.08$). There were no significant correlations among physical factors (humidity, rainfall and temperature) and the total number of individuals or species. Moreover, butterfly numbers were not related to rainfall in any family. However, humidity was significantly negatively correlated with the individual numbers of Nymphalidae, and temperature was positively correlated with the individual numbers of Pieridae and Lycaenidae.

Keywords: butterflies, diversity, Lepidoptera, weather, Shannon–Weiner index, Songkhla

INTRODUCTION

Arthropods are good indicators of habitat biodiversity because they respond quickly to environmental changes, and are a highly diverse taxon. Lepidoptera (butterflies and moths) are the second largest order of arthropods and most are easily identified, making them particularly useful for biodiversity surveys (COLLINS AND THOMAS, 1989; ERHARDT, 1985; HILL *ET AL.*, 1995; KREMEN, 1994; MITTLER *ET AL.*, 1995; SPARROW *ET AL.*, 1994). Butterflies occur in a very wide range of situations but are particularly characteristic of humid tropical forests, in which the majority of known species occur. Two important measures of diversity are species richness (LANDAU *ET AL.*, 1999) and relative abundance of individuals (HAMMOND & MILLER, 1998). Species richness is a critical variable in conservation planning and natural resource management.

This research provides baseline data with which future butterfly surveys may be compared. Several long-term monitoring aims are: 1) to provide information on the rate and sequence of species turnover in regenerating forest; 2) to analyze changes in abundance of butterflies; and 3) to detect trends which may affect their status. In a previous study (BOONVANNO *ET AL.*, 2000), information was collected on fluctuations in diversity of and physical factors affecting butterflies at Ton Nga Chang Wildlife Sanctuary. This study was conducted to gather more information on butterfly diversity in order to compare with that of the previous study as well as to accumulate data for long-term monitoring.

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Received 28 December 2000; accepted 3 August 2001.

STUDY AREA

Ton Nga Chang Wildlife Sanctuary, a 365-km^2 protected area, is located in the mountainous section of Songkhla and Satun Provinces. Twelve study sites were selected in open areas within the tropical rain forest at 260–500 m above mean sea level. These sites were located near the Forest Department headquarters which is at Ban Phru Chaba (2) village, near the Ton (= Don) Nga Chang Waterfall, on the east side of the sanctuary. Five sites were within 1 km north and west of headquarters, and 7 sites were on the east slopes of Khao Ton Nga Chang mountain, up to 2 km south of headquarters. The 12 sites were within the area of 100° 13.8–14.6' E longitude, 6° 55.5–57.3' N latitude. A 0.5-km transect was established at each site.

The plant community at the study sites areas is tall canopy forest typical of hillside and valley. The dominant species of plants were described in BOONVANNO *ET AL.* (2000).

Data on the temperature, humidity and rainfall were obtained for the Hat Yai International Airport in the lowland about 10 km east of the sanctuary, from the Meteorological Department. The total rainfall during the year between Sept. 1999 and Aug. 2000 was 2305 mm.

METHODS

Collection and Identification

A transect was placed in each study site to monitor cylindrical hanging fruit-baited traps for butterflies. Trapping was carried out from September 1999 to August 2000. Each transect was walked twice per month. Butterflies were captured in two ways: by handnet and by modified Pollard's transect baited traps (SPARROW *ET AL.*, 1994). Butterflies that were seen while walking transects were chased with a handnet, although not all were caught. Twelve hanging traps baited with rotting fruits (pineapple, mango and banana) were set at 40-m intervals along each transect and were hung on the tree at about 3 m from the ground. At each trapping site, a 15-minute visual survey for capturing more butterflies seen was conducted within a 10-m radius of the trap after the traps had been emptied. Date, location, time, species and number of individuals were recorded. The butterflies were identified by comparison with pictures in LEKAGUL *ET AL.* (1977) and PINRATANA (1981, 1983, 1985, 1988, 1992 and 1996). The preserved specimens are deposited at the diurnal Lepidoptera collection of the Natural History Museum, Prince of Songkla University, Hat Yai, Songkhla.

Statistical Analysis

Data from netting and trapping were combined to assess species richness and abundance of individuals. Butterfly species diversity was calculated using the Shannon-Weiner index (*H*), and correlation analysis of abiotic factors that are the average over all sites for each month associated with the total number of individuals, number of species and number of individual butterflies in each family, with the Spearman rank correlation using SPSS for Windows, version 7.0.

