FIRST SOUTH EAST ASIAN LEPIDOPTERA CONSERVATION SYMPOSIUM

HONG KONG 2006

Proceedings

KFBG
Kadoorie Farm & Botanic Garden
嘉道理農場暨植物園

Proceedings of the

First South East Asian Lepidoptera Conservation Symposium

Hong Kong 2006

Edited by

Roger C. KENDRICK

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SOUTH EAST ASIAN
LEPIDOPTERA
CONSERVATION

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SEALCS 2006 Delegates on the final day

Back row, standing, left to right:
Clive Lau, Roger Kendrick, Tan Kit Sun, Gary Ades, Chin Boon Tat, Chey Vun Khen, Zdeněk Fric, Stanley Cabigas, Lim Kooi Fong, Yau Wing Kwong, Raymond Wong.

Front row, standing, left to right:
Tuah Atar, Hassan Haji Munab, Lydia Robledo, Helen Pang, Li See Wai, Joanne Loi, Judy Kiu, Mary Leung.

Seated, left to right:
Henry Barlow, Kailash Chandra, Li Hou Hun, Roger Kitching, Jan Beck, David Goh

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Preface

Butterflies and moths (the order Lepidoptera) are increasingly being recognised as a flagship group to monitor global warming and the rate and effects of habitat loss, globally. The symposium was organised to meet a perceived gap in the awareness of conservation needs for Lepidoptera in the region that have already been addressed by similar symposia in other continents; unlike Europe, the Americas and Africa, there has been no integrated approach to the conservation of butterflies and moths in the S.E.Asian Region (i.e. tropical and subtropical east, south and south-east Asia). There exist various bodies at national and local levels, almost all non-governmental, that undertake conservation measures of some sort and to varying degrees. By bringing such bodies together, an overall assessment of the state of Lepidoptera conservation in the S.E Asian Region can begin.

This book aims to provide an account of what took place at the first South East Asian Lepidoptera Conservation Symposium, which took place in Hong Kong and was hosted by Kadoorie Farm & Botanic Garden from the 4th to 8th of September 2006 at The University of Hong Kong's Kadoorie Agricultural Research Centre. Most of the presentations have been written up in full and form the bulk of this publication.

Presentations were grouped into four main themes, conservation assessment, conservation strategy, butterfly gardens & butterfly farming and internet resources, which have been reworked a little by combining the first two themes and adding a local based Hong Kong section. Brief accounts of the other components of the symposium are added to as to provide a record of all the main activities.

This symposium was not intended to be an academic conference, rather a practical series of talks and workshops aimed at getting conservation actions identified and agreed upon for undertaking. The initial objectives of the symposium were to facilitate the conservation of S.E.Asian Lepidoptera by (1) assessing the current conservation status; (2) creating a regional network of organisations under an umbrella body and (3) developing a regional conservation strategy. This book goes part way to meeting these objectives, but follow up action is required, not just by the symposium participants, but by the many governments and non-governmental bodies in the region who have the commitment and energy to undertake the actions required to conserve Lepidoptera and their habitats in South East Asia.

R.C.Kendrick
August 2007
Hong Kong

Acknowledgements

There are a large number of people who assisted in the organisation, running and follow up work for the first South East Asian Lepidoptera Conservation Symposium. There is space only to credit the main contributors to this project.

Firstly, though I must thank Kadoorie Farm & Botanic Garden [KFBG] for agreeing to host and partly fund the symposium, without whose generosity the whole project would never have started. Amongst the staff at KFBG who assisted my co-ordinatory role, thanks must go to the following: Tan Kit Sun for being my deputy and providing audio-visual equipment to record the proceedings; to Mary Leung, Carmen Ng and Margaret Leung for ably dealing with administrative issues, to Judy Kiu for organising volunteers to assist with logistics during the symposium, and to Dr. Gary Ades for agreeing to act as master of ceremonies on the opening day.

I wish to give my thanks to those who hosted site visits for the delegates: the Hong Kong Government's Department of Agriculture, Fisheries and Conservation (Tai Po Kau Special Area), Tai Po Environmental Association (Fung Yeun Butterfly Reserve), Ruy & Karen Barretto (Tai Po Kau Headland) and KFBG's Joanne Loi & Judy Kiu (KFBG Butterfly Garden).

At the symposium, my thanks are extended to the key speakers, for their assistance with chairing presentation and workshop sessions, and in particular to Prof. Roger Kitching for overseeing the assessment of the symposium, providing a summary and drafting the agreement and declaration. I also extend my thanks to all the delegates who prepared presentations that stimulated plenty of discussion on how to proceed in the future, and most of whom have made their presentations available in a written form for this proceedings, and finally to the rest of the delegates who took time out to travel long distances to attend and who contributed much to the discussion and workshop sessions and the agreements and declaration derived therefrom.

R.C.Kendrick
SEALCS 2006 Organising Committee Chairperson
Kadoorie Farm & Botanic Garden
Hong Kong
August 2007.

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TIGERS, LOBSTERS, HAWKS & PUGS: MOTH ASSEMBLAGES IN CONSERVATION

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Abstract

The 'conservation of Lepidoptera' brings to mind usually the preservation of viable populations of paradise birdwings, or large blues, or koh-i-noors. That is, of relatively large showy 'charismatic' species for which an approach to conservation can be taken which is comparable to that taken for tigers, giant pandas or argus pheasants. This species-level approach is to be encouraged and brings a level of prominence and simple understanding to our science that is essential. Curiously when 'recovery strategies' for these focal species are developed they almost always involve the management of habitat quality (except in the few desperate cases where re-introduction to remote offshore islands is being considered). My work, in recent years, has focused on thorough investigations of moth assemblages, examining ways in which these may indicate underlying ecosystem health or heterogeneity. Work in isolated rainforest patches in North Queensland showed clearly that patch quality could be assessed rapidly by examining the taxonomic profile of moths in a light-trap sample. Work in Central America showed, again, that differences at the subfamily level within moth assemblages showed clear and usable differences between ground and canopy samples within the forest. Last, on-going work in Yunnan has used the same approach to distinguish between rainforest remnants on different substrates (limestone vs alluvium). Recent work on other herbivores by Vojtech Novotny *et al*. in Europe and Papua New Guinea provides excellent theoretical explanations for such differences. From a conservation viewpoint this provides a powerful tool for determining ecosystem health and thus promote the overall well-being of a fauna, rather than hoping that flagship species act as surrogates for the entire faunas of which they are part. Future avenues of research will also be discussed.

EDITORS NOTE

What follows is an abridged notes version of the powerpoint presentation given, as prepared by the author with assistance from the editor, rather than a formally written paper.

Birdwings, Apollos & Kaiser-i-Hinds

Big, colourful butterflies invoke the 'vertebrate' approach to Lepidoptera conservation because they are invaluable 'ikons' - charismatic species that imply 'heroic' conservation measures should be taken to conserve them, which often leads conservationists to demand species-specific 'recovery plans'.

Recovery Plans

In 99% of cases recovery plans say: 'Expand, improve, preserve HABITAT'

It is all about environmental health. We (humans) are the health practitioners. We have 'cures' but our diagnostic tools are slow and imprecise. There is a role for all the Lepidoptera.

Example studies

1. Moth Assemblages and the quality of rainforest remnants - North Queensland 2000

Fragmentation is the primary impact of human activities on forested landscapes. What is the impact on diversity? Can we use such measures as a management tool?

The Atherton Tablelands - A First Test Of The Idea

An North Queensland tropical landscape, with declining agriculture. Originally forested overall, it is now a mosaic of remnants. It is biologically rich and can provide a focus for forest restoration and rehabilitation

The Great Patch Experiment

Nine forest remnants; three never cleared, three of 60 year regrowth and three a recently cleared mess. Dry season & wet season sampling with light traps. See Kitching *et al*. (2000) and Orr & Kitching (2003) for full details.

The catch contained 15,632 moths of 835 species, representing 17% of the total named Australian Fauna. The dominant families were Geometridae, Pyralidae, Noctuidae and Arctiidae.

Are moths good indicators of disturbance? In a word: YES!

But which ones?

Basically more disturbed sites dominated by 'grass' moths (noctuids), less disturbed sites by 'loopers' (geometrids). The ratio of noctuids to geometrids is an excellent indicator.

Very quick and easy

The predictor set:

Negatives (i.e. decline with disturbance):

Ennominae, Geometrinae, Larentiinae, Oenochrominae, Epipaschiinae.

Positives (i.e. increase with disturbance):

Arctiinae, Amphipyrinae, Catocalinae, Hadeninae, Heliothinae, Hypeninae, Noctuinae, Plusiinae, Herminiinae, Phycitinae.

2. Moth Assemblages in rainforest canopy and ground layers - Panama 2003 (IBISCA)

The Hypotheses

- There will be turnover in faunas between canopy and ground reflecting life histories and behaviour;
- These patterns may vary from place to place within a forest;
- The Lepidoptera are an appropriate group with which to quantify these phenomena

Processing the Catch

Target Families picked out at the field lab.

A rapid and generous assessment, with most specimens set immediately. The collection was then data based, and identified at the National Museum of Natural History, Washington D.C.

Table 1.1. The Catch

	Individuals	Species	Id To Spp (%)	Id To Genus (%)
All Targets	1784	483	305 (63)	379 (78)
Arctiidae	421	89	73 (82)	84 (94)
Geometridae	385	130	101 (78)	126 (97)
Pyraloidea	978	264	131 (50)	169 (64)
Crambidae	774	181	104 (57)	136 (75)
Pyralidae	204	83	27 (32)	32 (38)

Geometridae: are they layer specialists? Are multiple individuals, restricted to ground or canopy. How do we identify species that may be canopy or ground specialists?

Three basic approaches:

1. Layer Specialists 1

'common' species >80% in one layer

Canopy specialists - 1 ennomine

Ground 'specialists' -1 geometrine; 4 ennomines; 1 larentiine; 1 sterrhine

Ignores the rarities – bulk of the biodiversity

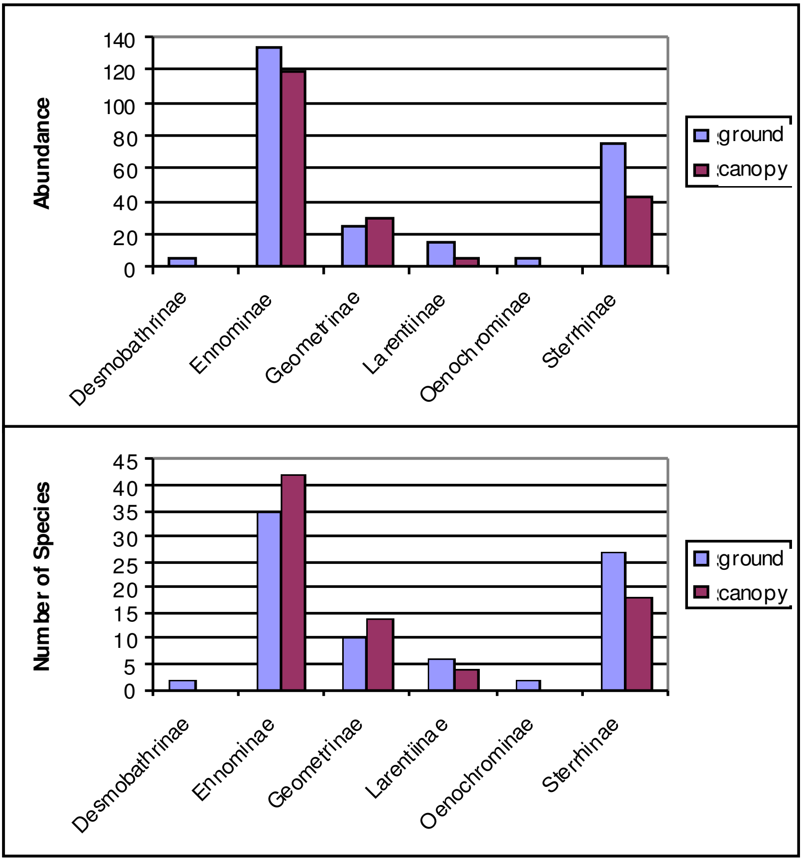

Figure 1.1
Comparisons of the abundances (upper figure) and species richness (lower figure) of moths from geometrid subfamilies in canopy and ground layers.

2. species in sites - Detrended correspondence analysis

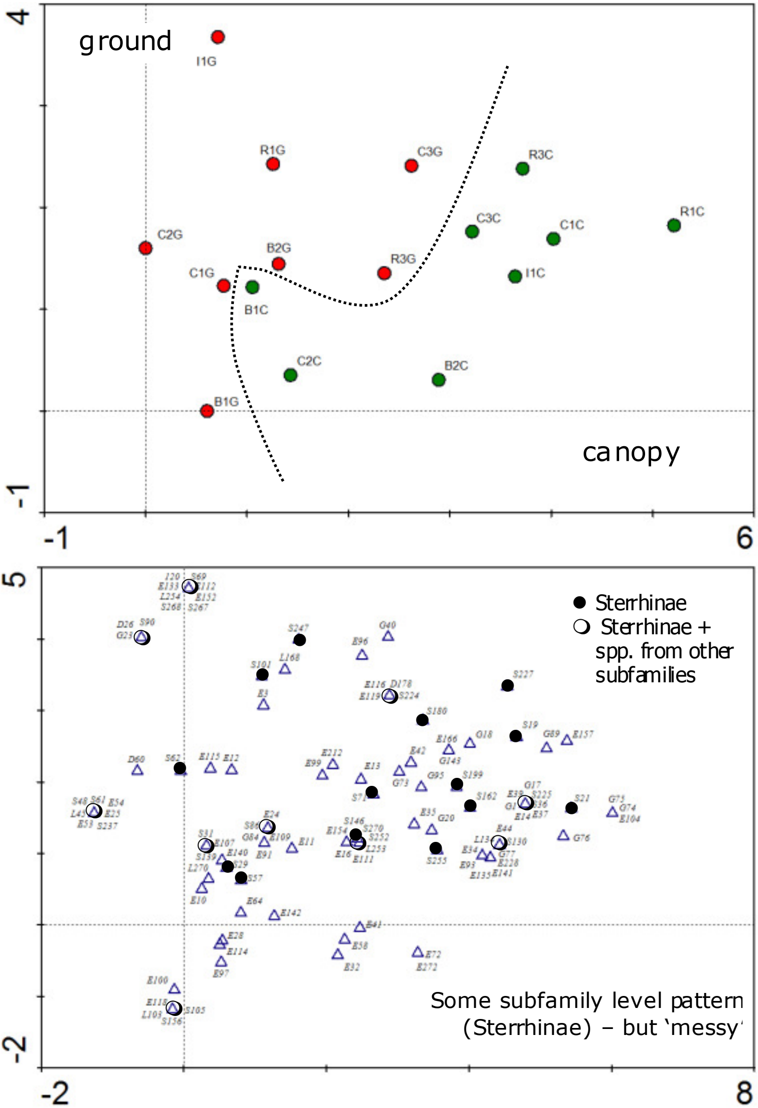

Figure 1.2
Ordination of numbers of Geometridae using canonical correspondence analysis.
Upper ordination:- red (light) symbols show canopy sites, green (dark) symbols are ground zone sites; lower ordination:- D = Desmobathrinae, E = Ennominae, G = Geometrinae, L = Larentiinae, S = Sterrhinae

3. Layer Specialists including rarities

Table 1.2. [Caption]

Taxon	Ground Uniques	Canopy Uniques
Desmobathrinae	2	0
Ennominae	**14**	**22**
Geometrinae	3	6
Larentiinae	4	2
Oenochrominae	2	0
Sterrhinae	**19**	**10**
All	44	40

3. Moth Assemblages and rainforest substrates - Yunnan 2004

The China Project

Xishuangbanna Tropical Botanic Garden

An agricultural landscape with rainforest remnants, with limestone and alluvium geology. The sites are well known botanically

The Yunnan Experiment

Eight Rainforest Remnants; four limestone, three alluvial; three moth traps each remnant and a minimum of a hundred moths per trap.

Preliminary Results

3145 moths of 1394 'morphospecies'

Limestone 1722 (856); Alluvium 1423 (746)

Overlap within types 0.159±0.016

Overlap between types 0.135±0.008

Much more 'specific' analysis awaits identification

Noteworthy Issues

Huge diversity; many research opportunities; "digital" collection

4. Moth Assemblages across rainforest altitudinal gradients

In progress, following the IBISCA Panama model: IBISCA Queensland 2006-2007; IBISCA Santo, Vanuatu 2006

Conclusions

* The assemblage approach has an important role to play in conservation
* Using large sets of moths gives us statistical power
* Light traps are powerful survey instruments (cf sheets, exposed lights)
* There is a growing resource base for identifying Asian moths (Korea, Taiwan, China, Thailand, Borneo, Sumatra, Japan)
* Asian lepidopterists have a bright and important future

Thanks to:

The meeting organisers

Atherton co-workers - Dr Bert Orr, Ms Heather Mitchell

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Schmidl, Dr Evandro de Oliviera, Ms Aydee Cornejo, Dr Scott Miller

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My staff - Ms Sarah Boulter, Mr David Putland, Ms Heather Christensen

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QUANTITATIVE LIGHT-TRAP SURVEYS OF MOTH ASSOCIATIONS AS A BASIS FOR DEVELOPING CONSERVATION AND LANDSCAPE MANAGEMENT POLICIES: FOUR DECADES OF PILOT STUDIES FROM MALAYSIA TO NEW CALEDONIA

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Abstract

This essay describes the quantitative light trap survey work undertaken over four decades from the 1960s to document moth associations in South East Asia and eastwards. Reasons are given for working with associations of species across sites rather than with assemblages of species at individual sites. The surveys the author has been involved with particularly are revisited, noting briefly the more interesting points that arose from each one from the perspective of biodiversity survey and inventory, including conservation aspects, and the measurement of human impact on natural levels of moth diversity.

Introduction: the initial stimulus from Mt. Kinabalu

In 1965 Henry Barlow, Jonathan Banks and I made an expedition as students to Mt. Kinabalu in the Malaysian State of Sabah. We had all run light-traps at school and home, undertaking modest scientific projects that involved a modicum of quantification. The Asian tropics called us and, though our original plan was to go to Nepal, practicalities led to us adopting Kinabalu as Plan B, as Henry already had visited Labuan as a volunteer teacher, had climbed Kinabalu, and had other strong connections with the region. Both plans involved making a quantitative survey of the larger moths over an extensive altitudinal transect. Much of the area surrounding Mt. Kinabalu had, at the time of our visit, just been gazetted as Malaysia's first National Park. At the end of ten weeks we had made significant samples from about 1000m to just below the summit.

Preparation, sorting, identification and analysis of these samples made up a significant part of my doctoral research programme, the other part being the adaptation of numerical methods of classification such as cluster analysis to sort biogeographic data both by classifying areas in terms of shared taxa and by classifying species in terms of significant coincidence in distribution, an approach that is usually referred to now as phenetic biogeography.

It was obvious then that this methodology was applicable also to the analysis of quantitative transect data, both in terms of classification of samples, effectively assemblages of species in a given biotope or point locality, and in terms of recognition of sets of species that were associated through commonality of distribution across the samples or assemblages.

I also became interested at that time in measures of diversity from species rank abundance models and in the ecological significance of such models, much of which was developed further in a twelve-year programme of moth sampling on Norfolk Island.

But the initial impetus for this approach came, through my friendship with Jonathan Banks, from sharing a house when a doctoral student with him and Nick Jardine. Nick and colleagues were conducting extensive research into the philosophical basis of numerical classificatory methods, and the advantages and defects of the various clustering approaches available then and still applied today. My preferences amongst these various methods have inevitably been influenced by the principles that Nick and colleagues established. My preference for working, where possible, with species associations rather than sample assemblages also dates from this period.

There are two connected reasons for this. The first is that, through the mobility of adult moths, the samples may include some or many individuals that have come from a distance, particularly for those groups with a high proportion of strong fliers or migrating tendencies where habitat fidelity may be low. An extreme example of this comes from Norfolk Island where, at certain times of the year, migrant individuals of several non-resident species that have flown 1000km across the Tasman Sea from Australia may significantly boost samples.