Table 1. A summary of the number of individuals and species of butterflies at Ton Nga Chang Wildlife Sanctuary, Songkhla Province.

Family	Number of individuals	Number of species
Papilionidae	18	4
Nymphalidae	182	35
Danaidae	13	5
Amathusiidae	58	7
Satyridae	156	18
Pieridae	29	7
Ridionidae	6	3
Lycaenidae	33	16
Hesperiidae	3	3
Total	498	98

RESULTS

Species Richness, Abundance, and Diversity.

I collected 498 butterflies of 98 species in 9 families (Table 1) at Ton Nga Chang Wildlife Sanctuary. All species found in each family, from both hand netting and hanging traps, are shown in the Appendix 1. Fifty of the 498 individuals collected were singletons (species represented by only one individual). Nymphalidae and Satyridae were the most common families, whereas Hesperiidae and Ridionidae were the rarest. Libytheidae and Acraeidae were not found.

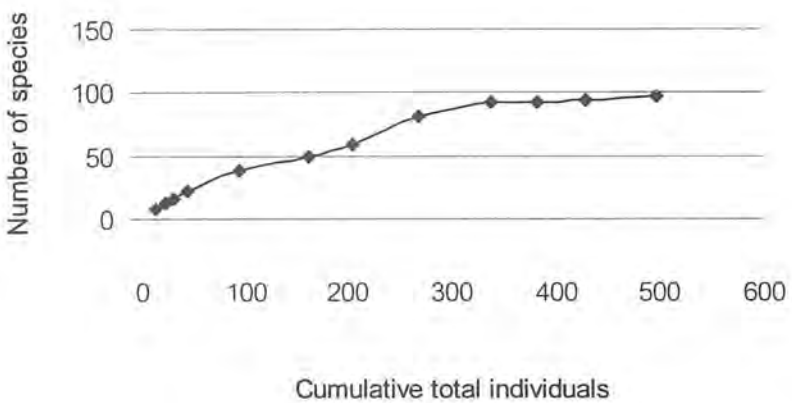

Figure 1. The relationship between the cumulative number of butterfly species and the total number of individuals collected at Ton Nga Chang Wildlife Sanctuary.

Table 2. Most common butterflies caught in each month at Ton Nga Chang Wildlife Sanctuary, Songkhla Province.

Rank	Species	Individual numbers per month (* =peak month)												Total
		J	F	M	A	M	J	J	A	S	O	N	D	
	Melanitis leda leda (Linnaeus)	1	**28***	11	6	2	3	5	2	0	0	2	1	61
2	*Euthalia dunya dunya* Doubleday	6	7	4	5	3	**8***	4	**8***	4	2	1	1	53
3	*Mycalesis oroatis ustulata* Distant	5	5	3	2	0	**10***	4	3	0	1	0	2	35
4	*Euthalia teuta gupta* (deNiceville)	1	0	0	3	5	3	**11***	4	0	0	0	0	27
5	*Neorina lowii neophyta* (Fruhstorfer)	0	3	0	4	3	4	3	**6***	1	0	0	0	24
6	*Zeuxidia amethystus amethystus* Butler	**6***	0	3	0	1	1	1	2	0	2	3	2	21
7	*Lexias dirtea merguia* (Tytler)	**7***	0	0	2	0	3	0	**7***	0	0	0	0	19
	Prothoe franck uniformis Butler	**3***	**3***	1	**3***	**3***	2	1	**3***	0	0	0	0	19
9	*Appias nero galba* Wallace	0	0	0	2	**8***	0	0	6	0	0	0	0	16
10	*Euthalia evelina compta* (Fruhstorfer)	1	0	0	0	1	0	**6***	1	0	0	0	0	9
	Amathuxidia amythaon amythaon Doubleday	0	0	0	2	**4***	1	0	2	0	0	0	0	9

The 11 most abundant species and their monthly counts are given in Table 2. The most abundant species was *Melanitis leda leda* (Linnaeus) (Satyridae) (Table 2), with 61 individuals. It was most abundant in February, but was not found in September and October. *Euthalia dunya dunya* (Doubleday) (Nymphalidae), the next most abundant species, was found all year round. Another important family of butterfly was Amathusiidae (Table 1) which was found frequently but not in high numbers. Nine of the 11 species had peaks in numbers between May and August, whereas none of the common species had peaks during September to December (Table 2). Among the 11 most common species, only 4 species (*Melanitis leda, Euthalia dunya, Euthalia teuta,* and *Lexias* (*Euthalia*) *dirtea*) were also among the 10 most common butterflies of the previous study.