The second reason is that assessment of the existence of associations of species (or not, in the case of ecological continua) enables these to be related to ecological factors such as forest type, including altitudinal zonation, and, within each type of forest, successional stages. Samples are very often composite assemblages derived from two or more overlapping associations.

These associations may have very different rank abundance curve profiles when examined in isolation, and will generate composite, and possibly atypical profiles when they make contributions to individual samples: composite assemblages. It is therefore important to explore diversity measures, rank abundance curves and their meaning with reference to associations as well as samples, illustrated particularly clearly by the very large total sample (a quarter of a million) yielded by the twelve years of work on Norfolk I. (Holloway, 1977, 1983a, 1996; Holloway & Stork, 1991) and by survey data on dung beetles in Borneo (Davis *et al.*, 2001) where I contributed to the analyses.

After the Kinabalu survey, my further quantitative sampling has been widely spaced because I have always felt it important to introduce a strong taxonomic dimension into the work and to ensure that this fed through into the more ecological aspects. I see this as an essential adjunct, a sort of 'ground truthing', to the more frequently applied rapid assessment approaches to survey, perhaps thereby building confidence into these quicker methods when results coincide with those of a more laborious but thorough approach.

These field programmes were to New Caledonia and Norfolk Island (where local naturalists continued the sampling) in 1971, to Borneo again (G. Mulu National Park, Sarawak) in 1978, Sulawesi (Dumoga-Bone National Park) in 1985 and Seram (Manusela National Park) in 1987. I have also provided support for further fieldwork in Peninsular Malaysia (Henry Barlow, Jurie Intachat), Borneo (Chey Vun Khen, Ashley Kirk-Spriggs, John Willott) and Sulawesi (Bulansyarih) and assisted with more qualitative surveys of remote oceanic islands (Easter, Pitcairn and Henderson in the Pacific, Cocos-Keeling and Chagos Archipelagoes in the Indian Ocean).

I have appended a list of the publications that I have been particularly involved with, but enjoyed the companionship of Gaden Robinson in the early days with his surveys of Fiji and Vanuatu, and later with Kevin Tuck on microlepidoptera in Sulawesi and in Brunei. Paul Hebert sampled a montane transect in Papua New Guinea at about the same time as our Pacific work. Over the last decade or more there has been a gratifying increase in this type of work with, in addition to those colleagues mentioned above, programmes in Borneo conducted by Jan Beck, Christian Schulze and Konrad Fiedler, in Australia and Borneo by Roger Kitching and others, and along the Andean chain by Gunnar Brehm and colleagues.

For the remainder of this essay I will revisit the surveys I have been involved with particularly, and note briefly the more interesting points that arose from each one from the point of view of biodiversity survey and inventory, including conservation aspects (Holloway, 1984a; Chey, 2007), and the measurement of human impact on natural levels of moth diversity.

I will discuss these examples in the order of increasing diversity, starting with the surveys of oceanic islands (Holloway, 1983b, 1987, 1990; Holloway & Nielsen, 1999 [1998]; Barnett *et al.*, 1999), in both in the Indian Ocean (Cocos-Keeling, Chagos; both atoll systems) and Polynesia (the Pitcairn group). Endemics are much more frequently found on the high volcanic islands, with endemism very low on atolls.

Makatea (raised coral) islands are intermediate. Most species, however, are extremely widespread and are drawn from very widespread genera, themselves falling into only a handful of macrolepidoptera families (Sphingidae, Geometridae, Arctiidae, Noctuidae; Holloway & Nielsen, 1999 [1998]).

Norfolk Island: a 12-year time series from a natural biogeographic 'experiment'

The survey of Norfolk Island (Holloway, 1977, 1983, 1996; Holloway & Stork, 1991) differs from those that follow in several respects. The island is subtropical, with definite summer and winter seasons. It is of recent volcanic origin as land, though it sits on a much older geological structure, the Norfolk Rise. It is extremely isolated. Its closest neighbours, Australia, New Caledonia and New Zealand, are significantly, though variably, larger in area and biodiversity. The survey had a significant time dimension of 12 years that included climatic variations such as several ENSO-induced periods of drought. This period also meant that the sampling built up to a total of a quarter of a million individuals. The seven to fourteen samples made virtually every month were distributed over the island's main ecosystems from the coastal cliffs to the hilltops, and covered a range of disturbance from native forest to pasture.

The size of the total sample enabled two major species associations to be recognised (Holloway, 1977, 1996), one generally distributed and one restricted to the remaining areas of native forest, now protected in a National Park or protected reserves. The survey contributed to the planning stages for this Park and established data on the key endemics. There was also a very small coastal cliff association. The associations differed in their diversity profiles, proportions of families and seasonal phenology. Both profiles of the main associations showed the impact of drought conditions in the form of an increase in the evenness of abundance of the species, and of rank-order changes in each association that have a biogeographic and ecological basis (e.g. savannah versus even rainfall climate pasture-feeding species).

The length of the survey also revealed significant arrivals of migrant individuals at certain times of the year, almost entirely from Australia when frontal systems were passing across the Tasman Sea, but with one individual that could definitely be associated with New Caledonia. The number of species involved was approximately equal to that of the resident fauna, but there was little evidence of the establishment of these species for anything more than a generation. The taxonomic and biogeographic profile of these migrant species differed significantly from that of the resident fauna, indicating that deterministic factors (e.g. prior presence of host plants) as well as stochastic ones were in play. However, the migrant profile has much in common with that of the faunas of the oceanic islands discussed earlier (Holloway & Nielsen, 1999 [1998]).

The well-defined source areas of different sizes and at different distances from Norfolk Island provided a means to test the validity of the MacArthur & Wilson exponential model of dispersal between islands by examining the proportion of affinities with these areas of different components of the Norfolk biota, particularly components where some gross measure of dispersal process for each can be estimated. The model was supported by the results (Holloway, 1977).

New Caledonia:
a survey of an isolated, insular botanical hotspot.

The survey of New Caledonia (Holloway, 1979, 1993b) was conducted over a period of four months and covered as many of the main vegetation types present as possible. Of particular interest are the very rich and endemic associations of plants that are found on the overthrust massifs of ultrabasic rocks that yield rich deposits of nickel and other heavy metals. These deposits contribute significantly to the economy of the island, but obviously, when mined, can pose significant conservation problems for the unique and diverse flora that these massifs support.

The sampling was sufficient to enable three clear associations of moth species to be identified, but further sampling at altitude might have revealed more clearly a further small association of montane species. The analyses (Holloway, 1979) also enabled a variety of numerical methods to be compared, including both the coefficients used and various clustering approaches and ordination methods.

The largest association was found in areas of rain forest in different situations, mostly on sedimentary and metamorphic rock substrates but also in wet gullies on the ultrabasic rocks where some humus had accumulated; these forests had various degrees of disturbance that graded through to the extensive *Melaleuca* savannahs that have replaced forest over much of the island, either naturally on poor soils or through human activity, and the moth association also showed evidence of a successional continuum.

The smallest association was found in a variety of *Acacia*-dominated types of shrubby forest that occurred on the dry west coast or on less extreme volcanic rocks such as granodiorite. The moth species involved had a strong Australian affinity.

The association most typical of the areas of ultrabasic rock was intermediate in size, but found particularly where nutrient-poor lateritic soils derived from these rocks predominated on hillsides and in sedimentary basins. These were covered in a shrubby maquis of low diversity.

Sampling from the richer plant assemblages on the ultrabasic rocks tended to yield smaller samples and no additional species that appeared definitely associated with them rather than with plants of the more widespread but much less diverse maquis flora. The foliage of these plants was usually very tough, and many are known to be accumulators of nickel and other heavy metals. Here, at least, defoliator diversity appears significantly decoupled from plant diversity.

Though the greatest diversity at sample and association levels was found in the forest association, the interesting endemic species were found almost entirely in the maquis association, and endemics in general were slightly higher in total. Thus for macrolepidoptera, including butterflies, floristic and faunistic hotspots are not correlated within the New Caledonian ecosystems, and the diversity hotspot for Lepidoptera does not support the highest endemism.

Sundaland, Sulawesi and Seram: high diversity across biogeographic boundaries

Sampling in Peninsular Malaysia (Holloway & Barlow, 1992, Intachat *et al.*, 1997; Intachat, Holloway & Speight, 1999; Intachat, Chey, Holloway & Speight, 1999; Holloway, 1998; Intachat & Holloway, 2000; Intachat *et al.*, 2001; Intachat *et al.*, 2005), Borneo (Holloway, 1970, 1973, 1984b, 1985, 1989, 1994, 1998; Chey *et al.*, 1992 [1993], 1997; Holloway *et al.*, 1992; Intachat, Chey, Holloway & Speight, 1999; Davis *et al.*, 2001), and in Sulawesi (Holloway *et al.*, 1990, Holloway & Stork, 1991; Holloway, 1998) and Seram (Holloway, 1993a, 1998) in Indonesia has involved much more diverse faunas over much more extensive altitude transects. Seram is similar in size and topography to New Caledonia, though not geology, but supports a much higher diversity of Lepidoptera, almost certainly due to its greater proximity to the diversity of the New Guinea fauna and, to a lesser extent, that of Sulawesi. The Sulawesi fauna is of intermediate diversity to those of Borneo and Seram, but the process of faunal enrichment there through the latter part of the Tertiary has involved significant speciation within the island, a process seen to an even greater extent in New Guinea. Taxonomic input has been critical in providing a foundation for observations on the nature of this process (reviewed in Holloway & Nielsen, 1999 [1998] and elsewhere), for example, instances of such speciation in Geometridae show close relationships to essentially lowland forest species in Borneo, but span a considerably greater range of altitude in Sulawesi, perhaps indicative of some kind of ecological release.

Sampling in all these more diverse areas has included the analysis and recognition of species associations as well as of features of individual samples. The rank abundance plots for the original Kinabalu associations (Holloway, 1970, 1973) provided a useful comparison for the much less diverse ones on New Caledonia and Norfolk I. (Holloway, 1977, 1979).

All sets of samples have shown a peak in diversity as measured by the alpha statistic at middle altitudes, between about 600m and 1200m, though the basis for this needs further exploration. All surveys have shown segregation of species associations that replace each other with altitude, but with significant overlap, so individual samples will often be composites of such associations. There are also indications from sampling in Malaysia there may be a greater element of beta-diversity in moths of lowland forest, with segregation of associations specific to forest type amidst a more general lowland forest fauna.

Profiles of diversity with altitude differ amongst taxonomic groups, and the peaks of diversity amongst these may range from the lowlands (e.g. Lymantriidae) to (e.g. larentiine Geometridae) about 2000m (Holloway, 1987, 1993; Holloway *et al*., 1990). Hence these groups will vary in vulnerability to various types of disturbance and will therefore have different conservation needs. It is possible to obtain profiles of such groups in two-way tables that segregate species in terms of ecological association and biogeographic range categories, to indicate the interplay of richness and endemism as was described earlier for New Caledonia. General analyses of such tables for Borneo (Holloway & Barlow, 1992; Holloway, 1994) have been augmented subsequently by further tables in the more recent volumes of The Moths of Borneo.

The impact of human disturbance:
logging, conversion to plantation, shifting and permanent cultivation

All these sampling programmes covered both pristine forest and various degrees of disturbance, planting and management. Field crop cultivation and non-forestry plantation (e.g. coffee, coconut, oil-palm) systems supported moth assemblages of significantly lowered alpha diversity, with elimination of many of the less species-rich families (Holloway & Stork, 1991; Holloway, 1998) Species associations characteristic of such habitats included a high proportion of geographically widespread taxa. In effect, the moths of such systems were not dissimilar in character from those of the oceanic islands mentioned earlier.

Chey Vun Khen (Holloway *et al*., 1992, Chey *et al*., 1997; Intachat, Chey, Holloway & Speight, 1999) extensively sampled forestry plantations, mostly of various softwoods in clear-felled areas. They presented a fauna of intermediate species diversity but also with reduced higher taxonomic representation. The analysis of associations revealed a few species that could probably be considered pests of various tree crops, and a much more widespread association of species that appeared to be typical of secondary forest, elements of which were able to survive and form a weedy understorey within the plantation, which thus coexists with successional early stages of the natural forest. The extent to which this level of diversity could be maintained through successive softwood crops will depend on the ability of the early forest successionals to maintain their seed bank, or on recruitment from more natural forest patches in the landscape mosaic.

Selective logging regimes (mostly extraction of hardwoods such as dipterocarps) with natural regeneration, and sometimes with enrichment planting, were the main focus of sampling by Jurie Intachat in Peninsular Malaysia (Intachat *et al*., 1997; Intachat, Holloway & Speight, 1999). Whilst values of alpha were not significantly different between logged and unlogged forests, there were differences in sample abundance and faunal composition (Intachat, Holloway & Speight, 1999), with several species considered to be associated with dipterocarps becoming much less abundant in the logged forests, where these trees had been extracted. The associations between moths and dipterocarps had been established from host records and from circumstantial evidence gained from comparing samples from a mature dipterocarp plantation with those from selectively logged forest (Intachat *et al*., 1997).

Jurie Intachat also processed an important major time sequence of samples made in primary forest in the Pasoh Forest Reverve, and herself made samples at three levels on a tree-tower to assess stratification in moth adult flight (also assessed by John Willott at Danum in Borneo). The time sequence (sampled by the late Tho Yow Pong) extended for three years, along with weather recording and measurement of aspects of forest tree phenology. Correlations were found between the moth data (abundance, species richness, diversity) and tree-flowering, rainfall, relative humidity and minimum temperature (Intachat *et al*., 2001), usually with a time lag of one to three months. It was interesting to note that a positive influence of rainfall on moth abundance had the same three month time lag as was observed for the widespread association on Norfolk Island.

The tree-tower sampling (Intachat & Holloway, 2000; Basset *et al*., 2003) also continued for over a year, and analysis of species associations over the vertical column showed that at least some species had a distinct preference for flight at a particular level in the forest, but that there was no strong coincidence of such preferences into distinct flight strata, more a continuum both of depth of flight range and of turnover up the column. The sampling was conducted partially during a period in 1994 when haze from extensive forest fires elsewhere was present in the atmosphere, but any impact of this on the sampling was difficult to assess.

What capacity does natural forest and its dependent fauna have to return to land that has been heavily utilised by humans? Moth diversity in Peninsular Malaysia in the vicinity of an abandoned tin mine in an area that had been clear-felled only attained in twenty years half the geometroid diversity (measured by alpha) as forest selectively logged at the same time, itself equivalent to that in a sixty-year old dipterocarp plantation (Intachat *et al*., 1997). An area of old tea estate, farmland and forest patches in the Genting Highlands sampled by Henry Barlow (Holloway, 1987; Holloway & Barlow, 1992) that had enjoyed a fallow period of about thirty years yielded alpha values in pooled monthly samples that were again about half that expected for undisturbed forest at an altitude of 600m, but the cumulative alpha for the samples pooled over the thirteen months of the survey was at the expected level. The light source (tungsten lamp) used was not very powerful, and it is likely that the steady increase in alpha (found also for microlepidoptera in Bornean lowland forest by Gaden Robinson and Kevin Tuck) was due to the progressive sampling of the complex mosaic of habitats surrounding the site, but perhaps this is indicative of the importance of landscape mosaics for maintaining diversity, providing the capacity for even degraded habitats of low diversity within the mosaic to eventually attain that of the richest fragment if allowed to regenerate. Sadly, extensive illegal cultivation in the area in the years since the survey has put this process into reverse.

If any kind of human disturbance epitomises that of a landscape mosaic, it is shifting cultivation or swidden. The survey of Seram (Holloway, 1993a, 1998) included sampling from such an area around Kanikeh village in a central enclave between 500m and 1000m in the Manusela National Park. The population of the area had probably fallen over the previous few decades, so the area under cultivation had been reduced and much of the surrounding valley was in an advanced stage of regrowth. Samples were made in areas under cultivation and at various stages of fallow succession, and moth associations were identified that tracked this succession. Alpha values for early stages were significantly lower than those for undisturbed forest, but rose to match them in the later fallow stages. However, when the representation of the various associations over the rank abundance curves of the various stages was examined, it transpired that the late swidden stage, though producing alpha values equivalent to those of primary forest, was still dominated by species from the swidden and fallow associations, primary forest species remaining rare. Eventual recolonisation of these at sustainable levels will probably depend on undisturbed forest remaining part of the mosaic. Sustainability of biodiversity in this type of swidden system, in selective logging cycles in natural forest, and in the native forest components persisting in softwood plantations, will depend on the frequency and intensity of the cycles of disturbance and in the structure of the landscape mosaic in which they occur.

Some elements of a landscape mosaic may be natural, such as the interplay of alluvial forest, river terrace heath forest, and hill dipterocarp forest around the rivers of the G. Mulu Park in Sarawak, and maybe the Lepidoptera associated with these forest types will show very different responses to disturbance, as did the dung beetles at Danum mentioned earlier (Davis *et al*., 2001). Species of beetle were grouped into natural forest associations that were riparian, forest interior or generalist. These showed, respectively on average, positive, negative or neutral responses to disturbance such as logging. The logged forest assemblages were mostly drawn from the riparian ones, and it was these species that also persisted into the very low assemblages recorded in plantations. But only the study of associations as well as of assemblages is likely to reveal the full extent of what is occurring.

Postscript: full circle on Mt. Kinabalu

Just over four decades on, students at the University of York and Universiti Malaysia Sabah (Dr Suzan Benedick and I-Ching Cheng) are preparing to re-sample the transect on Mt. Kinabalu, with the support of Chris Thomas, Jane Hill, Henry Barlow and the author. Changes of varying intensity have occurred over the transect, such as: further deforestation near sampling sites outside the Park and within its original boundaries on the Pinosuk Plateau; regrowth along the road to the start of the ascent, which had been cut only a few years before 1965. The most intriguing question is whether more general effects from global climate change will be detected.

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3

THE DISTRIBUTION PATTERN AND CONSERVATION STRATEGY OF MICROLEPIDOPTERA

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Abstract

Environmental change often leads to the population depression of some species due to loss of habitat, which is caused primarily by human activity. In general, the influence is not important for widespread species, but it is vital for groups with restricted distributions, especially archaic and relict groups. Therefore, applying different strategies according to their distribution patterns should conserve Microlepidoptera. The best conservation strategy is to protect and preserve natural environment for the endangered species so as to maintain the biodiversity.

Key Words : Lepidoptera, distribution pattern, conservation strategy

Introduction

Universally, we do not consider moths needing conservation, because some of them are notorious pests for vegetation. But in fact most moths are harmless; instead we can get plentiful benefits from pollination and a balanced environment, or monitoring environmental quality using the population fluctuation of indicator species.

Environmental change often leads to the population depression of some species due to loss of the habitat, which is caused primarily by human activity. So nowadays, species extinction occurs almost every day. As Microlepidoptera species are usually small, they are more likely to be affected by environmental change. Here we provide some cases to show how they have been affected and propose some general conservation strategies.

Case Studies

Same group with different distribution

Coleophora is a very large genus of the family Coleophoridae, with over 1100 described species. It is unevenly distributed on all continents. The majority occur in arid and semiarid zones of the Nearctic and Palaearctic, especially around Mediterranean region. Baldizzone (1989) recognized eight *Coleophora* species in Jinsha Jiang

Valley, Sichuan Province of south-western China based on the specimens collected during 1930s by a German, Dr. H. Höne.

Coleophora species recorded by Baldizzone in Jinsha Jiang Valley:

Coleophora hoeneella Baldizzone, 1989
Distribution: China (Shaanxi; Jinsha Jiang Valley, Sichuan).

Coleophora tibetana Baldizzone, 1989
Distribution: China (Jinsha Jiang Valley, Sichuan).

Coleophora alecturella Baldizzone, 1989
Distribution: China (Jinsha Jiang Valley, Sichuan).

Coleophora summivola Meyrick, 1930
Distribution: China (Jinsha Jiang Valley, Sichuan; Tibet; Yunnan).

Coleophora artemisiella Scott, 1861
Distribution: China (Heilongjiang; Inner Mongolia; Qinghai; Shaanxi; Jinsha Jiang Valley, Sichuan), Transpalaearctic.

Coleophora denticulata Baldizzone, 1989
Distribution: China (Jinsha Jiang Valley, Sichuan).

Coleophora tuberculata Baldizzone, 1989
Distribution: China (Jinsha Jiang Valley, Sichuan).

Coleophora batangica Baldizzone, 1989
Distribution: China (Jinsha Jiang Valley, Sichuan).

However, with the vegetation in Jinsha Jiang Valley being cut down for firewood by humans, only two widespread species *Coleophora summivola* and *Coleophora artemisiella* have recently been found in the area of the original locality.

In China, about 150 *Coleophora* species have been recognized, more than 90 % of which are distributed in north-western and north-eastern China and Inner Mongolia (Li, 2005). In north China, the notorious pests *Coleophora sinensis* Yang and *Coleophora obducta* (Meyrick) have high density in the forest, so their population has to be controlled to protect larch trees and other vegetation. However in south China, *Coleophora* species are rare and their abundance low. Any change of environmental factor may result in depopulation. In this case, we should protect them so as to prevent species from extinction. As we can see that the same group can have different distribution pattern in different regions, so the conservation strategy should not be the same.

Expedition to Mt. Tianmu

Mt. Tianmu (Tianmushan) in Lin'an County, Zhejiang Province of China is a famous National Nature Reserve. This is a Buddhist sanctum with many temples. The vegetation has been well preserved due to protection of the temples by the local government. Dr. Höne. collected many lepidopteran specimens here in 1930s. Based on his collection, A. Caradja and E. Meyrick (1933-1938) described more than 500 species of Microlepidoptera (Li, 2001). Regarding Pyraloidea only, Caradja recorded 239 species in this very site.

In the last decade, several expeditions to Mt. Tianmu were undertaken and many Microlepidoptera specimens collected. Even though the natural environment in Mt. Tianmu seems to have improved, the results of the recent study shows some species can no longer be collected in the same locality (Table 3.1). Quite a number of species found in the 1930s are not traceable now, possibly due to environmental change or natural disasters. This is a gradual process and seems negligible in human eyes. But it has vital impact on some insect species.

Table 3.1. Pyraloidea in Mt. Tianmu, Zhejiang Province, China

Subfamilies	Species collected in 1930's	Species collected since 1999	Notes
Galleriinae	2	0	
Crambinae	19	5	
Schoenobiinae	3	1	
Phycitinae	41	29	excluding n. r. and n. sp.
Epipaschiinae	19	3	
Endotrichinae	11	3	
Pyralinae	32	6	
Acentropinae	17	10	
Scopariinae	6	8	genitalia dissection
Pyraustinae	89	19	Pyraustini only
Total species	239	84	65% reduction in total spp.

From the table we can see that many species have apparently disappeared from the environment.

Primitive fairy - Neopseustidae

The Neopseustidae, archaic bell moths (Figure 3.1), has only eleven species belonging to four genera in the world (Davis, 1997). They perhaps have significance in the phylogenetic and biogeographical study of Lepidoptera. Their forewing and hindwing have similar venation (homoeurous), peculiarly with jugate wing coupling and special genitalia in the primitive group of Lepidoptera.

It is not known if this family is cosmopolitan in the geological history because there is no any fossil evidence. But this family is very archaic and the distribution has obvious disjunction. Four species in two genera are distributed in South America and seven species in other two genera are mainly found in the Oriental region (Davis, 1997). Recently, ten species have been recognized in the Old World, and more new localities have been found in China. The obvious biogeographic characters of all the species in this small family can be found by drafting their phylogenetic relationship (Figure 3.2).

Checklist of the Neopseustidae in the Old World

Neopseustis archiphenax Merick, 1928
Distribution: China (Henan, Hunan, Sichuan), Myanmar.

Neopseustis bicornuta Davis, 1975
Distribution: China (Sichuan).

Neopseustis calliglauca Meyrick, 1909
Distribution: India (Assam).

Neopseustis fanjingshana Yang, 1988
Distribution: China (Guizhou).

Neopseustis meyricki Hering, 1925
Distribution: China (Taiwan).

Neopseustis sinensis Davis, 1975
Distribution: China (Sichuan).

Neopseustis n. sp. 1
Distribution: China (Ningxia).

Neopseustis n. sp. 2
Distribution: China (Sichuan).

Nematocentropus omeiensis Hwang, 1965
Distribution: China (Sichuan).

Nematocentropus schmidi (Mutuura, 1971)
Distribution: India (Assam).

The diversity of this family is very low. They should be apparently evolutionary relicts and should be grouped into the endangered species. Although their host plants and biology are unknown, they usually emerge in the areas not disturbed by human activity. If environment continues to change, most of them may become extinct.

Declining group - Carposinidae

Carposinidae, fruitworm moths, relicts of an ancient population, seems to harbour a widely spread fauna, but it is strongly reduced in number and now in a state of decline. Most species of the family have isolated distribution (Li, Wang & Dong, 2001). But a few species, e.g. *Carposina sasakii* Matsumura, are widespread and can cause serious loss to many kinds of fruit. These harmful species have to be controlled to save human crops. However, it is possible to adopt different conservation strategy, say using biological control instead of pesticides, for conserving most of species in the environment.

Figure 3.1.
Adults of *Neopseustis* species.
left: *N. archiphenax* Meyrick from Mt. Baiyun, Henan, photo by X. C. Shen;
right: *N. meyricki* Hering from Mt. Hu, Taiwan, photo by S. W. Wu

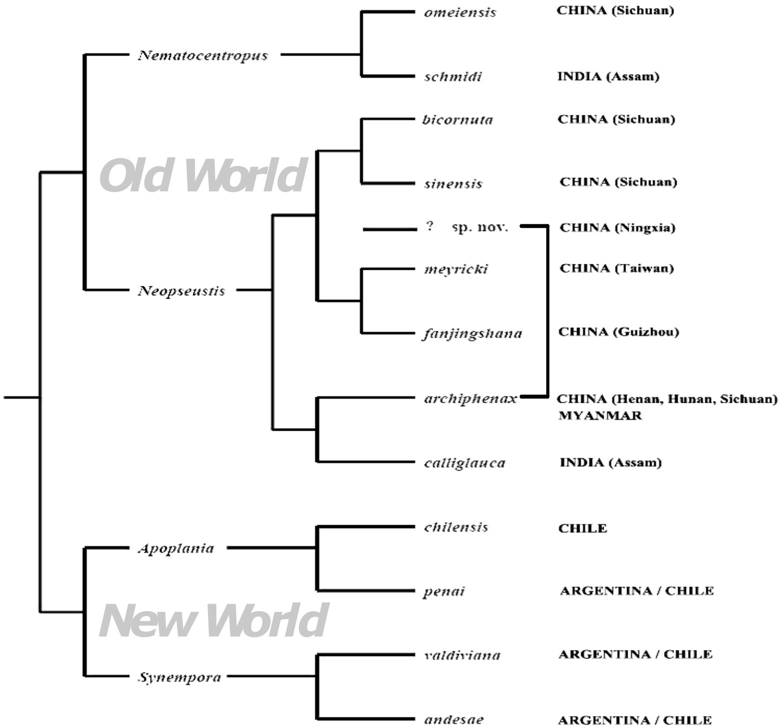

Figure 3.2. Draft for Phylogeny and Biogeography of Neopseustidae

Frail beauty - Pterophoridae

The Pterophoridae, plume moths, is a unique group of slenderly-built moths with long legs and narrow, clefted wings. It is distributed throughout every continent with 1228 known species in 91 genera under 4 subfamilies worldwide (Gielis, 2003). Only one species, *Emmelina monodactyla*, is distributed worldwide except Australian Region. Every region is rich in both endemic genera and species, but the population density of each species is usually very low.

All representative subfamilies of Pterophoridae occur in China, with 221 species in 44 genera being recognized (Hao, 2005). In each locality, only limited species with a few individuals can usually be found. So in our collection (Insect Collection, College of Life Sciences, Nankai University), most species are represented by just one or two or only a few specimens.

As most pterophorid species cause no damage and have viewing value, we should avoid over collection of specimens. Only in this way can we give maximum protection for the rare and frail group.

Widespread group - Pyraloidea

The Pyraloidea, Snout Moths, is one of the largest superfamilies of Lepidopetra. It has two families, Pyralidae and Crambidae, and comprises about 16,000 described species worldwide (Heppner, 1991). This superfamily can probably provide a typical example of what conservation strategies should be taken for the different Microlepidoptera groups.

Amongst all Lepidoptera, pyraloids have enormous diversity and show the most diverse adaptations. Their larvae can feed on any living plants and dry stored food products, even animal detritus. With such a variety of living habits, pyraloid species are usually widespread. Some species are of economic importance, e.g. rice stem borers, sod grass webworms, and forest pests.

Mangrove trees are common on tropical and subtropical seaboards, such as in Shenzhen City, Southeast China. *Syntaractis* sp. is a serious mangrove pest belonging to Phycitinae of Pyralidae. In 2004, this pest was abundant in the southeast seaboard of China. The enormous disaster made the diversity of mangrove community rapidly decline. Our study shows this species is widespread in mangrove-grown regions ranging from Australia to South China. It was also reported to occur in Singapore (Murphy, 1990).

Galleriinae is a small subfamily of Pyralidae, including about 330 species in 70 genera under 3 tribes (Xu & Li, 2006). The galleriine moth, *Trachylepidia fructicassiella* Ragonot is a pest injurious to *Cassia fistula* Linn. and other trees in South-east Asia (Bhatta and Bhatnagar, 1986). It was found in the *Cassia* pods imported from Malaysia by

Hainan Entry-Exit Inspection and Quarantine Bureau. Though the natural distribution of this species has not been reported in China, its main host plant, *Cassia fistula* has been widely planted as roadside and ornamental trees in South China. So the departments in charge of environmental conservation usually treat it as an important pest and keep it out of the country.

From above two cases, it can be seen that some widespread or economically importance pests should be controlled without delay.

Conservation Strategy

When controlling pests, what strategies should be adopted in order to preserve other species of the community? In practice, environmental change is not important for the widespread species, such as most Pyraloidea that usually need to be controlled as pests. But it is vital for almost the entire Carposinidae and some other low population groups with narrow distribution, especially the archaic and relict groups like members of Neopseustidae.

Therefore, Microlepidoptera should be conserved by taking different strategies according to their distribution patterns. These strategies include:

- Preserving natural environment for the endangered species to maintain the biodiversity;
- Using biological methods to control the pests;
- Educating the public about the nature of protecting the environment.

However it is one thing to make strategies, but another to put them into practice under rapid development of human society. We have a long way to go before our existent environment has been well protected.

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4

THE SPECIES RICHNESS OF ENDEMIC GEOMETRID MOTHS IN NORTHERN BORNEO

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Abstract

We present analyses on the proportions and species richness of endemic geometrid moths from Borneo and their reaction to habitat differences such as altitude and human-caused forest disturbance. We conclude that, among many other reasons, primary forest are worth conserving for their higher proportion of island endemics, and that montane regions, especially forests around 2000 m elevation, deserve a special focus of conservation. We critically discuss these results in the light of land-use patterns in Borneo and the surrounding region.

Introduction

Various criteria can be used to assess the 'conservation worthiness' of a habitat in a scientific manner. In invertebrates, where a 'target species' approach to conservation (cf. 'indicators', 'key-stone species', 'icons'; e.g. Great Panda (*Ailuropoda melanoleuca*)) is unlikely to be successful due to lack of public interest, often agreed-upon criteria are species richness or the species richness of particularly threatened or endemic taxa. On a large spatial scale, various studies have shown that these different aspects of species richness do not necessarily lead to the same conclusions (e.g. Orme *et al.*, 2005; Beck *et al.*, 2006a; and references therein).

While the ultimate goal of conservation is the preservation of ecosystem functions (Diamond, 2005; Tilman *et al.*, 2006), our understanding of functional aspects of biological communities is, in most cases, far too imperfect to allow conclusions on the value of specific taxa. In a conservative approach we should therefore aim to protect as many aspects of biological diversity as feasible. Protecting endemic taxa or other aspects of the uniqueness of biological communities (i.e. β-diversity) aims at putting a focus on those species that cannot be protected elsewhere, whereas it also serves to conserve regional species richness by protecting a high heterogeneity of local assemblages (e.g., Beck & Chey, 2007; and references therein).

We used data on geometrid moths (Lepidoptera, Geometridae), a speciose moth family with ca. 1100 species known from Borneo. These data have recently been used to analyse other aspects of moth biodiversity on Borneo (Beck & Chey, 2006, 2007). Here we investigate whether, and in what way, local habitat conditions affect the proportions and species richness of endemic species.

Methods

Quantitative light-trapping samples of geometrid moths from Borneo were compiled from published sources and our own field work (see Beck & Chey, 2007 for details). This led to data for almost 27,000 specimens from 65 sites, covering 836 species. Sites were classified as 'primary', old-grown forest, 'secondary' forest of various age and disturbance, or 'open, disturbed' landscape, the latter representing either small-scale agriculture of indigenous peoples or soft-wood monocultures. Furthermore, elevation, forest stratum (understorey vs. canopy), sampling schedule (full night vs. first part of the night), and year of sampling (from the early 1960s to 2003) were used to characterize samples. We also classified sampling months as relatively 'wet', 'dry' or 'mixed' (Intachat *et al.*, 2001) according to means of precipitation data over 18 years (Cranbrook & Edwards 1994; Danum Valley Field Centre unpubl.). Geographic ranges of species were taken from Holloway (1993 [1994], 1996, 1997) and were used to classify species as endemic to Borneo or Sundaland.
(see www.mothmap.unibas.ch for details, databank and visualization).

We calculated the proportion of endemic species at sites as endemic sp. richn./total sp. richn. and used this as dependent variable in multivariate General Linear Models (GLMs; StatSoft 2005), testing for effects of habitat parameters. Raw, observed species richness usually does not provide meaningful data for direct comparisons in notoriously undersampled, species-rich tropical insect samples. To obtain an estimate of absolute endemic species richness (rather than just their proportion, see above), we calculated the rarefied richness of all species per sample at $n = 50$ (i.e. the number of species expected if exactly 50 individuals were collected at each site; software: Primer-E 2005). We then calculated rarefied endemic species richness as the proportion of endemics (see above) multiplied by rarefied richness of all species. As our sample sizes varied greatly (50 up to >2200 specimens per site), these estimates might be criticized for potential biases due to systematic under-recordings of rare species in small samples, caused by a presumed positive range-abundance relationship of species (cf. Beck *et al.*, 2006b). However, we found no correlation between sampling effort (number of individuals) and the proportion of endemics (N = 65, r^2 <0.01, p >0.45), nor do results of analyses using only the 24 best-sampled sites (>300 individuals) deviate from results presented here.

Results

26 percent of Borneo's known geometrid fauna is currently considered endemic to the island, whereas 56 percent of species are confined to the Sundaland region (http://www.mothmap.unibas.ch; Holloway, 1993 [1994], 1996, 1997 for further details).

Proportion of endemic taxa

Test results from the GLM are shown in Table 4.1.

Table 4.1.
Results of Generalized Linear Models predicting the proportions of Borneo endemics (R^2_{corr} = 0.87, $F_{df=8,56}$ = 55.17, p < 0.0001) and Sundaland endemics (R^2_{corr} = 0.60, $F_{df=8,56}$ = 13.10, p < 0.0001) in 65 samples.
Significant effects of predictor variables are indicated in bold print.

	BORNEO		SUNDALAND	
Variable	F_{df}	p	F_{df}	p
Disturbance	**4.01** $_2$	**0.024**	1.95 $_2$	0.151
Stratum	0.28 $_1$	0.599	0.15 $_1$	0.696
Sampling schedule	**9.26** $_1$	**0.004**	3.74 $_1$	0.058
Precipitation	1.27 $_2$	0.290	**15.53** $_2$	**<0.0001**
Elevation	**102.03** $_1$	**<0.0001**	**26.21** $_1$	**<0.0001**
Year	0.08 $_1$	0.774	**6.48** $_1$	**0.014**

The proportions of Borneo endemics in samples increase linearly with the altitude of sample sites (Figure 4.1). A similar, though less steep pattern was found for Sundaland endemics (not shown). Furthermore, independently of this effect we found a higher proportion of Borneo endemics in primary forests than in both disturbed habitat classes (least square differences (LSD), p <0.02). We also found that significantly higher proportions of Borneo endemics are contained in samples taken during the first part of the night, indicating that many endemics have earlier nightly flight times than other species (cf. Beck & Linsenmair, 2006 for flight niches of sphingid moths). While this effect is also present (marginally significant) for Sundaland endemics, we could not find effects of habitat disturbance on these data. Their proportions do, however, react to precipitation (with significant increases from wet to mixed to dry months; LSD, p <0.0001) and increase with the year of sampling.

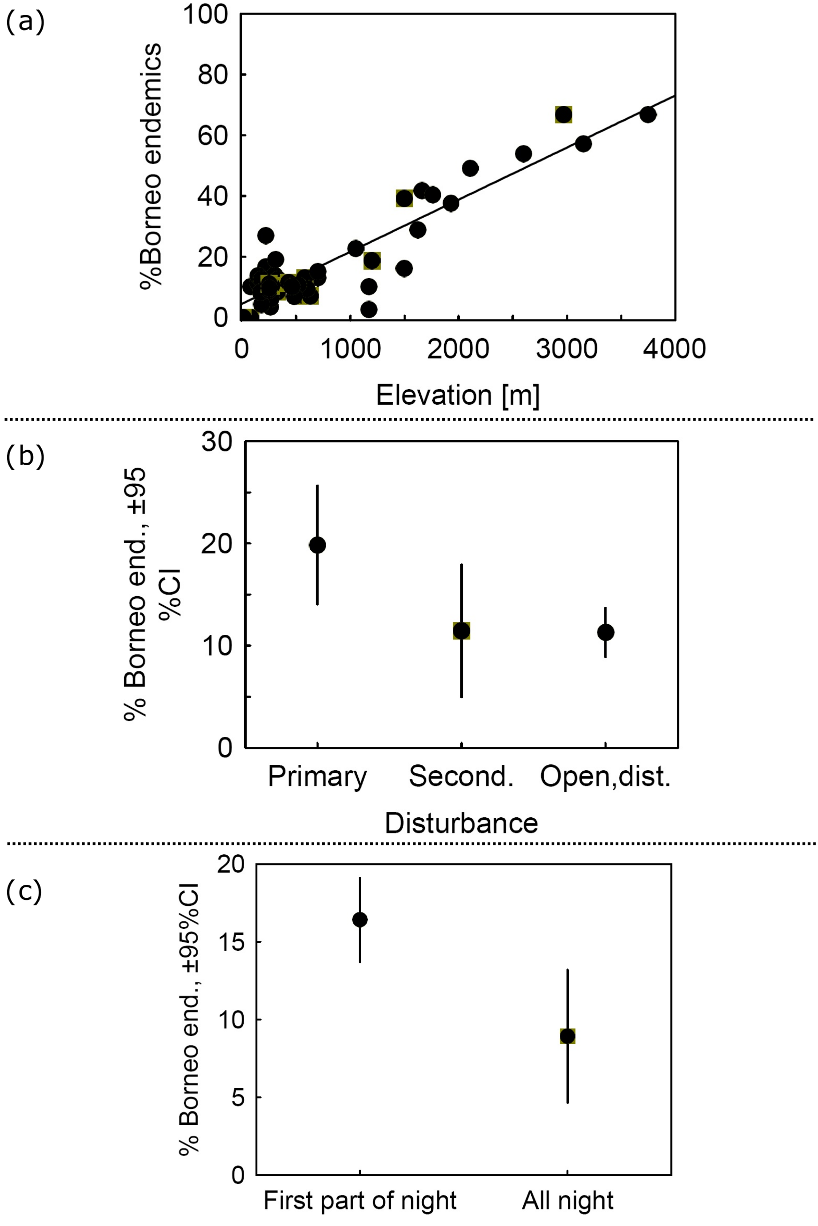

Figure 4.1
Significant effects of (a) elevation, (b) disturbance and (c) sampling schedule on the proportion of Borneo endemics
(weighted means, see Table 4.1 for multivariate test results).