The rate of accumulation of species (S) against the cumulative total of individuals (N) collected is shown in Fig. 1. Total species richness (S_T) of butterflies was 98. Above about 340 individuals, the rate of accumulation of individuals was very slow.

The species diversity index calculated using the Shannon-Weiner equation (H) is shown in Fig. 2. The maximum value was observed in April (H = 3.41) and the lowest in November (H = 1.08).

Relationship between Physical Factors and Butterfly Numbers

Monthly values of humidity, rainfall and temperature are shown in Appendix 2. From Table 3, none of the physical factors (humidity, rainfall and temperature) was significantly correlated with the total number of individuals or the total number of species of butterflies caught per month. Humidity was significantly negatively correlated with the number of individual butterflies in Nymphalidae (r_s = –0.69, P < 0.05), and temperature was significantly positively correlated with the numbers of Pieridae (r_s = 0.58, P < 0.05) and Lycaenidae (r_s = 0.69, P < 0.05). However, there was no evidence of a correlation between rainfall and butterfly numbers for any family.

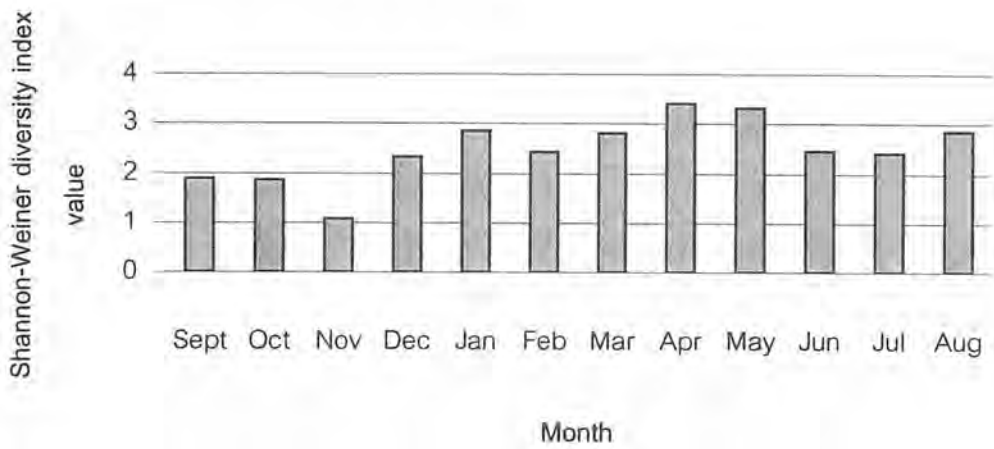

Figure 2. Species diversity index of butterfly calculated by Shannon-Weiner equation from September 1999 - August 2000.

Table 3. Correlation between butterfly abundance and species richness and physical factors, using the Spearman rank correlation coefficient (r_s).

Physical factor: r_s - value	Humidity (%)	Rainfall (mm)	Temperature (°C)
Total individuals	–0.50 (P=0.10)	–0.47 (P=0.13)	0.43 (P=0.16)
Species	–0.21 (P=0.51)	–0.28 (P=0.38)	0.52 (P=0.08)
No. individuals in			
Papilionidae	–0.53 (P=0.08)	–0.17 (P=0.61)	0.22 (P=0.49)
Nymphalidae	**–0.69** (P=0.01) *	–0.27 (P=0.40)	0.41 (P=0.18)
Danaidae	–0.38 (P=0.22)	–0.31 (P=0.33)	0.44 (P=0.15)
Amathusiidae	0.05 (P=0.88)	0.09 (P=0.78)	0.34 (P=0.28)
Satyridae	–0.37 (P=0.24)	–0.41 (P=0.18)	0.31 (P=0.33)
Pieridae	–0.22 (P=0.50)	–0.17 (P=0.59)	**0.58** (P=0.05) *
Riodinidae	–0.08 (P=0.80)	–0.05 (P=0.88)	0.18 (P=0.58)
Lycaenidae	–0.17 (P=0.59)	–0.41 (P=0.19)	**0.69** (P=0.01) *
Hesperiidae	0.25 (P=0.43)	–0.31 (P=0.33)	0.03 (P=0.93)

*Correlation is significant at the 0.05 level (2-tailed)

DISCUSSION

Species Richness, Abundance and Diversity

The diversity of butterflies collected during the one year of this study, comprising 98 species and 53 genera in 9 families, was low compared to that reported in BOONVANNO *ET AL.* (2000). In that study 147 species and 77 genera in 9 families were found. It is possible that the butterfly habitats were more degraded. Sampling intensity (number of baited traps, length of transects) was higher in this study than in the previous one; however, only mature forest habitat was sampled in this study, whereas disturbed forest habitats were included in the previous one. In the previous study, only 71 species were found in "dense forest" habitat.