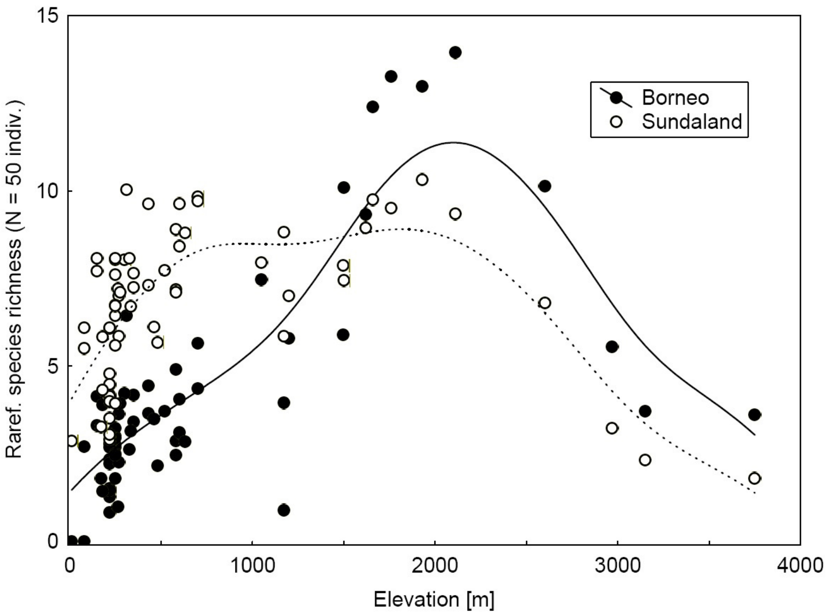

Figure 4.2
Estimates of rarefied species richness of endemics in different altitudes (see main text for calculation; fit: distance-weighted least squares).

Species richness of endemic taxa

The (estimated) species richness of endemics peaks sharply in montane forests around 2000 m (Figure 4.2), a pattern created by a peak of overall species richness around 650m (J. Beck & Chey V.K., in press.) and the increase in the proportion of endemics as shown in Figure 4.1. The elevational pattern of species richness for Sundaland endemics does not show a pronounced peak, but also sharply declines above ca. 2000 m. Various multivariate, polynomic modelling approaches (not shown) confirmed the significance of a unimodal distribution of the species richness of Borneo endemics.

Endemism and phylogeny

Different phylogenetic lineages might have different habitat preferences as well as having different proportions of endemics, hereby creating an only indirect relation between habitat type and endemism. We tentatively approached this problem by predicting endemism of species from their taxonomic association and their habitat preferences. We assessed habitat preferences as medians of elevations, disturbance classes and forest strata where species were recorded (using only 24 sites >300 individuals, eliminating data for less than three individuals at a site to prevent biases due to 'vagrants'; 440 species left for analysis).

General non-linear models (logit-link; StatSoft 2005) were used to predict endemism vs. non-endemism from habitat preference (continuous variables) and subfamily classification (categorical variables). All models showed a significant effect of elevation (Wald-statistic >11.3, p <0.0001; high-altitude species are more likely to be endemic), whereas only for Borneo endemics an independent trend (Wald-stat. = 3.1, p = 0.08) was found for habitat disturbance (primary forest species are more likely to be endemic). Forest stratum and taxonomic affiliation have no predictive value for endemism status in this analysis. The same conclusion was reached in an alternative analysis using tribal-level (instead of subfamily) classifications. Our analyses suggest that endemism is directly related to habitat conditions, and not mediated by phylogenetic effects.

Discussion

Our data showed clearly that primary forest contains, independently of other factors, a higher proportion of endemics than other habitats. While this is a relevant finding for various aspects of evolutionary ecology and biogeography (cf. Ricklefs & Bermingham, 2002, and references therein), it also gives yet another argument for preserving South East Asian rainforests. Pristine forests were also often found to contain higher total species diversity than disturbed habitats in tropical Lepidoptera (e.g. Holloway *et al.*, 1992; Beck *et al.*, 2002; Brehm *et al.*, 2005; Hilt *et al.*, 2006).

Our data also indicated that the highest number of endemic species is found in upper montane forests. In combination with a peak in total geometrid species richness in mid-elevations (data not shown; J. Beck & Chey V.K., unpubl.), results suggest that the hill- and montane forest zones between ca. 500 and 2500 m have the highest conservation value for geometrid moths in Borneo, and resources should thus be concentrated on the protection of these habitats.

However, although the concept of 'indicator taxa' is often employed in biodiversity studies, we must point out that results should not be generalized uncritically without further evidence (cf. Lawler *et al.*, 2003; Schulze *et al.*, 2004; Summerville *et al.*, 2004, and references therein). While we believe that ecological patterns are probably very similar in adjacent regions of Sundaland (e.g. Sumatra, Peninsular Malaysia), studies have shown that different taxonomic groups often show very different reactions to habitat change, even within the Lepidoptera (e.g., Hilt & Fiedler, 2005).

Land use patterns in South East Asia

Human population and economic pressure on natural ecosystems are worldwide typically highest in productive, accessible, species-rich lowlands (e.g. Araújo, 2003; Evans *et al.*, 2006; and references therein). Across South East Asia and the Malay Archipelago, for example, natural vegetation now covers a lower proportion of land area than disturbed, opened landscapes below ca. 1500 m, whereas the ratio inverses above that altitude (data based on Stibig *et al.*, 2002; analysis not shown). This pattern is even more pronounced in the Sundaland region, partly because the commercially valuable trees of the family Dipterocarpaceae occur in numbers only below ca. 800 m, which makes lowland forests most susceptible to logging and consequent land conversion. In the Malaysian state of Sabah, for instance, economic pressure has turned much of its cleared lowland dipterocarp forest area into monoculture oil palm plantations, and more than 15% of its total land area has been converted (Chey, 2006). A focus of conservation, thus, might not only be justified on scientific grounds as outlined above, but is also feasible for socio-economic reasons: Less political and financial effort may be needed to protect a montane region, compared to an equal area of lowland (cf. Wilson *et al.*, 2006).

However, two factors cast a shadow on this so far optimistic outlook, a general one and one with particular reference to Borneo. Firstly, even although montane regions contain the highest species richness of endemic geometrids, many of these species may not be completely confined to highlands (data are not sufficient for geometrids, but those on South East Asian sphingid moths corroborate this idea; e.g. Beck *et al.*, 2007). Across most mountainous regions of South East Asia, area decreases approximately exponentially with elevation (analysis based on a digital elevation model, not shown), which may be linked to species richness by the species-area relationship (e.g., Rahbek, 1997; for moths: J. Beck & I J. Kitching, unpubl.). Destruction of forests in the lowlands might not only lead to increasing fragmentation of those mountainous habitats (cf. Benedick *et al.* 2006), but may also diminish available area, hence population sizes, below a viable level.

Secondly, Borneo has, within Sundaland, probably the best conservation prospect. It still has the largest stretches of Asian rainforest, human population density is lowest among the major Sunda Islands, and most major threats to nature and (ultimately) local economy are due to non-local, often foreign interests (e.g. Laurance, 2004). A conservation strategy that focuses on endemics but inherently assumes that non-endemic species will survive elsewhere might therefore be flawed: Borneo might be the only place where S.E Asian lowland forest taxa have chances of surviving the current crisis (if politics finally understand the social and economic costs of ecological destruction; cf. Diamond, 2005). However, as pointed out above, our results are probably also valid for similar regions such as Sumatra and the Malay Peninsula, where a focus on the protection of montane endemics might be just feasible.

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5

DIVERSITY AND CONSERVATION STATUS OF DAY-FLYING MOTHS IN TAIWAN

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Abstract

Compared with butterflies, the diurnality of moths is far less well investigated either in scientific literature or popular books because diurnal moths are usually ignored by collectors in the field and poorly presented in museum collection. Although almost every lepidopteran family has diurnal species, their diversity and taxonomic distribution were never surveyed. A preliminary survey of diurnality among the Lepidoptera, in respect to their evolutionary relationships, is given. In recent years there is an increasing interest from insect trading market in some Asian diurnal moths, especially those with "butterfly appearance", e.g. Chalcosiinae (Zygaenidae), Geometridae and Epicopeiidae. These moths exhibit extremely high diversity in colouration, sexual dimorphism, polymorphism and complicated mimetic patterns. They are usually only associated with primary forests and specific hostplants. Overcollecting and habitat alternation may have threatened their survival, however, their biology is still poorly known.

Furthermore, some examples to explain how commercial collecting and habitat alternation have threatened diurnal moths in Taiwan are given. The history and execution of the Wildlife Conservation Law in Taiwan since the 1980s is introduced. Suggestions and perspectives of conservation of diurnal moths are also provided.

Citation:

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AN INVENTORY OF LEPIDOPTEROUS INSECTS IN SOUTH CHINA AND THEIR CONSERVATION

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Abstract

An inventory of biodiversity is of primary importance as part of biodiversity conservation for sustainable development, particularly in tropical and subtropical regions that harbour such great numbers of species. In comparison with higher plants and larger animals, the inventory of insects is still fragmentary and incomplete.

Lepidoptera is a group of insects that contains many large and showy species. Among these, butterflies have received much attention from the average layperson due to their diurnal activity and colourful wing patterns. Consequently the conservation of butterflies is much better than any other group of insects.

South China is located in the northeastern part of the Indo-Burma area, one the hottest hotspots of biodiversity in the world. Since the 1950s, many multidisciplinary surveys of insects have been conducted in southwest China, including Yunnan, Sichuan and Xizang (Tibet) Provinces, but those in South China seems rather few.

At the beginning of the new century, we started the inventory of Lepidoptera in South China from selected Nature Reserves [NR] (Guangdong Province: Nanling NR, Shimentai Natural Reserve; Guangxi Province: Shiwandashan NR, Maoershan NR, Cenwanglaoshan NR; Hainan Province: Jiangfengling NR, Diaoluoshan NR, Yinggeling NR). So far, over 2,400 species, including 650 butterfly species, belonging to 65 families have been documented. A few families and many species are recorded for the first time from the region, e.g., Micropterigidae, Neopseustidae. Some large and showy moths are only recorded from the region within the country, such as *Actias chapae* from Nanling, Guangdong, and *Salassa lemaii* from Hainan.

Citation:

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MOTH DIVERSITY OF MADHYA PRADESH AND CHHATTISGARH, INDIA, AND ITS CONSERVATION MEASURES.

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Abstract

The status of the moth fauna of Madhya Pradesh and Chhattisgarh states, central India, along with species distribution in various districts and protected areas, is presented, based upon studies carried out from 2001 to 2004 in various localities. Although 313 species have been recorded from these states, the present study recorded only 142 species of moths, of which 101 species of moths pertaining to 90 genera and 16 families represent new records from these states and four new records to India. Of these 142 species, 139 species/ subspecies in 114 genera and 16 families are from Madhya Pradesh and 58 species/ subspecies in 52 genera and 13 families are from Chhattisgarh. In the current study many previously reported species were not encountered. Conservation measures are also discussed.

Introduction

The order Lepidoptera belong to holometabolous endopterygotes, scale-winged insects, which includes butterflies and moths. The moths are very familiar to mankind on account of their beautiful coloration, size and plant relationships. They are cosmopolitan in distribution, occurring in every conceivable habitat, from coastal areas and plains to deserts, forest and valleys of hills and mountains.

Recent estimates reveal the report of over 127,000 species of moths from the world, of which over 12,000 species are recorded from India. The comprehensive work on moths of different region of Central India was mostly carried out before 1950. Cotes and Swinhoe (1886, 1887, 1888 & 1889) in six volumes of "A Catalogue of Moths of India" included 120 species from Madhya Pradesh and Chhattisgarh. However, Hampson (1892, 1894, 1895 & 1896) and Bell and Scott (1937) in five volumes of "Fauna of British India" included 76 species from Central India (Madhya Pradesh and Chhattishgarh). Since then, not much has been carried out on the moth fauna of Madhya Pradesh.

Only scattered papers on pest species and in other regional studies are available through the works of Mandal and Bhattacharya (1980), Rawat and Verma (1980), Singh and Rawat (1980), Vaishampayan and Veda (1980), Verma *et al.* (1980), Gupta *et al.* (1984), Singh (1987), Khan *et al.* (1988), Joshi and Meshram (1989), Mandal and Ghosh (1991, 1997), Mandal and Maulik (1991, 1997), Singh *et al.* (1991), Gujarati *et al.* (1993), Bhattacharya (1997), Ghosh and Chaudhary (1997), Kulkarni and Joshi (1998), Arora (2000) and Agrawal (2002), who added 73 species from these two states. Chandra and Nema (2004, 2006) and Chandra *et al.* (2004, 2006) also published information on moths of few protected areas and Jabalpur district in Madhya Pradesh. Presently, 313 species of moths belonging to 221 genera and 25 families are known from Madhya Pradesh and Chhattisgarh through the publication of Chandra and Nema (2007).

Study area

The study area is about 443,400 Sq. km. and covers Madhya Pradesh and Chhattisgarh of central region of India, which lies between latitudes 18°- 26° N and longitudes 74°-84° E., which covers 13.4 % of the total area of India. The Tropic of Cancer passes through the northern part of the states. The forest types found in the area are classified as tropical moist deciduous forests, sub-tropical hill forests, tropical dry deciduous forests and tropical thorn forests.

Collection & identification

Generally the moths are nocturnal in habit. The collection of moths is generally made through the light traps, using a 250-watt mercury vapour bulb. Majority of moths are attracted to light at night. Several traps have been devised and are in practice. But presently, the most convenient method used is the sheet, which allows collection of all the specimens individually without any damage. The white 10' x 6' cloth sheet is hung between two vertical poles in such a way that it touches the surface and extends forwards over the ground slightly away from the direct source of light. The source of light should be placed at such a point that the whole sheet from edge to edge brightly reflects the light. The number of specimens collected from the various protected areas and the survey period is given in Table 7.1. The moths were then studied with the help of stereoscopic binocular microscope. The collected specimens were identified and classified with the help of available literature. The male genitalia also helps in the process, especially for the discrimination of the species. Each specimen was also compared with the reference collection available at Zoological Survey of India. The classification used mainly follows Hampson (1892, 1894, 1895, 1896) and subsequent changes (based on Kristensen, 1999) in the families are also followed.

Table 7.1.
Collection data of Protected areas

Site No	Protected Area Name	Survey period (4.6.01 to 2.7.04)	No. of Specimens
1.	Achanakmar Wildlife Sanctuary	June, July	179
2.	Bandhavgarh Tiger Reserve	Jan., Feb., Sep., Oct.	276
3.	Kangerghati National Park	March, April	84
4.	Kanha Tiger Reserve	September	229
5.	Madhav National Park	Nov., Dec.	73
6.	Pench Tiger Reserve	June, July	483
7.	Satpura-Pachmarhi Bori Tiger Reserve	Feb., June	174
8.	Van Vihar National Park	October	29
		Total	1527

Results

The present work gives the detailed information on moth fauna of Madhya Pradesh and Chhattisgarh, along with their distribution in various districts and protected areas in these states. The study reveals the new record of 99 species (64 species for Madhya Pradesh, 2 species for Chhattishgarh and 33 species for both the states) pertaining to 90 genera and 16 families. Total 142 species of moths belonging to 121 genera and 16 families are studied from Madhya Pradesh and Chhattisgarh. Of which, 139 species / subspecies pertaining to 114 genera and 17 families are recorded from Madhya Pradesh, however, only 58 species belonging to 52 genera and 13 families are so far included from Chhattisgarh. The list of all the species and their distribution in districts and protected areas is given in Appendix 7.1.

The superfamily Sesoidea is represented by the family Sesiidae, which is rare in occurrence; only one example of *Melittia eurytion* was collected from Pench Tiger Reserve. It is a diurnal moth, which feeds on wing and settle on leaves in hot sunshine, the flight is very rapid.

The superfamily Cossoidea is represented by the family Cossidae, of which three species are recorded. These species are notorious wood borers. *Xyleutes persona* (Le Guillou) larvae form numerous galleries inside the tissues of living trees and are not detected until the tree is sown. *Zeuzera* sp. is another well known Cossid borer in coffee, which is also reported to attack on sandal wood, citrus, cotton, jasmine and teak.

The superfamily Zygaenoidea is represented by the family Limacodidae, of which only *Parasa* sp. was collected, from both states.

The superfamily Pyralidoidea is represented by the family Crambidae. They are mostly found in rainforests as well as some are cosmopolitan pests of stored products. During the study, 21 species were collected.

The superfamily Hyblaeoidea is represented by the family Hyblaeidae and the teak defoliator species i.e. *Hyblaea puera*, known to be common pest of crops and vegetation, has been recorded from both states.

The superfamily Bombycoidea is represented three families i.e. Eupterotidae (one species), Saturniidae (three species) and Sphingidae (nineteen species). The family Eupterotidae is represented by the species *Ganisa plana*, recorded from Pench Tiger Reserve. The family Saturniidae often fly late at night, with an irregular flight and are readily attracted to light. Three species, *Actias selene*, *Antheraea paphia* and *Attacus atlas* are recorded from these two states. *Attacus atlas* is the biggest moth in the world. *Antheraea paphia* (Linn.) is reared for the production of tasar silk. The sericulture industry flourishes entirely on these silk moths and provides job to many people in urban and rural areas. They are generally diurnal or crepuscular moths with powerful flight. The moths have the unique habit of depositing their eggs while pairing on wing. The moth usually emerges in the evening, and settles quietly till after dark on the following day, allowing its wings to harden. The day-flying species, such as those of the genera *Macroglossum* and *Cephonodes* may be seen on the wing at any time of the day and late in the evening, the night-flying species are seldom seen except when visiting flowers or when attracted to artificial light. The food-plants of Indian Hawk-moths cover a very large range, comprising some hundreds of plant species and including the largest trees and small herbs and even grasses.

The superfamily Lasiocampodea includes the Lasiocampidae, which is represented by three species. Members of the family Lasiocampidae are susceptible to fungi and are also attacked by tachnid flies.

The superfamily Geometroidea is represented by two families; Geometridae (12 species) and Uranidae (one species). The flight of the adults is never strong and they may often be disturbed during the day from the foliage or tree trunks on which they rest. Few species are day-fliers, colourful and probably distasteful to predators. Some species females are wing less, or have degenerated wings. Most species appear to favour trees or shrubs as larval food-plants rather than low vegetation, others are flower feeders and can change colour with the flowers or plants on which they feed. The family Uraniidae is represented by one species *Micronia aculeata*.

The family Noctuidae includes the most species (54), followed by the families Pyralidae (21), Sphingidae (19), Geometridae (12) and Arctiidae (10). Among the 16 families recorded, these five families represent more than 80% species studied from the region. The number of genera and species representing each family are given in Table 7.2. The maximum number of species (106) of moths is recorded from Pench Tiger Reserve, followed by the Kanha Tiger Reserve (66 spp.), Bandhavgarh Tiger Reserve (50 spp.) and Achanakmar Wild Life Sanctuary (41 spp.). The number of species, genera and families representing each protected areas are given in Table 7.3.

Table 7.2.
Number of genera and species of moths from Madhya Pradesh and Chhattisgarh

Superfamilies		Families		Number of species	Number of Genera
A.	Sesioidea	I.	Sesiidae	1	1
B.	Cossoidea	II.	Cossidae	3	2
C.	Zygaenoidea	III.	Limacodidae	1	1
D.	Pyralidoidea	IV.	Crambidae	21	19
E.	Hyblaeoidea	V.	Hyblaeidae	1	1
F.	Bombycoidea	VI.	Eupterotidae	2	2
		VII.	Saturniidae	3	3
		VIII.	Sphingidae	19	14
G.	Lasiocampoidea	IX.	Lasiocampidae	3	3
H.	Geometroidea	X.	Geometridae	12	10
		XI.	Uraniidae	1	1
I.	Noctuoidea	XII.	Notodontidae	4	4
		XIII.	Lymantridae	3	3
		XIV.	Arctiidae	11	10
		XV.	Nolidae	3	3
		XVI.	Noctuidae	54	46
			Total	142	121

Table 7.3.
Number of families, genera and species of moths in protected areas of Madhya Pradesh and Chhattisgarh

Protected Area		Number of Families	Number of Genera	Number of Species
1.	Achanakmar WildLife Santuary	11	38	41
2.	Bandhavgarh Tiger Reserve	10	47	50
3.	Kangerghati National Park	8	25	27
4.	Kanha Tiger Reserve	13	25	62
5.	Madhav National Park	5	10	10
6.	Pench Tiger Reserve	15	96	106
7.	Satpura-Pachmarhi, Bori Tiger Reserve	10	35	38
8.	Van Vihar National Park	4	15	15

The interesting outcome of the above studies is the first India records of four species i.e. *Chiasma translineata* Walker, *Chrysocraspeda conversata* Walker (Family: Geometridae), *Orvasca subnotata* Walker. (Family: Lymantridae) and *Ercheia multilinea* Swinhoe, (Family: Noctuidae).