Many species found in the previous study were not found in the present study. Of the 98 species found, only 53 had been found previously and 45 were new. This shows that long-term surveys of all habitats are necessary to detect all the species at a given site.

In both studies the families Libytheidae and Acraeidae were missing. It is possible that the species of these families are too small and rare in the study area to be detected.

Nymphalidae were the most dominant group, followed by Satyridae. Nymphalidae is the largest family of butterflies. Nymphalids can often be found sunning themselves while satyrids usually have a slow, jerky flight and stay close to the ground; hence, they are easier to catch. The satyrid *Melanitis leda leda*, a widespread species (HILL *ET AL.*, 2001) in this study, is active only at dusk and dawn (LEKAGUL *ET AL.*, 1977; PINRATANA, 1988), and has a peak of emergence in February. It was not found in September and October, when it passes through its immature stages.

The total species richness (S_T) of butterflies (98 in this study) is a straightforward measure of diversity, but if the survey time were prolonged the curve would continue to creep upwards as new species are added to the list. Hence, the true species richness is still higher than the number caught, as the cumulative curves shows no sign of leveling off completely.

When a diverse fauna is sampled it is always found that a few species are represented by a lot of individuals and a large number of species are represented by one or a few individuals. These relative abundances are considered in the diversity index. From the Shannon–Weiner equation, the monthly species index value was maximal in April. There is no obvious reason for this. However, it may depend on the flowering of the host plants that affect butterflies feeding on nectar and other biotic factors. November had the lowest species index. Perhaps during this time most butterflies were in the immature rather than adult stages. In comparison with the previous study, total diversity did not peak in the same months exactly. The maximum diversity in the previous study was observed in February ($H = 3.2$) and the lowest in September ($H = 1.72$). More study of what influences diversity is needed.

The Relationship between Physical Factors and Butterfly Numbers

In this study, none of the physical factors was significantly related to the total number of individuals or species richness. This result is consistent with that of BOONVANNO *ET AL.* (2000), but it contrasts with YOUNG (1982), POLLARD (1988), POLLARD *ET AL.* (1993) AND MOSS & POLLARD (1993). It may reflect the differences between tropical and temperate climate patterns. Environmental fluctuation in temperate countries is relatively greater and may have more severe effects on the abundance and species richness of butterflies.

Humidity and rainfall were negatively correlated with the number individuals and species in Pollard's studies (POLLARD, 1988; POLLARD *ET AL.*, 1993). For humidity, this study shows parallel results with respect to the number of Nymphalidae. Our results contrast with the former study (BOONVANNO *ET AL.*, 2000) in which numbers of hesperid butterflies were positively correlated with humidity. Perhaps hesperids can shelter themselves from rainfall or high humidity by folding leaves.

In the previous study (BOONVANNO *ET AL.*, 2000), periods of very heavy rain resulted in significantly increased mortality of butterfly adults in the Amathusiidae and Satyridae. Indeed, the numbers of individuals and species of butterflies should be reduced by high rainfall (YOUNG, 1982), as adult emergence is suppressed by rain. In the present study, however, the lack of significant correlations between rainfall and numbers of butterflies indicated that rainfall did not have an important influence on butterfly numbers.

Temperature was positively correlated with the numbers of individuals and species of Pieridae and Lycaenidae. This result is in agreement with some other field research (POLLARD, 1988; POLLARD *ET AL.*, 1993). Butterflies of these families often sun themselves. High temperature also facilitates oviposition, courtship behavior, and larval development. In addition, temperature indirectly affects the growth of food plants (POLLARD, 1988).

This study was too short for an analysis of population trends; long term monitoring is needed for more accurate information. Furthermore, additional work is needed to compare Lepidoptera diversity among general categories of vegetation types within forested ecosystems, to provide better baseline data. Butterfly–plant relationship are therefore being studied to further our understanding of biotic effects on butterfly numbers and diversity.