Discussion

South-East Asia is one of the rich biodiversity areas on the earth, wherein more than 6500 species of Micro-Lepidoptera are known (Robinson *et. al*. 1994). '*The Moths of Borneo*' series in 18 parts published by J.D. Holloway, includes 3629 species covering the area of 743,330 sq. km. Chandra and Kumar (1992) listed 415 species from Andaman and Nicobar Islands, which covers only 0.25 % geographical area of India. Ghosh (2003) studied the Geometrid moths of Sikkim and reported 525 species, wherein record of 460 and 260 species of the family Geometridae respectively from Meghalaya and West Bengal was also mentioned. Hampson (1896) in '*Fauna of British India*' included 1136 species of Pyralidae from India and Bhattacharya (1997) reported the occurrence of 184 species of Pyralidae from West Bengal. However, study of moth diversity in Madhya Pradesh and Chhattisgarh during the three years period revealed the addition of 99 species of moths from these two states, which indicates that many more species could be added, if more intensive surveys are undertaken. After the evaluation of collection data of 142 species studied, 59 species were found to be fairly common, 50 species were uncommon and 33 species were rare in these states. It was also observed that due to topographical changes and habitat loss of natural habitats, the population of many species has also declined. Therefore, exhaustive surveys of all the regions are required to understand the overall picture of the group, which would not only help in assessment of it's diversity, but also in it's monitoring, conservation and management.

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Appendix 7.1

Moth species of Madhya Pradesh and Chhattisgarh; their distribution and status

Abbreviations used:-

Districts in Madhya Pradesh (M.P.)

Bg – Balaghat Bp – Bhopal C – Chindwara H – Hoshangabad
I – Indore J – Jabalpur M – Mandla N – Narsinghpur
Se – Seoni Sh – Shivpuri Si – Sidhi U - Umaria

Districts in Chhattisgarh (C.G.)

B – Bastar Bi – Bilaspur

PAs - Protected Areas:

1 - Achanakmar Wild Life Sanctuary; 2 - Bandhavgarh Tiger Reserve;
3 - Kangerghati National Park; 4 - Kanha Tiger Reserve;
5 - Madhav National Park; 6 - Pench Tiger Reserve;
7 – Satpura-Pachmarhi Bori Tiger Reserve; 8 - Van Vihar National Park.

NR - New Record: MP- New Record for Madhya Pradesh; CG- New Record for Chhattisgarh; I- New Record for India.

Status: C – Common; U – Uncommon; R – Rare.

No.	Scientific Name	M.P.	C.G.	PAs	NR	Status
A	**SESIOIDEA**					
I.	**Sesiidae**					
1.	*Melittia eurytion* (Westwood)	Se	-	6	MP	R
B	**COSSOIDEA**					
II.	**Cossidae**					
2.	*Xyleutes strix* (Linnaeus)	Se	-	6	MP	U
3.	*Xyleutes persona* (Le Guillou)	Se	Bi	6 1	MP CG	U
4.	*Zeuzera* sp.	Bp C M	Bi	8 3 6 1	MP CG	U
C	**ZYGAENOIDEA**					
III.	**Limacodidae**					
5.	*Parasa* sp.	M	Bi	4 1	MP	U
D	**PYRALIDOIDEA**					
IV.	**Crambidae**					
6.	*Cirrhochrista brizoalis* (Walker)	Bg M Se U	-	4 6 2	MP	U
7.	*Nymphula fluctuosalis* Zeller	Bp C Bg U	-	8 6 4 2	MP	C
8.	*Spoladea recurvalis* (Fabricius)	Bp H M Se U Sh J I	Bi	8 7 4 6 2 5 1	MP CG	C
9.	*Haritalodes derogata* (Fabricius)	C M	-	6 4	MP	U
10.	*Tyspanodes linealis* Moore	U J	Bi	2 1	MP CG	C
11.	*Synclera traducalis* (Zeller)	Se U	-	6 2	MP	U
12.	*Syngamia latimarginalis* Walker	Se	-	6	MP	R
13.	*Cnaphalocrocis medinalis* (Guenée)	Bp U M	-	8 2 4	MP	C
14.	*Euclasta vitralis* Maes	Se U Sh	-	6 2 5		C
15.	*Diaphania indica* (Saunders)	I J H M Se	Bi	7 4 6 1		C
16.	*Glyphodes bivitralis* (Guenée)	U	-	2	MP	R
17.	*Glyphodes bicolor* (Swainson)	Se	-	6	MP	R

No.	Scientific Name	M.P.	C.G.	PAs	NR	Status
18.	*Agathodes ostentalis* Hübner	H M Se	Bi	7 4 6 1	MP CG	C
19.	*Nausinoe geometralis* (Guenée)	C	B Bi	6 3 1	MP CG	U
20.	*Nausinoe perspectata* (Fabricius)	Se	B	3 6	MP CG	U
21.	*Pygospila tyres* (Cramer)	Se M J	-	4 6		C
22.	*Maruca vitrata* (Fabricius)	Bp C Se U M	B	8 6 2 4 3	MP CG	C
23.	*Terastia egialealis* Walker	C J	-	6	MP	U
24.	*Sameodes cancellalis* Zeller	Bp H Se U M J	B Bi	8 3 1 7 6 2 4	MP CG	C
25.	*Omphisa anastomosalis* Guenée	H M	-	7 4	MP	C
26.	*Prophantis octoguttale* (Felder)	M	-	4	MP	U
E	**HYBLAEOIDEA**					
V.	**Hyblaeidae**					
27.	*Hyblaea puera* Cramer	Se H M J	B	6 7 4 3		C
F	**BOMBYCOIDEA**					
VI.	**Eupterotidae**					
28	*Ganisa plana* Walker	Se	-	6	MP	R
29.	*Eupterote* sp.	H Se	Bi	6 1		C
VII.	**Saturniidae**					
30.	*Actias selene* (Hübner)	J Se U	Bi	6 2 1	MP CG	C
31.	*Attacus atlas* (Linnaeus)	M	-	4	MP	U
32.	*Antheraea paphia* (Linnaeus)	C M J	Bi	6 4 1	MP CG	C
VIII.	**Sphingidae**					
33.	*Acherontia lachesis* (Fabricius)	I Se	-	6		R
34.	*Acherontia styx* (Westwood)	I J Se	-	6		U
35.	*Agrius convolvuli* (Linnaeus)	J Se M	-	6 4	MP	U
36.	*Psilogramma menephron* (Cramer)	Bp Se U	Bi	8 6 2 1	MP CG	C
37.	*Marumba dyras* (Walker)	H M Se U	Bi	2 4 6 7 1		C
38.	*Clanis* sp.	U	Bi	2 1	MP CG	U
39.	*Polyptychus dentatus* (Cramer)	I Se	-	6		R
40.	*Ambulyx* sp.	U	Bi	2 1	MP CG	U
41.	*Cephonodes* sp.	H	-	7		R
42.	*Macroglossum* sp.	Se	Bi	1 6		R
43.	*Nephele hespera* (Fabricius)	Se Sh U	-	6 5 2	MP	C
44.	*Daphnis nerii* (Linnaeus)	J H	-	7		R
45.	*Hippotion boerhaviae* (Fabricius)	Se U H M	B	6 2 7 4 3		C
46.	*Pergesa acteus* (Cramer)	Bg U M	-	2 4	MP	C
47.	*Theretra alecto* (Linnaeus)	I J H M Se U	Bi	6 2 7 4 1		C
48.	*Theretra nessus* (Drury)	J C	-	6	MP	U
49.	*Theretra boisduvalii* (Bugnion)	Se U	Bi	1 6 2	MP CG	U
50.	*Theretra silhetensis* (Walker)	J	-		MP	U
51.	*Theretra oldenlandiae* (Fabricius)	J I H M Se U	Bi	6 2 7 4 1		C
G.	**LASIOCAMPOIDEA**					
IX.	**Lasiocampidae**					
52.	*Gastropacha pardale* Walker	C U M	-	6 2 4	MP	U
53.	*Lebeda* sp.	Se U	-	6 2	MP	U
54.	*Trabala* sp.	H	-	7	MP	U

No.	Scientific Name	M.P.	C.G.	PAs	NR	Status
H.	**GEOMETROIDEA**					
X.	**Geometridae**					
55.	*Petelia delostigma* Prout	Se	-	6	MP	R
56.	*Plutodes transmutata* Walker	Se	-	6	MP	R
57.	*Heterostegane urbica* Swinhoe	Se	-	6	MP	R
58.	*Chiasmia eleonora* (Cramer) [=*Macaria fasciata* Fabricius]	J H M Se	B Bi	3 1 6 7 4	MP CG	C
59.	*Chiasmia translineata* (Walker)	U	-	2	MP **I**	R
60.	*Hyposidra talaca* (Walker)	C H M U Sh	B Bi	3 1 6 7 4 2 5	MP CG	C
61.	*Pingasa ruginaria* Guenée	-	B	3	CG	R
62.	*Pingasa chlora* Stoll	Se J Sh	-	6 5	MP	C
63.	*Aporandria specularia* Guenée	Se M Bg	B	3 6 4	MP CG	C
64.	*Chrysocraspeda conversata* (Walker)	U	-	2	MP **I**	R
65.	*Antitrygodes cuneilinea* (Walker)	H M Se U	-	7 4 6 2	MP	C
66.	*Somatina anthophilata* Guenée	Se	-	6	MP	R
XI.	**Uraniidae**					
67.	*Micronia aculeata* Guenée	H M Se U	-	7 4 6 2	MP	C
I.	**NOCTUOIDEA**					
XII.	**Notodontidae**					
68.	*Spatalia argentifera* (Walker)	M Se U	-	4 6 2	MP	C
69.	*Phalera raya* Moore	H M Se U	Bi	7 4 6 2 1	MP CG	C
70.	*Cerura liturata* Walker	J M Se U	Bi	4 6 2 1	MP CG	C
71.	*Antheua servula* Drury	I H Se U	-	4 6 2		C
XIII.	**Lymantridae**					
72.	*Lymantria* sp.	Se H	B Bi	6 7 1 3		C
73.	*Orvasca subnotata* Walker	Bp U	B	8 3 2	MP CG **I**	U
74.	*Perina nuda* (Fabricius)	M	B	4 3		U
XIV.	**Arctiidae**					
75.	*Syntomoides imaon* Cramer	Bp	-	8	MP	U
76.	*Olepa ricini* (Fabricius)	M U J	Bi	4 2 1		C
77.	*Creatonotos gangis* (Linnaeus)	Bp Se C H U M Sh J B		8 6 7 2 4 5 3		C
78.	*Creatonotos transiens* (Walker)	H M	B Bi	3 1 7 4	MP CG	U
79.	*Amsacta lactinea* Cramer	Se U Bg	Bi	6 2 4 1	MP CG	C
80.	*Argina astrea* (Drury)	Bp Se H M	-	8 6 7 4		C
81.	*Nyctemera lacticinia* Cramer	-	B	3	CG	R
82.	*Oeonistis altica* (Linnaeus)	Bg H	B	7 3	MP CG	C
83.	*Macrobrochis gigas* (Walker)	H	Bi	7 1	MP CG	R
84.	*Utetheisa pulchelloides* Hampson	H Se I	B	7 6 3	MP CG	C
85.	*Cyana puella* Drury	M Se H	B Bi	4 7 1 3	MP CG	C
XV.	**Nolidae**					
86.	*Pseudelydna rufoflava* Walker	Se	-	6	MP	U
87.	*Carea angulata* (Fabricius)	M C	-	4 6	MP	U
88.	*Westermania argentea* Hampson	Se M C	-	6 4	MP	C

No.	Scientific Name	M.P.	C.G.	PAs	NR	Status
XVI.	**NOCTUIDAE**					
89.	*Asota caricae* (Fabricius)	Se U H M J Bp	B Bi	8 6 2 7 4 1 3	MP CG	C
90.	*Hypena rhombalis* Guenée	Se	-	6	MP	R
91.	*Polytela gloriosae* (Fabricius)	Se	Bi	6 1	MP CG	U
92.	*Psimada quadripennis* Walker	M Bg Se	-	4 6	MP	R
93.	*Cosmophila fulvida* (Guenée)	Se H	-	6 7	MP	U
94.	*Eutelia adulatricoides* (Mell)	Se	-	6	MP	R
95.	*Cetola dentata* Walker	Se U	-	6 2		C
96.	*Erebus hieroglyphia* Drury	Se	-	6	MP	U
97.	*Erebus macrops* Linnaeus	Se Bg J	-	6 4	MP	U
98.	*Ischyja manlia* Cramer	Se M	-	6 4	MP	R
99.	*Sphingomorpha chlorea* Cramer	N C	-	7	MP	R
100.	*Nagia linteola* (Guenée)	Se M	-	6 4	MP	U
101.	*Episparis varialis* (Walker)	Bp Se U M J	B Bi	8 6 2 4 3 1		C
102.	*Eudocima materna* (Linnaeus)	Bp Se J	-	8 6		U
103.	*Hypocala* sp.	Se M C Sh	-	6 2 4 7 5	MP	C
104.	*Hypospila bolinoides* (Guenée)	M	-	4	MP	R
105.	*Azazia rubricans* (Boisduval)	Se M J	-	6 4	MP	U
106.	*Serrodes inara* Cramer	Se	-	6	MP	R
107.	*Trisula variegata* Moore	Se M	Bi	6 4 1	MP CG	U
108.	*Chrysopera combinans* (Walker)	Se	-	6		R
109.	*Fodina* sp.	Se	Bi	6 1	MP CG	U
110.	*Trigonodes disjuncta* (Moore)	M	-	4	MP	U
111.	*Trigonodes hyppasia* (Cramer)	Se M U C Sh J	B	6 4 2 7 5 3	MP CG	C
112.	*Ercheia multilinea* Swinhoe	Se U	-	6 2	MP **I**	R
113.	*Homaea clathrum* Guenée	C M	-	6 4		U
114.	*Entomogramma tortum* Guenée	Se	-	6	MP	U
115.	*Grammodes geometrica* (Fabricius)	Se M U	-	6 4 2		C
116.	*Chalciope mygdon* (Cramer)	Se H Sh	-	6 7 5		C
117.	*Thyas honesta* (Hübner)	U	-	2		R
118	*Thyas coronata* Fabricius	Se Si J	-	6		C
119.	*Bastilla joviana* (Cramer)	C U	-	6 2		U
120.	*Bastilla crameri* Moore	Se	Bi	6		U
121.	*Dysgonia algira* Linnaeus	Se	Bi	6 1		U
122.	*Ophiusa triphaenoides* Walker	U	B Bi	2 1 3		U
123.	*Ophiusa tirhaca* (Cramer)	Se Si M	-	6 4		C
124.	*Achaea janata* Linnaeus	Se C M Si J	Bi	6 4 2 1	MP CG	C
125.	*Mocis undata* Fabricius	Se M	-	6 4		C
126.	*Pericyma cruegeri* Butler	Se H	-	6 7	MP	C
127.	*Spirama retorta* Cramer	Se U	-	6 2	MP	C
128.	*Acontia intercepta* Guenée	Se	-	6	MP	U
129.	*Acontia transversa* Guenée	Se H J	-	6 7	MP	C
130.	*Trichoplusia orichalcea* Fabricius	C H	-	7		U
131.	*Chrysodeixis eriosoma* (Doubleday)	Se H U M J	-	6 7 2 4		C
132.	*Zalissa transiens* (Walker)	Se	Bi	6 1	MP CG	R
133.	*Aegocera venulia* Cramer	C	-	6	MP	U
134.	*Mimeusemia* sp.	Se	Bi	6 1	MP CG	U
135.	*Callyna jugaria* Walker	Bg J	Bi	4 1	MP	U

No.	Scientific Name	M.P.	C.G.	PAs	NR	Status
136.	*Callyna costiplaga* Moore	Se	-	6	MP	R
137.	*Brevipecten captatus* Butler	H	-	7	MP	R
138.	*Helicoverpa armigera* (Hübner)	C Sh U M	B	6 5 2 4 3		C
139.	*Helicoverpa assulta* Guenée	C U M	-	6 2 4	MP	C
140.	*Callopistria maillardi* Moore	Se	-	6	MP	R
141.	*Spodoptera litura* (Fabricius)	Bp H Se M J	B	8 7 6 4 3		C
142.	*Agrotis* sp.	-	B Bi	3 1		U

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PALAEARCTIC BUTTERFLY ECOLOGY MODEL FOR ORIENTAL SPECIES CONSERVATION

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Abstract

A phylogenetic study of origin of seasonal polyphenism of nymphalid butterflies of the genera *Araschnia*, *Mynes* and *Symbrenthia* revealed that the phenomenon did not evolve under condition of Palaearctic climate, but likely in area of transient zone of Palaearctic and Oriental regions of SE Asia, where ancestors of the butterfly group occurred. Another study, of phylogeny and parasitic myrmecophily in Lycaenidae of *Glaucopsyche* section, showed that Palaearctic *Maculinea* and Oriental *Phengaris* form a monophyletic group with similar life cycles. Based on long-term studies in Europe, the distribution of host ants seems to be a key factor of the occurrence of seriously endangered *Maculinea*, and we suppose that the occurrence of ants is important for conservation of *Phengaris* as well. These two examples show that understanding of critical phenomena in ecology of butterflies occurring in a biogeographic region may depend on a thorough knowledge of their relatives distributed elsewhere. We call for collaborative studies of ecological traits of selected butterfly taxa spanning across regions, for better sharing of basic life history information among professionals and amateurs from different regions (e.g. via internet publications) and for efforts to make information stored in older literature, including that written in minor languages, more accessible internationally.

Introduction:

Ecological phenomena & evolution of butterflies

The combination of ecology of Palaearctic butterflies and conservation of Oriental species looks rather odd. At least since the time of Wallace (1876), we know that fauna of different geographic regions of the world developed under different environmental conditions and that these regions have different history, as reflected in so-called biogeographic regions. They are useful for delimiting of faunal or ecology study. For instance, in studies of effect of logging on butterfly fauna, species with different geographic ranges are differently affected (cf. Lewis, 2001; Nummelin & Kaitala, 2004; Dumbrell & Hill, 2005; Cleary & Mooers, 2006).

On the other hand, evolution of individual taxa may transgress current biogeographic regions. For instance, in studies of Pieridae (Braby & Trueman, 2006) or Nymphalidae (Wahlberg *et al*., 2005), the changes of species distribution between Neotropic and Australian, or even between Gondwanian and Laureasian are quite frequent. Ecological similarities within regions may be caused either by common descent or by convergence, which may be distinguished only by phylogenetic analysis. Another important point is that present ecological phenomena could have evolved under different condition than in present species distribution. Then, analysing phylogeny could answer shed some light on phenomena for which we fail to find adaptive explanations. Valid phylogenetic analysis obviously requires to study all related taxa, not limited only to one region. The questions are more important in present time, where we observe severe deterioration of fauna of both tropical and temperate regions.

Myrmecophily of Large Blues (*Maculinea *spp.)

The blues of the genus *Maculinea* belong among the most intensively studied insects in Europe. It is quiet often, that caterpillars of butterflies of Lycaenidae are somehow connected with ants. Usually, the ants in such, so-called myrmecophilous, species, protect the larvae against their natural enemies, and the protection is paid by producing special secrets from caterpillars' secretory glands. In majority of the species, however, this type of mutualism is only obligatory and the caterpillars can survive well even without the ants. On the other hand, the blues of genus *Maculinea* are dependent on the ants. When the larvae enter the third instar, they drop to ground and wait for ants of the genus *Myrmica*. Then, after a specific adoption ritual, they are carried by the ants into the ant nests and then reared until pupation. There are two different strategies how to live inside of ant nest. One strategy is just to eat the ant larvae. The other strategy is "cuckoo" – the caterpillar is fed by worker ants.

These peculiar butterflies underwent strong declines across Europe in the last few decades, which led to a number of conservation-oriented studies, and also gave rise to speculation about the origin of the mutualism. Surprisingly, until very recently, nobody attempted to reconstruct a phylogeny of the group to look how many times the special life history evolved and how related the life histories of individual species are. In 2004, two such studies finally appeared. One used molecular data (Als *et al.*, 2004), the second, morphology characters (Pech *et al.*, 2004). The two papers closely converged in their results, showing that butterflies classified to Palaearctic genus *Maculinea* and Oriental genus *Phengaris* form one monophyletic group. Both papers supported monophyly of cuckoo-species. Moreover, mapping of character states and looking for the most parsimonious scenario in character evolution revealed that the Oriental species share the dependence on *Myrmica* ants with the Palaearctic ones.

The presence of *Myrmica* ants is one of the key factors influencing the presence of *Maculinea* (e.g. Thomas *et al.*, 1989); the presence of *Phengaris* is likely to be determined by the same factor. *Myrmica* is a typical temperate group of ants, they are restricted to cold "temperate" habitats if occuring in Oriental region (Elmes *et al.*, 2001; Pfeiffer *et al.*, 2003). These habitats seem to be extremely vulnerable to the environmental changes due to global warming etc. Hereafter, the environmental changes could easily evoke the strong changes in the myrmecofauna composition (e.g. Elmes *et al.*, 1998). There are no serious data about Asian population. But, because there are very rapid habitat changes, connected to either intensification of agriculture or abandonment of traditional habitat use, accompanied with afforestation of abandoned land in the other side, we can expect similar declines even in the East.

Seasonal polyphenism in European Map buttefly (*Araschnia levana*)

The second story resembles the chicken or egg riddle. European Map Butterfly was described by Linnaeus in 1758 as two distinct species – red & black *Papilio levana* and black & white *Papilio prorsa* (Figure 8.1). During the 19th century, it was found that these two differently coloured butterflies represent just two seasonal forms, regularly changing at spring (f. *levana*) and during summer (f. *prorsa*). The formation of colour pattern is controlled by the timing of ecdysteroid release after pupation (Koch, 1992; 1996). The timing itself is controlled by length of day (short days induce diapause). Although the physiological background is well known, there is uncertainty regarding the ecological significance of the phenomenon. Windig (1999) and Windig & Lammar (1999) studied the evolutionary genetics of the species. They found that various wing pattern traits reacted differently to environmental variation, and did not overlap across environments. All of the studies in reality answered, how the differences and colour changes are made, but fail to explain why it is.

One of the hypotheses explaining seasonal polyphenism assumes that phenotypic differences in different generations allow a species to cope with seasonally changing environments (Shapiro, 1976; Brakefield, 1996). For this reason, we compared population structure and behaviour of the two generations and found that diurnal periodicity and mate-locating behaviour were essentially identical in spring and summer animals (Fric & Konvička, 2000). However, the summer generation was more numerous, and we obtained an indirect evidence of its higher mobility. The differences in mobility were further supported by movement and biomechanic analyses (Fric & Konvicka 2002). Stil, this did not resolve the question about the origin of different seasonal morphs. Therefore we carried out phylogenetic and phylogeographic analyses to answer a question where this phenomenon evolved (Fric *et al*., 2004). For tracking of the evolution of this phenomenon, we used Farris optimisation to construct ancestral state. We still did not find why it happened, but we found, what colour pattern occurred first – surprisingly it was red & black, but black spots enlarged by the same way as in black & white form (Figure 8.1)! The biogeography analysis showed that the seasonal polyphenism of *Araschnia* butterflies originated in continental South-East Asia and probably predated dispersal towards the Palaearctic.

Lack of knowledge

How reliable are the results? It should be admitted that in both *Maculinea* and *Araschnia* cases, origins of some ecological traits remain unresolved. In Large Blues, the unresolved question concerns ancestral host plant family, as two equally likely scenarios suggest either Lamiate or Rosid line (Fabaceae and Rosaceae). In the study of Map butterflies, the phylogeny has not yet answered whether the seasonal polyphenism in Nymphalini arose twice or more times (Figure 8.2). In both cases, the uncertainties were due to missing data in matrices used to reconstruct the phylogenies: in other words, due to lack of basic biological knowledge of the species studied. The information was almost complete for Palaearctic representatives of the groups, but there were many white spaces concerning life histories, habitat requirements and behaviour of Oriental representatives. A phylogeneticist would replace these gaps in knowledge by question marks, but then, several alternative scenarios may attain the same probability.

What are the sources of the gaps in knowledge? Some can be indeed due to missing knowledge. However, it often happens that the knowledge exists, but is not readily available. The constraints can be temporal (critical information had been published in old and therefore hardly accessible literature) spatial (important bits of information scattered in weird regional journals) or even personal (huge amount of information is limited to few regional experts who know everything, but do not publish). Moreover, huge amount of literature is too expensive even for relatively rich public institutions. And of course, language barriers play an important role, especially for information written in native languages, be Czech or Cebuano. Last but not least, animosities between some researchers, or jealousy on their theme of interest, do not help to overcome the constraints. Of course such problems are not limited only to less developed countries, for instance in Europe, there are numerous regional enthusiasts, speaking with their native languages, but not working and publishing in scientific world.

It should be noted that the gaps do not limit only those working with morphology and life history traits. Even if molecular phylogenies alow constructing trees without much knowledge of life history of individual species, resulting trees would be useless, if not examined for geographic, ecological or any other patterns. To map distribution of such patterns, we again need a basic information on individual species.

What to do?

It is evident, that knowledge of many species remains scattered or superficial, and that it is still necessary to study the whole butterfly spectrum with respect to their ecological, physiological and geographical aspects. However, as it is nearly impossible to study all taxa in the same detail and there should be some priorities. For the same reason, it is necessary not to discard the huge amount of information now buried in old books, local journals, or even in minds of individual butterfly enthusiasts.

A good point to start with single-species studies, especially if ones desires to be cited, are either species whose ecology had been studied in other, more distant parts of their ranges, or species belonging to otherwise intensively studied clades (e.g., close relatives of *Maculinea*). Examples of such studies exist (Wahlbergovina, ti noví Číňani…) but are still too rare to allow, e.g., comparative studies of different adaptations within single species, or reliable mapping of ecological characters in phylogenies. Similarly, close relatives of species known to be endangered in a region may be endangered elsewhere, as they may display high levels of specialisation. Although endemic taxa will remain attractive, restricting focus to endemics is not necessarily the best choice, as we showed, at least in West-Palaearctic region, that more widespread species can be more seriously endangered (Konvicka *et al*., 2006). We strongly urge for collaborative research of such widely distributed (and regionally well known) groups as *Maculinea*, Parnassiinae or Coliadini.

Regarding accessibility of information, obvious tools are displaying old (and hence both inaccessible and expensive) literature, especially books on internet; such activities already have started (cf. Moths of Borneo – http://www.mothsofborneo.com, Biologia Centrali-Americana - http://www.sil.si.edu/digitalcollections/bca or BioLib - http://www.biolib.de/), but much more can be done. Similarly, individuals and learned societies may wish to display their publications in local journals, perhaps (if they are written in native languages and have no abstracts) accompanied by short synopsis in English. A common goal should be creation of widely accessible peer-reviewed databases of butterfly life histories, which would facilitate reaching a new level in both comparative studies and practical conservation.

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THE CONSERVATION ASSESSMENT OF MOTHS IN HONG KONG

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Abstract

An overview of the Hong Kong moth fauna is given by way of a summary of recording effort and the species composition. Patterns of species richness, distribution and community composition are explored. These habitat and spatial data are combined with species data and compared against IUCN "Red List" criteria and local criteria, to establish which approaches are required for the conservation of the moth fauna in Hong Kong.

To date, from a base of almost 50,000 records, some 2,200 moth species have been recorded in Hong Kong, of which over 300 are thought to be undescribed by science and a similar number await identification to species level. At least 70 species have, to date, only been recorded from Hong Kong. Some 80 species meet IUCN "Red List" criteria in the categories "Critically Endangered", "Endangered" and "Vulnerable", not all of which occur inside protected land. Suggestions and discussion of further possible actions are given.

Introduction

This presentation aims to explore simple methods of assessment for conservation of moths in Hong Kong using available records. The methodology is aimed at relatively rapid assessments, allowing the best use of often scant or minimal resources.

The main focus is on single species assessment, whereby a species is assessed according to its known distribution and population status. Secondly, the richness of species is investigated at a landscape scale (base unit = $10km^2$), in order to obtain a rough idea of where the most species have been recorded so far. Thirdly, the species diversity (a measure of the species richness and abundance of each species) is assessed at the same scale as species richness to find out if there is anything in common, or if these measures give different results. Finally the assemblages found in different habitat types are compared to see if different habitats have different assemblages, and hence need conserving for their moth assemblages.

Methods

Data collection - Hong Kong Moth Recorder Database [HKMRD]

Data was collected primarily by light trapping (using Robinson or Skinner traps with a 125W mercury vapour light - see Fry & Waring, 1996, for details), although observations from other methods (casual observation records by day, rearing larvae and malaise trapping) are included in the data. Data validation was a critical component of this phase. Species were identified by cross referencing with published literature and reference collections held in Hong Kong (Kadoorie Farm & Botanic Garden and Tai Lung Farm) and The Natural History Museum, London, as well as elsewhere (see Kendrick, 2002 [2003] for the full list of collections and literature), either from voucher specimens of material collected (now housed at Kadoorie Farm & Botanic Garden), or by in situ determination based upon initial collection of voucher material from previous field work. Some more recent records are based upon photographic evidence from other recorders. Most light trap data included abundance of each species recorded.

For HK data, an MSAccess® database was constructed to store records. In this case the main data tables store information on species, sites, recorders, taxonomic ranking, recording events. The principle method of data entry is a "record". One record represents a species being seen on a defined date at a defined location. Abundance data may or may not be included, though inclusion is preferred. Additional tables for site data (including basic habitat information, ownership and abiotic variables such as aspect and elevation), weather conditions for a recording event, recorder/determiner data are related to each other by the recording events.

Species assessment

Two methods were used to assess which species are of conservation concern. Species not yet identified (almost 500 spp., or 24% of the total known so far from Hong Kong) were not assessed, even though some of these species are though to have only been found in Hong Kong.

(a) Single Species – IUCN assessment

Assessing the level of conservation concern for a species according to IUCN (2001) Red List criteria, one considers 11 aspects of a species' ecology:

Population and Population Size
Subpopulations
Mature individuals
Generation
Reduction
Continuing decline
Extreme fluctuations
Severely fragmented
Extent of occurrence
Area of occupancy
Location

These aspects were considered for each threshold per criteria, which resulted in a species being ranked within one of five levels of conservation concern (CR – critically endangered; EN – endangered; VU – vulnerable; nt – near threatened; lc – least concern). Species may also be listed as "dd" (data deficient) or as unassessed. Most of the published information available for the moth species that are found in Hong Kong relates to their global distribution; there is very little information available on ecological parameters pertaining to population size or structure, life history or fluctuations, and there is no long term (decades) monitoring in place to assess population reduction or continuing decline. Thus most of the data from the last ten years can only give estimates of population size and structure, fragmentation, extent of occurrence and area of occupancy. Consequently each species' assessment must be regarded as a provisional Red List evaluation, with the exception of species known to have a widespread global distribution and therefore ranked as least concern.

(b) Single Species – Hong Kong assessment

Because the IUCN criteria contain requirements for which many assumptions on population information have to be made, usually due to insufficient recording data, the methodology described in Fellowes *et al*. (2002), that considers the conservation status of a species based upon known distribution, was used for each species:

Global restrictedness. A measure of a species' dependence on the Region, South China, versus other regions of comparable size. South China is defined for these purposes as the area encompassing the provinces of Guangxi, Guangdong, Hainan, a land area of some 450,000 km^2. Global ranges are based on sources given under the species summaries. Global restrictedness is simplified as follows:

A = known to occur in this region alone;

B = known to occur in only two regions.

No species known to occur in more than two regions is considered globally restricted.

Regional restrictedness. A measure of dependence on the subregion, Hong Kong, versus other subregions of comparable size in South China (typically counties). Hong Kong Special Administrative Region has a land area of some 1,100 km^2. Regional restrictedness is simplified as follows:

A = known to occur in this subregion alone;

B = known to occur only in two subregions;

C = known to occur only in three or four subregions.

Local restrictedness. A measure of dependence on the particular locality, versus other localities of comparable size in Hong Kong. A locality is taken to measure 1 km^2. Local restrictedness is simplified as follows:

A = known to occur in this locality alone;

B = known to occur in two localities;

C = known to occur in three to four localities;

D = known to occur in five to eight localities;

E = known to occur in nine to 16 localities;

F = known to occur in 17 to 32 localities.

No species known to occur in more than 32 localities is considered locally restricted. However, for this study, category E was not assessed unless the species meet IUCN criteria and category F was not assessed at all, as this would include around 75% the species of moths found in Hong Kong, due to insufficient numbers of recorders to provide data for many sites. Each species was assessed using available distributional data: both published data for international distributions, and the observed presence/absence data from the HKMRD.

The data from both the IUCN and Fellowes *et al*. methods were then combined (tabulated, as per Fellowes *et al*.) to identify the moth species apparently most in need of conservation actions, following critera in Fellowes *et al*. that define species as concern locally (LC), regionally (RC) or globally (GC), or is potentially of global (PGC) or regional (PRC) concern, or is not of conservation concern. The data presented in this study updates that for the moths in Fellowes *et al*. as regional data has been made available since the publication of Fellowes et al., principally through checking the collection held at South China Agricultural University, Guangzhou. Only species that meet IUCN criteria are listed.

Habitat Assessment

Three methods were chosen to assess which habitats were most likely to be of high conservation interest for their moth assemblages. They were selected for their relatively simple approaches that allow fairly rapid assessment.

(a) Species Richness

This method provides a coarse assessment of where habitats with moth assemblages of high species richness occur in Hong Kong.

The most basic representation of biological diversity is generally recognised to be species richness – i.e. the number of species that occur within a specified area (Magurran, 1988). From the species incidence data (as opposed to abundance data) on HKMRD, queries were constructed to investigate number of species per 10km^2 grid square by collating all the records for each 10km^2 and then summing the number of species present. The total number of species for each

10km^2 grid square was then plotted over a map of Hong Kong (Universal Trans Mercator grid, WGS1984 datum) showing amount of recording effort per 2km^2 grid square.

(b) Species Diversity

This method provides an indication of where habitats with highly diverse moth assemblages occur in Hong Kong and operates at the same scale to species richness, above.

There are many different measures of diversity that are more complex than species richness. This is not the place to discuss this issue and one is referred to Magurran (1988) and Holloway & Stork (1991) for a better understanding of what diversity index should be used in any given situation (the latter with reference to invertebrates). Suffice to say that Fisher's alpha diversity index (Fisher *et al*., 1943) is used in this instance, as it is independent of sample size (Taylor, 1978). From the inputted species data, queries were constructed to investigate number of species per 10km^2. The abundance data, from light trapping data only, were collated from site records for each 10km^2 and the Fisher's alpha diversity index of each 10km^2 was calculated using PRIMER v5 (Clarke & Gorley, 2001). The calculated Fisher's alpha index for each 10km^2 grid square was then plotted over a map of Hong Kong.

(c) Similarity of moth assemblages in different habitats

This approach identifies how unique each habitat type is regarding the moth assemblages contained therein, and therefore allows prioritisation of habitats for conservation of moth assemblages.

Analysis of similarities (ANOSIM) (Clarke, 1993) is a randomisation test rather than a test for significance as the similarities are not independent of sample size. The test is used here to compare the intra- and inter-habitat moth assemblages, testing the hypothesis that there was no difference in community composition among habitats. An ANOSIM test of the light trap moth data was undertaken using PRIMER v5 (Clarke & Gorley, 2001), with the Bray-Curtis index used to measure similarity between samples and the number of randomised permutations per analysis set at 20,000. The ANOSIM test statistic is:

$$R = (r_b - r_w) / (n/(n-1)/4)$$

where r_b is the average of paired habitat rank similarities resulting from, r_w is the average of intra-habitat rank similarities and with n being the total number of samples. If random rearrangement of samples has no effect on R, then the inter-habitat communities do not differ significantly from the intra-habitat community variation. The value of R ranges from 1 to -1, equalling one only if all intra-habitat variation is less than inter-habitat variation from that habitat, equalling zero if the average similarity among intra- and inter- habitat variation for a habitat is the same, and less than zero if inter-habitat similarity exceeds intra-habitat similarity for that habitat.

Results

Single species - HK "Red List"

The single species assessments analyses resulted in 54 species representing 11 families being considered as of conservation concern. (see Table 9.1). This total represents about 3.5% of assessable species in Hong Kong. A further 26 species (not listed) whose identity have not been confirmed will probably also meet the criteria to be listed as being of conservation concern, but have insufficient data for assessment at the current time.

Table 9.1.
Moth species of conservation concern in Hong Kong
(see methods text for explanation of category codes)

Family	Species	pIUCN	Global	Regional	Local	Concern
Gelechiidae	"*Harpagidia*" *amplexa*	VU	A	B	C	GC
Sesiidae	*Gaea variegata*	EN	A	A	C	GC
	Toleria sinensis	EN	A	A	A	GC
Epipyropidae	*Fulgoraecia bowringii*	nt	A	A	D	PGC
Limacodidae	*Narosa ochracea*	nt	A	B	C	PRC
Tortricidae	*Phalonidia pista*	EN	A	A	C	GC
	Stenodes hapala	VU	B	A	A	RC
Thyrididae	*Herdonia hainanensis*	nt	A	B	E	RC
	Hypolamprus sp. nr. *emblicalis*	VU	A	A	D	RC
Pyralidae	*Coenodomus* sp. A.	VU	A	A	D	GC
	Palpita minuscula	nt	A	B	E	PRC
	Tyndis sp. A.	VU	A	A	B	PGC
Geometridae	*Acrodontis hunana*	nt	B	A	A	PRC
	Axinoptera anticostalis	nt	A	C	A	RC
	Calletaera digrammata	lc	A	B		PRC
	Chiasmia fulvida	nt	A	B	D	PRC
	Eupithecia sekkongensis	nt	A	B	A	RC
	Maxates brevicaudata	EN	A	A	B	GC
	Microcalicha reelsi	nt	B	C	A	LC
	Psilalcis galsworthyi	lc	A	B		PRC
	Pseudothalera carolinae	lc	B	B		PRC
	Sigilliclystis kendricki	lc	A	A		PGC
	Somatina obscuriciliata	lc	A	B		PRC
	Spiralisigna gloriae	EN	A	A	B	GC
	Thalassodes maipoensis	EN	A[#1]	A	B	GC
Notodontidae	*Besaia obliqua*	nt	B	A	A	PRC
	Cerura priapus	nt	B	A	E	PRC
	Micromelalopha albifrons	nt	B	B	E	LC
	Neodrymonia ignicoruscens	nt	A	B	D	RC
	Neodrymonia taipoensis	VU	A	A	C	GC
Noctuidae	*Acidon evae*	VU	B	A	E	RC
	Acidon paradoxa	EN	B	A	D	RC
	Atacira sp. A.	CR	A	A	B	GC

Table 9.1. (continued)

Family	Species	pIUCN	Global	Regional	Local	Concern
Noctuidae	*Athetis bispurca*	CR	A	A	A	GC
(continued)	*Athetis hongkongensis*	nt	A	A		PGC
	Belciana scorpio	VU	A	A	E	GC
	Bertula retracta	nt	B	A	E	PRC
	Britha bilineata	nt	B	A	B	PRC
	Cerynea discontenta	nt	A	A		PGC
	Chasmina sinuata	CR	A	A	B	GC
	Egira ambigua	CR	A	A	B	GC
	Eublemma marmorata	nt	B	A	A	PGC
	Feliniopsis margarita	EN	A#2	A	B	PGC
	Hepatica sp. A	VU	A#3	A	E	PGC
	Hyposada kadooriensis	nt	B	A	E	LC
	Luceria striata	nt	A	A		PGC
	Lysimelia lucida	nt	A	A		PGC
	Mixomelia rivulosa	lc	B	A	A	PRC
	Oglasa stygiana	nt	A	A	E	PGC
	Pangrapta bicornuta	nt	A	A		PGC
	Pangrapta roseinotata	nt	A	A		PGC
	Pseudeustrotia bipartita	nt	B	A	B	PRC
	Schrankia bilineata	EN	A	A	D	GC
	Ugia purpurea	lc	A	A		PGC
Nolidae	*Xenonola limbata*	nt	B	A	A	PGC

Notes:

#1 – there is an unverified report of this species from Thailand (J.Moore, pers. comm).