ACKNOWLEDGMENTS

I would like to thank Chief of Ton Nga Chang Wildlife Sanctuary for permitting me to work and collect butterflies. I would particularly like to thank Mr Vira Samalee of the Meteorological Department for useful meteorological data. Further thanks are due to anonymous referees whose comments that led to considerable improvement of the text. The Faculty of Science, Prince of Songkla University, financially supported this research.

REFERENCES

BOONVANNO, K., S. WATANASIT, AND S. PERMKAM. 2000. Butterfly diversity at Ton Nga-Chang Wildlife Sanctuary, Songkhla Province, Southern Thailand. *Science Asia* 26: 105–110.

COLLINS, N. M., AND J. A. THOMAS. 1989. *The Conservation of Insects and their Habitats.* Academic Press, London. pp. 412–417.

ERHARDT, A. 1985. Diurnal Lepidoptera: sensitive indicators of cultivated and abandoned grassland. *Journal of Applied Ecology* 22: 849–861.

HAMMOND, P. C., AND J. C. MILLER. 1998. Comparison of the biodiversity of Lepidoptera within three forested ecosystems. *Conservation Biology and Biodiversity* 91: 323–328.

HILL, J. K., K. C. HAMER, L. A. LACE, AND W. M. T. BANHAM. 1995. Effects of selective logging on tropical forest butterflies on Buru, Indonesia. *Journal of Applied Ecology* 32: 754–760.

HILL, J. K., K. C. HAMER, J. TANGAH,. AND M. DAWOOD. 2001. Ecology of tropical butterflies in rainforest gaps. *Oecologia* 128: 294–302.

KREMEN, C. 1994. Biological inventory using target taxa: a case study of the butterflies of Madagascar. *Ecological Applications* 4: 407–422.

LANDAU, D. D. PROWELL, AND C. E. CARLTON. 1999. Intensive versus long-term sampling to access lepidopteran diversity in a southern mixed mesophytic forest. *Conservation Biology and Biodiversity* 92: 435–441.

LEKAGUL, B., K. ASKINS, J. NABHITABHATA, AND A. SAMRUADKIT. 1977. *Field Guide to the Butterflies of Thailand.* Kurusapha Press, Bangkok. 260 pp.

MITTLER, T. E., F. J. RADOVSKY, AND V. H. RESH. 1995. Butterfly conservation and management. *Annual Review of Entomology* 40: 57–83.

MOSS, D., AND E. POLLARD. 1993. Calculation of collated indices of abundance of butterflies based on monitored sites. *Ecological Entomology* 18: 77–83.

PINRATANA, A. 1981. *Butterflies in Thailand.* Vol. 4. Viratham Press, Bangkok. 216 pp.

____ 1983. *Butterflies in Thailand.* Vol. 2. Viratham Press, Bangkok. 71 pp.

____ 1985. *Butterflies in Thailand.* Vol. 5. Viratham Press, Bangkok. 152 pp.

____ 1988. *Butterflies in Thailand.* Vol. 6. Viratham Press, Bangkok. 61 pp.

____ 1992. *Butterflies in Thailand.* Vol. 1. Viratham Press, Bangkok. 79 pp.

____ 1996. *Butterflies in Thailand.* Vol. 3. Viratham Press, Bangkok. 140 pp.

POLLARD, E. 1988. Temperature, rainfall and butterfly numbers. *Journal of Applied Ecology* 25: 819–828.

POLLARD, E., C. A. M. VAN SWAAY, AND T. J. YATES. 1993. Changes in butterfly numbers in Britain and the Netherlands, 199091. *Ecological Entomology* 18: 93–94.

SPARROW, H. R., T. D. SISK, P. R. EHRLICH,. AND D. D. MURPHY. 1994. Techniques and guidelines for monitoring Neotropical butterflies. *Conservation Biology* 8: 800–809.

YOUNG, A. M. 1982. *Population Biology of Tropical Insects.* Plenum Press, London. pp. 289–377.