#2 – may also occur in central China, but taxonomic work is required to resolve this issue (Galsworthy, 1997).

#3 – A very similar undescribed species, or possibly this species, from Thailand is illustrated in Kononenko & Pinratana (2005).

Habitats

Species Richness & Diversity

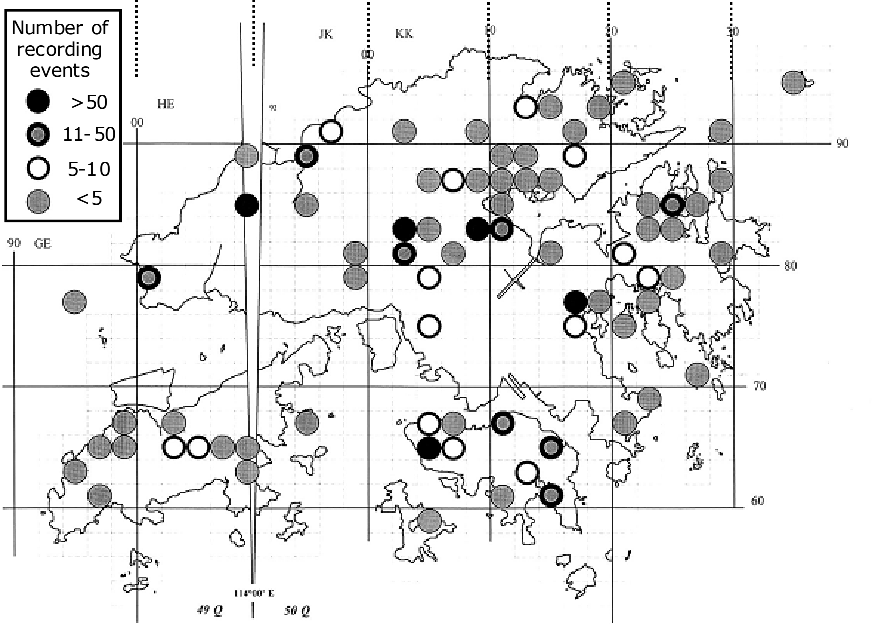
Most of the 10km^2 grid squares species richness and diversity figures (Table 9.2) are highest are highest in the central New Territories. However, the figures for richness do not rank in the same order as those for alpha diversity. Species richness figures appear to directly reflect recording effort. This is not apparently the case with alpha diversity, as (for example) can be seen when comparing grid squares JK98 & JK96, and thus it can not be said that species richness is directly proportional to species alpha diversity.

The grid squares with high species diversity coincide with the areas that contain the best secondary forests as identified by Ashworth *et al*. (1993).

Table 9.2 & Figure 9.1.

Species Richness (R) & Fisher's alpha diversity (α) per $10km^2$ grid square (UTM WGS 1984 datum, schematic) of moths in Hong Kong
(n/a = not assessable, no abundance data for that $10km^2$ grid square)
Number of recording events per $2km^2$ illustrated to provide context for species richness figures (not independent of sampling effort) and alpha diversity from Table 9.2
(note the UTM projection division along 114°E splits when expanded to a regular grid)

		49Q	50Q				
	GE	HE	JK	KK			
	9	0	9	0	1	2	3
9	R α		84 55	149 73	527 176	137 n/a	40 n/a
8		59 7.8	412 131	1554 283	749 275	660 253	
7	44 n/a	138 85	274 195	225 250	242 335	291 157	
6	91 n/a	379 188	114 460	371 201	446 164	322 109	
5		55 n/a	48 160	130 126	115 159		



Moth assemblages in different habitats

The analysis of similarities between habitats (Table 9.3) produced some pairs of habitats for which there is significantly more dissimilarity of moth assemblages between habitats than within habitat. These show that moth species composition in secondary forest is significantly different from that of all other habitats sampled, particularly grassland (the highest R value of all paired habitats), which also is significantly different from that of all other habitats sampled. Moth assemblages in mangrove also differ substantially from most other habitats, though not shrubland, nor agricultural land.

Table 9.3.
Analysis of similarities of moth assemblages between habitats, where R is the ANOSIM test statistic; figures in bold type represent habitat pairings that have significantly different moth assemblages (i.e. intra-habitat sample variation is less than inter-habitat pairing sample variation).

habitat	A	G	S	2° F	*FSW*	P	M
agriculture - A		**		**			
grassland - G	**0.172**		**	***	**	***	**
shrubland - S	0.005	**0.211**		**			
secondary forest - 2°F	**0.241**	**0.625**	**0.266**		*	*	**
feng shui wood - *FSW*	0.065	**0.296**	0.032	**0.212**		*	***
plantation - P	0.026	**0.284**	0.007	**0.187**	**0.118**		**
mangrove - M	0.083	**0.272**	0.076	**0.374**	**0.542**	**0.321**	

R values

* - $p < 0.05$, ** - $p < 0.01$, *** - $p < 0.001$.

Discussion

These methods of analysis provide a relatively simple and straightforward assessment of which species and habitats may benefit from the application of conservation measures. The methods are not foolproof, however, and only provide a starting point for more thorough and rigorous analyses. The amount of data available may not always be sufficient to provide a statistically valid analysis, or there may be gaps in the data – especially with regard to distributional data – that prevent an accurate analysis being carried out.

The logical next step from the single species analysis would be to assess which sites contain the most species of conservation concern and target these sites as a high conservation priority. However, this too is subject to overlook sites of conservation importance that may not have been surveyed, or sites insufficiently surveyed to pick out rare species that inherently will not be recorded at high frequency and usually require greater sampling effort to detect.

The broad brush approach to identifying the 10km^2 grid squares with either high species richness or high diversity, or both, so as to counter problems of varying recording effort per grid square, allows for rapid targeting of areas that are likely to be of conservation concern. More refined scales of surveying would then be able to pinpoint the best habitats for conserving. It is evident from the comparison of moth assemblages in the habitats analysed that examples of most different habitats will have to be conserved to maintain a full compliment of moth species in Hong Kong. Not all such habitats are covered by the protected areas system yet, and it remains to be seen if the conservation sector can compete with the powerful development sector for the remaining unprotected areas of the countryside that harbour high biodiversity.

It is evident that short surveys are insufficient to catalogue the actual species that utilise any one site, due to the differeing phenology strategies exhibited by different species and that habitats may not harbour species that which could exist therein at any one time (Hanski & Gilpin, 1991). More intensive surveying is the only method that accurately depicts assemblages of a site, though this is in practice usually considered too expensive an undertaking. Estimating the number of species (e.g. Colwell & Coddington, 1994) does only that, it does not tell one which species actually occur on the ground (so to speak), thus there can be no substitute for actually getting into each habitat type and recording as much biological information as possible. And recording what exists is just the start. If one really wants to know how to conserve a species and its habitat, then its complete ecology must be understood and that can only be done if the habitat exists. For now, without data the precautionary principle must be applied to conserve species through habitat conservation.

I have one final point to make. Recording butterflies is relatively easy, and has received probably the most attention for any group of invertebrates. Moth recording, however, is still very much in its infancy in Hong Kong and throughout South East Asia. Most work that has been achieved has been by very few people (measured in tens), rather than the hundreds, or possibly thousands of people who actively record or watch butterflies. Until such time as there are enough people recording moths to give a comprehensive idea of their distribution and ecology, the figures given in this presentation can only be regarded as very preliminary studies and, for all but the commonest species, any inference on their real status should be regarded with a large degree of ambiguity. Even so, that so many species should appear at this preliminary stage to be meritworthy of having IUCN Red List conservation concern status compared to only one Hong Kong butterfly (Fellowes *et al*., 2002), is perhaps indicative that the current conservation efforts in Hong Kong are perhaps not focusing on the most threatened of the Lepidoptera in Hong Kong.

Conclusions

There is a need to use several methods in conjunction to identify the most appropriate locations to conserve. Further basic distribution data is required to make accurate global and regional scale decisions. Conservationists may have to prioritise sites if resources are limited. The methods outlined for identifying species and habitats to conserve include neither site management (if needed), nor species autecology information that, together with habitat conservation, is paramount to conserving what remains of Lepidoptera biodiversity. Given the rate of habitat loss globally, it is imperative to take action to identify and conserve the best remaining unprotected sites before they are lost.

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10

TERRITORY-WIDE BUTTERFLY MONITORING PROGRAMME IN HONG KONG

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Abstract

Hong Kong supports 233 butterfly species of five families. The Agriculture, Fisheries and Conservation Department of the Hong Kong SAR Government initiated in 2002 a comprehensive and systematic program of surveying the butterfly assemblages in Hong Kong using the Pollard transect count method. The main objective is to establish a comprehensive ecological baseline to facilitate the implementation of nature conservation measures. A total of 400 surveys were conducted at 238 localities between 2002 and 2005, recording the abundance and distribution of 201 butterfly species. The number of butterfly species recorded per locality ranged from 3 to 101 (mean = 31, 90th percentile = 55). The survey transects were also divided into sections corresponding to 1-km grid squares based on the Hong Kong Metric Grid, and the dominant habitats along the transects within each grid square were recorded. A total of 554 1-km grid squares were surveyed and the butterfly species recorded per gird square ranged from 0 to 91. The survey findings revealed that most of the species recorded are represented in protected areas.

Keywords:
Butterflies, Protected areas, Transect count method, Species richness, Species diversity, Hong Kong

Introduction

Butterflies of Hong Kong

The Hong Kong Special Administrative Region lies on the south coast of China. Biogeographically, Hong Kong is within the Indo-Australian region and it shares its butterfly species assemblages with those of other areas like India and southern China within this region (Bascombe *et al*., 1999). In spite of Hong Kong's small size (1,103 km^2 land area), the checklist of butterflies in Hong Kong has 233 species in 5 different families, including 5 suspected species (Table 10.1). There have also been records of five vagrant species in the territory.

Table 10.1.
Number of species of the five butterfly families in Hong Kong.

Superfamily	Family	No. of Species
Hesperioidea	Hesperiidae	57
Papilionoidea	Papilionidae	21
	Pieridae	22
	Lycaenidae	52
	Nymphalidae	81
	Total	233

Butterflies can be used as indicators of habitat quality because they are (a) widespread, conspicuous, day-flying; (b) reasonably diverse for complete assessment and taxonomic identification; and (c) relatively sensitive to environmental changes because of their precise ecological requirements and short life cycles (New, 1997; Kocher and Williams, 2000; Hardy & Dennis, 2005).

Territory-wide survey programme

With a view to establishing a more comprehensive territory-wide ecological database for Hong Kong, the Agriculture, Fisheries and Conservation Department (AFCD) initiated a survey programme on butterflies in 2002. The main objectives of the programme were to undertake a systematic survey of butterflies in Hong Kong and to advance understanding of the needs for butterfly conservation here. The survey programme is geographically comprehensive by covering the major sections of the Hong Kong land area, but excluding areas expected to be of negligible interest to butterflies, such as the highly urbanized and/or disturbed areas and barren sites.

Materials and methods

Transect count method

Transect count method is a relative method which shows numerical trends between years or differences between localities (New, 1997). The Pollard transect count method, which has been used in similar programme elsewhere, was adopted in our butterfly survey programme (Pollard, 1977; Pollard & Yates, 1993).

The transect count method must meet certain prescribed recording conditions for standardization by countering influences of weather and the differing activity profiles of butterflies (Pollard, 1977, 1982). The method adopted in Hong Kong was modified to suit the survey design and the subtropical climate of Hong Kong. At each locality a fixed transect, typically of between 1 to 4 km in length, was walked. Butterflies observed either in flight or settled on vegetation within 5m on either side of the observers were recorded. There was no restriction on the distance in front of the observers or the height at which the butterflies were seen. Information recorded included species, abundance, sex (if possible) and the habitat types where each species was seen. The butterfly surveys were undertaken between March and November, which cover the flight period of most local species. Transects were walked between 09:30 and 16:30 on rainless days, when the temperature was generally high enough for butterflies to become active. Other variables recorded include time, weather, cloud cover, as well as the presence of butterfly eggs, larvae or pupae, and special behaviours such as mating and feeding. Photographs of the transect routes were also taken for future reference.

No minimum requirement for temperature or sunshine was set for the surveys, as the ambient temperature in Hong Kong during the prescribed period (March to November) is higher than the temperature threshold necessary for flight even in shade. Where individual butterflies flew in and out of the sight in front of the observers along transects, only one entry was made unless there was no doubt that this was another individual. Because of the high butterfly diversity in Hong Kong, there were occasional cases when particular species were not distinguishable in the field, and these were recorded as the commoner of the likely candidates.

Grid square analysis

To better represent the protection status and habitat types of the areas covered by transects, they were divided into sections corresponding to the 1-km grid squares in which they occurred, and the dominant habitats along the transects within each grid square were recorded. The land area of Hong Kong, including all reservoirs and islands, is covered by 1,220 1-km grid squares based on the Hong Kong Metric Grid.

Representation of butterflies in protected areas

About 38% of the 1,103 km^2 land area of Hong Kong is protected areas corresponding to the IUCN Protected Area Management Categories IV and V (Chape *et al*. 2003). These areas include Country Parks, Special Areas, Restricted Areas and Sites of Special Scientific Interest (SSSI) (AFCD, 2005).

The representation of butterfly species in protected areas was derived by spatial overlay of the species and protected area data layers in ArcView 8.1 (ESRI, 2001). Grid squares are classified as 'protected' if over 90% of the land area was within protected areas; 'unprotected' if over 90% of the land area was not; the rest were considered 'partly protected'. Occasional butterfly sightings recorded by AFCD staff were also included in the overlay.

Results

The butterfly survey programme carried out 400 transect visits to 238 localities between March 2002 and November 2005, during which a total of 46 373 butterfly counts of 202 butterfly species including one vagrant species were recorded, with four new species records to Hong Kong (Wong *et al*., 2002, 2003; Lo, 2002; Lo & Hui, 2004). Many of the 238 localities surveyed were of medium to low butterfly diversity, but some localities had exceptionally high butterfly diversity. The numbers of butterfly species recorded per locality ranged from 3 to 101 (mean = 31, 90th percentile = 55).

Grid square analysis

A total of 554 1-km grid squares were surveyed, of which 183 grid squares are 'protected', 226 'partly protected' and 145 'unprotected' (Figure 10.1). The butterfly species richness recorded per gird squares ranged from 0 to 91 (Figure 10.2). Among the 59 grid squares that ranked the highest 10% in terms of species richness, 11 are in 'protected' grid squares and 33 'partly protected'.

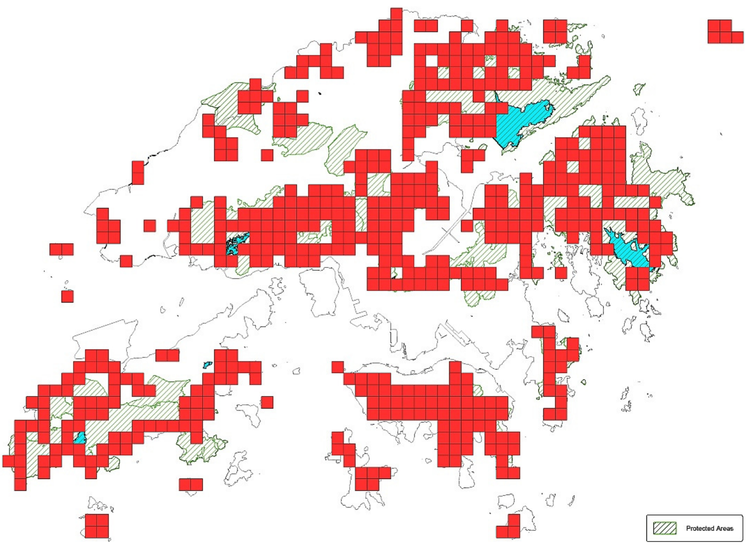
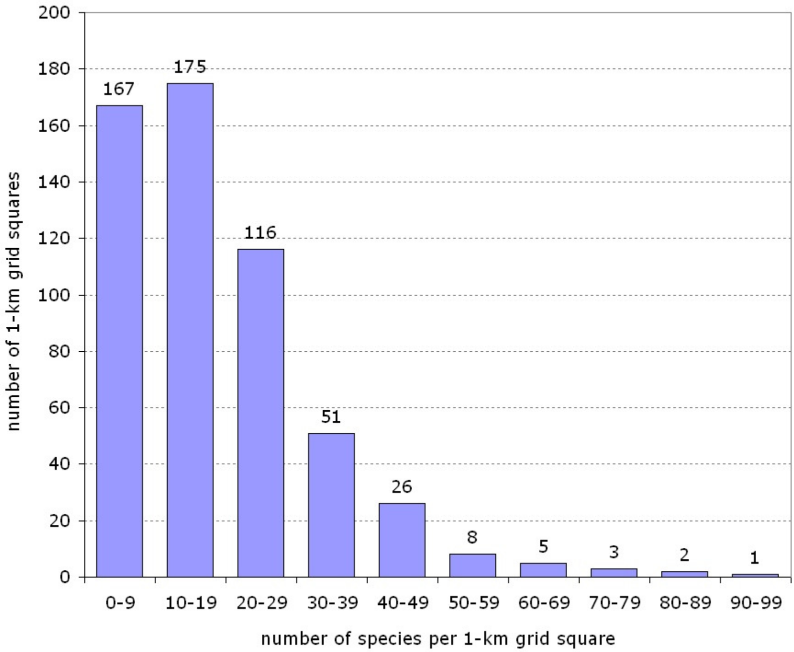


Figure 10.1.
Distribution of 1-km grid squares covered by Butterfly Survey Programme, Hong Kong, 2002-2005.

Figure 10.2.
Number of butterfly species recorded per grid square.



Representation of butterflies in protected areas

A total of 155 butterfly species were recorded in 'protected' grid squares, and all but one of the 202 butterfly species observed, including the four new local records, have records on grid squares which are either 'protected' or 'partly protected'. On the other hand, there were records of 149 butterfly species in the 'unprotected' grid squares. There were 31 butterfly species found only in the 'protected' grid squares.

Discussion and Conclusions

Limitations of data

Although the Pollard transect count method has proved practicable in Hong Kong, some limitations of the method were observed. Compared to the 69 butterfly species in the UK (Fox, 2001), where the method was developed, the higher species richness (233) in Hong Kong sometimes make species identification a challenge, particularly during a field survey. Butterfly species are neither equally detectable nor evenly distributed in a habitat. The distinctive behavioural and physical characteristics of different butterfly species may have resulted in taxonomic bias by over-estimating the more conspicuous, active or abundant species in relation to the cryptic, inactive or rare species. The survey found that the Pieridae and Lycaenidae were the least represented butterfly families (Table 10.2), as in other similar studies (Hardy & Dennis, 2005). Butterfly species of these families are usually less apparent to observers because many of them, being canopy species with swift flight, easily escaped observation.

Table 10.2.
Percentage of butterfly species in the family recorded in AFCD Butterfly Survey Programme, 2002-2005

Superfamily	Family	Species Recorded	
		Number	% of H.K. spp.
Hesperioidea	Hesperiidae	53	93.0
Papilionoidea	Papilionidae	20	95.2
	Pieridae	17	77.3
	Lycaenidae	41	78.9
	Nymphalidae	71	87.7
	Total	202	86.7

Settled butterflies are known to vary their posture to increase or decrease their exposure to the sun (Pollard and Yates, 1993), and such behaviour suggests that there may be an optimal temperature for butterfly activity (Pollard and Yates, 1993). The Pollard transect count method used in temperate countries like the UK only set the minimum temperature for recording. However, in hotter parts of the world like Hong Kong, butterflies may seek shade in dense vegetation in hot weather, and hence become less apparent to observers, as observed during the surveys. The experience of the observers and results of the survey indicate that fewer species and individuals were recorded on sunny days when temperature reached 34°C. The need to set an upper temperature limit for the survey requires further study.