Appendix 1. Annotated list of butterfly species at Ton Nga Chang Wildlife Sanctuary from September 1999 to August 2000. (N: New record when compared with the previous survey)

Family		Scientific name	Individuals	Month of occurrence
Papilionidae		1. *Graphium agamemnon agamemnon* Linnaeus	2	1
		2. *Papilio polytes romulus* Cramer	8	2, 4, 5, 8
		3. *Papilio nephelus chaon* Westwood	7	8–10
	N	4. *Papilio mahadeva mahadeva* Moore	1	5
		Total	**18**	
Nymphalidae		1. *Lexias dirtea merguia* (Tytler)	19	1, 4, 6, 8
		2. *Lexias pardalis dirteana* (Corbet)	4	1–3
		3. *Lexias pardalis jadeitina* Fruhstorfer	1	2
		4. *Lebadea martha malayana* Fruhstorfer	1	12
		5. *Euthalia dunya dunya* (Doubleday)	53	1–12
	N	6. *Euthalia recta monilis* (Moore)	2	4, 5
		7. *Euthalia teuta goodrichi* Distant	2	4
		8. *Euthalia teuta gupta* (de Niceville)	27	1, 4–8
		9. *Euthalia monina monina* (Fabricius)	1	4
	N	10. *Euthalia alpheda verena* Fruhstorfer	1	4
		11. *Euthalia evelina compta* (Fruhstorfer)	9	1, 4–8
	N	12. *Neptis clinia susruta* Moore	1	4
		13. *Neptis hylas papaja* Moore	2	1, 3
	N	14. *Neptis harita harita* Moore	2	5
		15. *Terinos terpander robertsia* Butler	5	1–3, 7
	N	16. *Tanaecia iapis puseda* (Moore)	1	1
	N	17. *Tanaecia palguna consanguinea* Distant	2	1, 11
		18. *Tanaecia pelea pelea* (Fabricius)	1	12
		19. *Tanaecia julii odilina* Fruhstorfer	2	3, 6
		20. *Tanaecia aruna aruna* (C.&R. Felder)	2	5, 6
		21. *Prothoe franck uniformis* Butler	19	1–8
	N	22. *Athyma pravara helma* (Fruhstorfer)	3	1, 3, 4
		23. *Cirrochroa orissa orissa* C.&R. Felder	3	9, 10
		24. *Cirrochroa tyche rotundata* Butler	1	3
	N	25. *Cirrochroa emalea emalea* (Guerin-Meneville)	1	3
	N	26. *Kallima inachus siamensis* Fruhstorfer	1	11
	N	27. *Cupha erymanthis lotis* (Sulzer)	1	4

Family	Scientific name	Individuals	Month of occurrence
	N 28. *Vagrans egista sinha* (Kollar)	1	5
	N 29. *Paduca fasciata fasciata* (C.&R. Felder)	1	4
	N 30. *Cethosia biblis biblis* (Drury)	4	1, 2, 5
	N 31. *Cethosia biblis perakana* Fruhstorfer	1	2
	N 32. *Junonia lemonias lemonias* (Linnaeus)	1	8
	N 33. *Junonia iphita horsfieldi* Moore	1	2
	N 34. *Junonia atlites atlites* (Linnaeus)	1	12
	N 35. *Rhinopalpa polynice eudoxia* (Guerin-Meneville)	1	10
	36. *Charaxes bernardus hierax* C.&R. Felder	1	7
	N 37. *Cyrestis themire themire* Honrath	2	3, 4
	N 38. *Euripus nyctelius nyctelius* (Doubleday)	1	5
	Total	**182**	
Danaidae	N 1. *Parantica aspasia aspasia* Fabricius	2	1, 12
	N 2. *Parantica aglea melanoides* Moore	1	9
	3. *Euploea tulliolus ledereri* C.&R. Felder	1	10
	4. *Euploea algae limborgii* Moore	3	8
	5. *Idea lynceus lynceus* Drury	6	4, 5, 7
	Total	**13**	
Amathusiidae	1. *Faunis canens arcesilas* Stichel	8	2, 3, 5, 6, 8
	2. *Xanthotaenia busiris busiris* Westwood	3	1 4, 9
	3. *Zeuxidia amethystus amethystus* Butler	21	1, 5–8, 10–12
	4. *Zeuxidia amethystus masoni* Moore	4	2-4
	5. *Zeuxidia doubledayi doubledayi* Westwood	2	5
	6. *Zeuxidia aurelius aurelius* Cramer	4	4, 5, 7
	7. *Amathuxidia amythaon dilucida* Honrath	6	2–4, 6, 12
	8. *Amathuxidia amythaon amythaon* Doubleday	9	4–6, 8
	9. *Amathusia phidippus* (Linnaeus)	1	2
	Total	**58**	
Satyridae	1. *Mycalesis mineus macromalayana* Fruhstorfer	1	5
	N 2. *Mycalesis orseis nautilus* Butler	1	5
	3. *Mycalesis oroatis surkha* Marshall	1	5
	4. *Mycalesis oroatis ustulata* Distant	35	1–4, 6–8, 10, 12

Family	Scientific name	Individuals	Month of occurrence
	5. *Mycalesis janardana sagittigera* Fruhstorfer	2	1, 2
	N 6. *Mycalesis anapita anapita* Moore	1	1
	7. *Mycalesis fusca fusca* C.&R. Felder	7	2, 6, 7, 9
	N 8. *Mycalesis distanti mucianus* Fruhstorfer	1	2
	9. *Ypthima baldus baldus* Fabricius	6	1, 2, 4
	N 10. *Ypthima horsfieldii* Moore	1	4
	N 11. *Ypthima yunosukei* Aoki & Uemura	1	3
	12. *Melanitis leda leda* (Linnaeus)	61	1–8, 11, 12
	N 13. *Melanitis zitenius auletes* Fruhstorfer	1	1
	14. *Melanitis phedima abdullae* Distant	1	2
	15. *Neorina lowii neophyta* Fruhstorfer	24	2, 4–9
	N 16. *Coelites epiminthia epiminthia* Westwood	1	2
	17. *Lethe europa malaya* Corbet	2	8
	18. *Ragadia crisilda critolaus* f. *crisilda* de Niceville	7	1–3, 5, 7, 12
	N 19. *Ragadia makuta siponta* Fruhstorfer	2	7, 12
	Total	**156**	
Pieridae	N 1. *Eurema hecabe contubernalis* Moore	2	1, 3
	2. *Eurema blanda silhetana* Wallace	5	8
	3. *Leptosia nina malayana* Fruhstorfer	1	3
	4. *Appias nero galba* Wallace	16	4, 5, 8
	5. *Appias albina darada* C.&R. Felder	3	5, 8
	N 6. *Cepora iudith lea* Doubleday	1	4
	N 7. *Saletara liberia distanti* Butler	1	5
	Total	**29**	
Lycaenidae	N 1. *Arhopala lurida* Corbet	1	2
	2. *Arhopala atosia jahara* Corbet	6	4, 5, 8, 9
	N 3. *Arhopala phanda phada* Corbet	2	4,
	4. *Arhopala democritus democritus* (Fabricius)	4	4, 5
	5. *Arhopala cleander aphadantas* Corbet	5	5
	N 6. *Arhopala psuedocentaurus nakula* (C.&R. Felder)	1	5
	N 7. *Arhopala labuana* Bethune-Baker	1	5
	N 8. *Arhopala buddha cooperi* (Evans)	3	5

Family	Scientific name	Individuals	Month of occurrence
	N 9. *Arhopala arvina aboe* de Niceville	1	5
	N 10. *Jamides malaccanus malaccanus* (Rober)	3	4–5
	N 11. *Discolampa ethion ethion* (Westwood)	1	4
	N 12. *Rapala pheretima* (Hewitson)	1	4
	N 13. *Allotinus horsfieldi nessus* Corbet	1	4
	14. *Sithon nedymond ismarus* Fruhstorfer	1	4
	15. *Jamides pura pura* (Moore)	1	5
	16. *Jamides alecto agelades* (Fruhstorfer)	1	5
	Total	**33**	
Hesperiidae	N 1. *Calaenorrhinus aurivittatus cameroni* Distant	1	2
	N 2. *Tagiades parra gala* Evans	1	10
	N 3. *Ancistroides armatus armatus* H. Druce	1	3
	Total	**3**	
Riodinidae	1. *Paralaxita orphna laocoon* de Niceville	3	2, 6
	2. *Paralaxita telesia boulleti* Fruhstorfer	2	3, 4
	3. *Stiboges nymphidia* Butler	1	6
	Total	**6**	

Appendix 2. Weather data collected at Hat Yai International Airport, Songkhla Province, for September 1999–August 2000. Source: Meteorological Department.

Month: Physical factor	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Humidity (%)	94.1	96.5	96.7	96.0	94.3	94.6	95.5	95.9	95.3	95.1	94.3	93.8
Temperature (°C)	28.1	27.9	26.9	25.4	27.0	27.2	28.6	28.5	28.7	28.0	28.5	28.2
Rainfall (mm)	228	247	328	380	44	23	215	251	178	253	9	149