Roles of protected areas to butterfly conservation

Habitat loss or degradation has been the major threat to the survival of wildlife, including butterflies, worldwide. It has been demonstrated (Thomas, 1984) in Europe and the USA that protected areas are important in preserving butterfly diversity, where populations of some species have contracted largely or entirely to protected areas (Thomas, 1984). The high representation of butterflies in Hong Kong's protected areas has also demonstrated their importance in in-situ conservation. Moreover, the four new species records for Hong Kong found in the protected area system suggest that these areas have much more biodiversity to be explored.

Many butterfly species are specific in their habitat requirements, and hence, are good indicator of habitat diversity of a locality (Kocher & Williams, 2000). Localities with greater diversity of habitats should generally support a greater number of butterfly species (Kocher & Williams, 2000; Hardy & Dennis, 2005). While the protected areas in Hong Kong support most local species, tailored management and maintenance of these habitats are equally important to maintain and enhance the habitat quality for butterflies, and it does not pre-empt the need for identification of additional areas for protection.

Some local butterfly species tend to form closed colonies that make them suited to locality protection (e.g. *Lamproptera curius* and *Tajuria maculata*). These species are more or less confined to sites that provide the special resources that they require. While some of these species are well represented in protected areas, conservation measures may be required if a species, particularly one of conservation concern, is recorded only outside the protected area system. However, inclusion of these localities in the protected area system is not always possible in Hong Kong due to various factors including land ownership and site management issues, and ex-situ conservation of these species by introduction into protected areas may be an alternative. The introduction of butterflies to a habitat may be more successful than for other taxa, since the presence of a butterfly species at a particular locality largely depends on the abundance and quality of suitable larval foodplants and nectar plants. There are plans, some of which are being implemented (e.g. Wong *et al*., 2005), to manage various sites in local protected areas with a view to enhancing the habitat quality as well as the public awareness of butterfly conservation.

The butterfly survey programme will continue to update and collect more information on the distribution and status of butterflies in Hong Kong, particularly for species that have so far not been recorded in the surveys. We are of the view that the establishment of such a butterfly database for Hong Kong would indeed facilitate the formulation of a more effective conservation action plan for local butterflies.

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A STUDY ON THE MIGRATION AND OVERWINTERING OF DANAID BUTTERFLIES (SUBFAMILY DANAINAE) IN HONG KONG

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Abstract

A series of capture-mark-recapture experiments was undertaken from November 2002 to January 2003 to trace the migration route of the overwintering Danaids (Subfamily Danainae) in Hong Kong and investigate the population dynamics of an important local overwintering Danaid population in a plantation under government management in Siu Lang Shui. A secondary woodland in a protected area (i.e. the Shing Mun Country Park) was confirmed as a transitional stop for the migratory butterflies. Six species of Danaid butterflies were recorded in the overwintering population in which 95% was *Euploea core* and *E. midamus*. Most butterflies arrived at the overwintering site within a week's time in mid November 2002 and stayed for about 6 weeks. The peak number of individuals recorded was about 45,000. This study forms a basis for the future study and conservation of the overwintering Danaids in Hong Kong.

Citation:

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12

LEPIDOPTERA IN CONTEXT: A HONG KONG CASE STUDY IN HABITAT CONSERVATION

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Abstract

A case study investigating a site of conservation interest is presented. Aspects of developing a process of site selection for conservation is identified, based upon the need in Hong Kong for a properly developed and transparent working system to evaluate and designate Sites of Special Scientific Interest [SSSIs], as per Article 8c of the Convention on Biological Diversity. The process included assessing: local importance of Habitat Type (Environmental Protection Department, 2002; note to Table 1), criteria evaluation (Ratcliffe, 1977; Environmental Protections Department, 2002; Table 2); and the comparative importance of the site in a local context. The study adopts a holistic approach to habitat conservation, evaluating not just the substantial Lepidoptera component, but many other faunal groups, flora, past management, cultural heritage and ecological processes such as metapopulation dynamics. It was found that the site had exceptionally high biological diversity for its size in those areas studied, especially Lepidoptera. Upon application of the SSSI process to the site, it was found that many criteria, not just a single criterion, were met. This evaluation provides a clear basis and context for future scientific study of not just this site, but for the restoration of South China coastal forest sites in general. The study is also a worked example of evaluation to assist future conservationists in line with internationally accepted principles.

Introduction

This paper introduces a strategy for species and habitat conservation in Hong Kong using the existing statutory framework (Town Planning Ordinance, Cap. 131), land use designations, facilitating ecological process survival that was developed to protect a forest headland site (Tai Po Kau Headland – TPKH) that contains a wealth of biodiversity, as well as archeological and cultural heritage (Kendrick & Baretto, 2006), taking almost a decade to come to fruition. The concept of SSSI, the scientific, international, and legally correct approach as adopted by Barretto & Kendrick (2006) is applicable to conserve a site of special scientific interest, and can be used and developed for Hong Kong as a transparent system for evaluating and designating SSSIs within a statutory Town Planning Ordinance zoning process. Additionally, the process shows how specific and holistic approaches to habitat conservation lead to more complete study, enable improved conservation and give rise to more ideas for scientific research. On an administrative and good governance basis, better decision making should lead to improved enforcement and protection. Lepidoptera provide an important component of the biodiversity studied to date, and underpin the work for the site's designation as of conservation and scientific interest.

There has been a fair amount of work undertaken in the past within Hong Kong to assess sites for scientific value. However, this assessment work appears in the main to have been based upon simplistic, local, unpublished criteria that omit over half of the Ratcliffe criteria, and in particular do not consider combinations of criteria. Decisions to list sites appear to have been confined to one particular taxon, rather than for combinations of taxa. This lack of an holistic approach has, in the opinion of the authors, led to some high quality sites being omitted from the current network of protected sites.

Methods

SSSI definition & intent

For Hong Kong, several different definitions of SSSI exist (Planning, Environment & Lands Branch, 1993; Town Planning Board, 2005, 2006), but all refer to sites that are special by reason of their flora, fauna, geographical or physiographical features, especially in a land zoning context. The main purpose or intention of SSSI zoning in biodiversity conservation is habitat conservation. Designation is not to be limited in all cases to just one special feature in a site – features such as rare or particular species of flora and fauna and their habitats, or areas of geological or biological (ecological or botanical) interest (Town Planing Board, 2006) can all be included and should all be assesed.

Scientific Approach

A scientific approach is more correct and objective. In some cases a single species merits SSSI for a site. However, a site is more likely to be scientifically special for a number of features or components of biodiversity that constitute its specialness.

Site Evaluation - Habitat Type

Evaluation process begins with identification of Important Habitat Types. For Hong Kong, these are defined in the note to Table 1 of Environmental Protection Department (2002), there being nine habitat types.

Site Evaluation - criteria

The valuation process expands upon Ratcliffe (1977), its successor (NCC, 1989) and Environmental Protection Department (2002; Table 2) by amalgamating the criteria and sorting them into groups that reflect the degree of scientific objectivity on one hand, and informed judgement on the other. The criteria titles are set out in Table 12.1, below:

Table 12.1
Amalgamated SSSI criteria derived from Ratcliffe (1977) & EPD (2002), listing the original Ratcliffe criteria and the criteria that were (re)defined by EPD.

group	Criteria (following Ratcliffe)	EPD equivalent criteria
scientific		
1.	Size	
2.	Diversity	Wildlife abundance/richness, i.e. α diversity; Species Assemblages, i.e. β diversity; Regional Comparison, i.e. γ diversity
3.	Rarity	Uniqueness; Endemicity
4.	Recorded History	Age; Recreatability (in part)
blend of scientific and judgemental		
5.	Fragility	Recreatability (in part) and Nursery/Breeding-ground
6.	Typicalness	
7.	Naturalness	
8.	Position in Ecological Unit	Fragmentation; Ecological linkage
judgemental		
9.	Intrinsic Appeal	Natural Landscape Beauty
10.	Potential Value	

At TPKH, there were a number of assessments for different taxa that give a baseline for further work on the site. These taxa were assessed with reference to the most authoritative works available for each taxa (Wilson, 1997; Ades, 1999; Bascombe *et al*., 1999; Lau & Dudgeon, 1999; Corlett *et al*., 2000; Carey *et al*., 2001; Ades *et al*., 2002; Kendrick, 2002) as well as other assessments by international specialists, and compiled to put each group into an overall framework (Fellowes *et al*., 2002; Kendrick & Barretto, 2006) in comparison with other sites.

Comparative Assessment

Comparative assessment of Special Scientific Interest is based on ascertaining the important feature(s) of the Site, such as whether it comes within one (or more) of the following, "Good Representative example/Typicalness" or "Rare Habitat Type" or "Good species focus or species or group of species", "Best example", "Uniqueness" or "Special scientific interest" based on other factors.

A comparative assessment may not be needed if the evaluation already meets the criteria as set out above.

Summary for TPK Headland Assessment

The TPKH fulfills and illustrates authoritative SSSI processes. It demonstrates that the TPHK:

(a) is a rare Important Habitat Type

(b) meets all the Ratcliffe SSSI Criteria

(c) on a comparative basis, is the most biologically diverse mature coastal forest known in Hong Kong

(d) is a good (i.e. typical) example of its kind, as well as probably the best representative example of its type

(e) has rarity in its species, from its individual rare species and also from its species composition and groups such as insects, birds and snakes. The moth fauna alone contains 23 species that meet IUCN res list criteria for endangered species.

(f) is scientifically special with species and groups requiring further research such as Lepidoptera and Lampyridae

(g) coastal location complements the important, but higher altitude and inland, Tai Po Kau Special Area and has rare species of insects, birds and snakes not found inside TPKSA

(h) has a unique history of protection, regeneration and observations which make further scientific study both attractive and essential;

(i) management and protection is practical at little cost to the public but with great public interest to be gained.

Discussion

Ecological Processes

Facilitation of ecological process survival through effective zoning is critical for any site that is to be conserved. If natural processes, especially metapopulation dynamics (Hanski & Gilpin, 1997; Hanski, 1999) can not take place, then sites will become genetically isolated, their biota will become less resistant to disease and eventually the species contained therein will become extinct. For TPKH, its geographic location with links between the sea and the existing Tai Po Kau Special Area provide an ideal opportunity to implement the study of metapopulation dynamics in Hong Kong, which has the potential for unlocking our understanding of the whole issue of connectivity of wildlife sites in Hong Kong (Urbis, 1979; Kendrick & Barretto, 2006). To understand these processes, having an inventory of the species present at a site is the first step. Subsequent analyses of what these species do, how they interact then gives a clearer picture of the interrelatedness of the species and how they use a site, thus giving a better picture of the intrinsic worth of a site.

Holistic Approach

Few sites have a unique history & features. It should be noted, though, that sites that have a recorded history are of greater scientific interest as the temporal changes that have taken place can be put into context and explained by the recorded events. Scientific research at such a special site is attractive and necessary and facilitated by history, records, and high quality and rarity. At TPKH, there is a long history of records of survival and regeneration, compiled from authoritative observations (see references in Kendrick & Barretto, 2006). The combination of these components in an holistic manner gives a much clearer picture as to the special nature of TPKH, and should be given more weight than any one component (e.g. Planning Dept., 1994; Environmental Protection Dept., 1997; Environment, Transport & Works Bureau and Agriculture, Fisheries & Conservation Dept., 2003).

Precautionary principle and evidence based conservation

Development and destruction of areas, like conservation, is done on the basis of assessment based on evidence, not on the basis of assumption and speculation. One cannot be complacent to deny protection to one proven biodiverse area in the hope that one future day perhaps a better place may be found, studied, and conserved.

Conclusions

Using both (a) specific and (b) holistic approaches reveals new areas for scientific study to reduce high levels of extinction and should encourage greater action for conservation by government and the public. The TPKH Study also explains a process and framework to facilitate authorities decision making for conservation, whereby findings from experts and amateurs lead to opinions from experts that form robust criteria against which findings can be judged in order for decisions to be made on a site's degree of specialness. Protection then can be implemented through designation and then the second phase of protection, the enforcement and management of a site's designation can begin.

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ROLES OF BUTTERFLY FARMS AND BREEDING FOR CONSERVATION OF LEPIDOPTERA

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Abstract

Butterfly conservation is dedicated to the saving of wild butterflies and their habitat. In order to contribute in this area, firstly we need to identify the current threats. Then, a case study of The Penang Butterfly Farm (PBF) will be used to exemplify the role it plays as a Live Butterfly Exhibitor and its Breeding Program in butterfly conservation. Butterfly related industry is relatively a very young industry compared to other very established ones such as zoos, aquaria and bird aviaries. The first live butterfly exhibit was set up in 1976 by Mr. David Lowe at Guernsey, Channel Islands, and presumably the 1st butterfly house in the Tropical Region, PBF, was opened to the public in 1986. Since Asian countries are still very new to this industry, thus looking to the west would be a good short-cut to facilitate the positive development for the good of education, promotion of nature awareness and environmental sustainability and hopefully in the long run, will help in the conservation of butterflies in our region.

Introduction

Before I go into the subject proper of this paper, I would like to touch on the recent history of Butterfly Houses in order to provide some background for the better understanding of this subject.

Live butterfly exhibition is relatively a very young industry compared to other very established ones such as zoos and bird aviaries. Though the first heated glass-house of live butterfly exhibit was set up in 1976 by Mr. David Lowe at Guernsey, Channel Island, it was not popularized until another tropical glass house of live butterfly called The London Butterfly House was opened for public in early 1980 by Mr. Clive Farrell who subsequently has set up a few other houses and also has extended his influence on several people, including me. In 1986 March, The Penang Butterfly Farm, presumably the 1st butterfly house in the Tropical Region, was opened to the public. At one time around late 1980's, there were more than 50 butterfly houses in the U.K. and many others in Continental Europe. In 1988, The Butterfly World in Coconut Creek, Florida was opened, followed by Day Butterfly

Centre at Callaway Gardens in Georgia, the same year. Since then, the industry bloomed and many big and moderate butterfly houses sprang up all over U.S.A. as well as in Canada.

Behind this boom lies a very strong phenomenon. That is a new-found tool for nature education, which effectively leads to motivation of awareness of particularly the very fragile aspect of nature. Suddenly the general public, both the old and the young, have realized the complexity and the mystery of our great Mother Nature through the magical metamorphosis and the life history of butterflies.

Threats to Butterflies in the Wild

Butterfly conservation is dedicated to the saving of wild butterflies and their habitats. In order to contribute in this area, firstly we need to identify the current threats.

1. Habitat Destruction – This is the most serious threat. But it is a highly controversial subject in the broad sense and I don't intend to go into details of it and neither can the world community do a lot to help except perhaps
   a) To help to slow down the process of destruction.
   b) To help and influence the individual governments to create more forest reserves and national parks.
2. General lack of awareness and love for nature - particularly the appreciation of resources that nature embraces and this leads to the misuse of chemicals, degradation of environments and non-coexistence with nature.
3. The spread of invasive plants, pests, predators and diseases brought about by disturbed ecological balance.
4. Not enough serious recovery plans by individual governments to save-guard the disappearance of butterflies in the wild.

Therefore, how do butterfly farms help to save these lovely, brilliant creatures? Before we go into this, let us first understand the 3 different categories of butterfly farms or butterfly houses.

1. Butterfly Glass-Houses (in Temperate Region) – Public display of live butterflies with very little or no breeding facilities.
2. Tropical and Sub-Tropical Butterfly Houses – Public display of live butterflies with elaborate breeding facilities for both self-need and outside market demand.
3. Butterfly Breeding Farms and Ranching – Facilities that focus mainly on the supply of pupae for butterfly houses and other market needs and do not have public exhibition. In the case of Butterfly Ranching, it usually occurs in villages near the forests such as in Papua New Guinea where natives grow butterfly host plants in the open to attract wild butterflies to come and lay eggs. Income derived from selling these pupae or adult

specimens will eventually stop the natives from cutting down trees or clearing forest to earn their living.

All these 3 categories of facilities have in their own ways opened up to the world of wonder and mystery of butterflies. The popularity of these public facilities has led to a new horizon of fundamental research of butterfly life history which in the past was not widely carried out by Lepidopterists except collecting and identifying them for taxonomic work and mapping their distribution worldwide as evidenced in many published literature during the 19th and 20th Centuries

Roles of Butterfly Houses

This life-history research has apparently lifted the century-old hobby to another level and it has also attracted a new breed of hobbyists and enthusiasts. Because of the great demand for pupae generated by the recent mushrooming of public butterfly houses during the last 2 decades, butterfly breeding has become widespread and it can be witnessed that a series of new phenomena has emerged in this young industry.

1. Economic viability - public live exhibits have been set up by institutions, non-profit organizations as well as private sectors, creating a chain-reaction of economic activities that provide new income for different level of people involved in this new industry. And this is the most vital role that triggers the various effects that help to save butterflies.
2. Education - This is the major concern and also the direction of most investors in this industry as well as those who care about nature in general and butterflies in particular. Perhaps it is easier if I pick one example of a butterfly house and elaborate on the role it plays directly and indirectly in butterfly conservation.

Penang Butterfly Farm

Penang Butterfly Farm (PBF) was established in 1986 in Penang, Malaysia with 2 main objectives:

1. to function as a tourist destination to build up its financial base.
2. to serve as a centre for education, recreation and scientific research.

Initially PBF operated as a tourist attraction, supported by its increasingly elaborate breeding facilities, which have six breeding stations that spread out on a total land size of more than 10 acres, between one to more than 100 km apart. Its well-landscaped public enclosure is filled with 3,000 to 4,000 live butterflies representing some 100 native species as well as some 300 varieties of tropical plants.

In order to make PBF very attractive to get wider patronage, many side-attractions have been created. These include: a big fish pond (about 1/3 of the flight area) with 70 over very big fresh water fishes made up of more than 20 species; other individual displays of invertebrates, reptiles, snakes, ducks, turtles and tortoises, free-flying seed-feeding birds inside the main flight area; adjacent to the flight area are a Hide and Seek garden with camouflaged insects, a little zoo of many more big live invertebrates housed in individual cases; an Insect Museum and a Gift-shop.

More recently, PBF has expanded its operation to encompass an Education and Resource centre. Several key components have made this aspect of PBF's work a success:

a) Comprehensive signage placing messages and information throughout the public facility to educate both the adults and the young visitors.
b) Science Projects such as "Be a Butterfly Breeder" and other outdoor educational programmes for children, taking full advantage of PBF's location next to the Forest Reserve.
c) Adult Programmes – familiarise grown-ups with insects and dispel their misconceptions and fears in order to help to widen the scope of nature education. PBF has also provided training for 300 teachers in 3 different sessions.
d) Insect Museum with relevant content of high educational value rather than just being academic or scientific as well as the vial-collection in alcohol of all the different early stages of the butterfly species that we breed.
e) New Audio Visual Theme Room with high resolution big screen video shows.
f) New Auditorium and Education Project Rooms for organised school groups with specific programmes according to different age-groups and school curriculum

In order to facilitate the educational and commercial aspects of PBF, much research has been carried out. This work has the following key elements that underpin all the other work undertaken:

a) Several years prior to the opening of the Farm to the public, a lot of field work had been done to research into the host plants of species that had no record or had never been bred before. At the same time habitat study was also carried out to understand the macro-climatic conditions required for both the butterflies and their host plants.
b) Being ideally located next to the Forest Reserve, P.B.F. has been able to take advantage of the nearby natural habitat and frequently release back a significant percentage of the captive-bred stock to the wild for several reasons.

i) To continuously sustain or increase the wild population which will back up the genetic problem that sometimes sets in in captive breeding.
ii) Some species do not mate in captive environment after having emerged from pupae for reasons that are still unknown. The only way is to release them back to the wild and recapture some of them for egg-laying purposes.

c) Restoration of butterfly habitats – Viable but disturbed habitats are repeatedly restored by planting or introducing more host plants to increase the wild population of butterflies. This is good for the breeders as they need occasional replenishment from the wild population to overcome:
   i) Genetic problems
   ii) Seasonal changes of species
d) As a centre for documentary work carried out by many T.V. stations and film-makers from all round the world. In the past, P.B.F. has received countless projects of such nature and this has helped to contribute towards its research fund.
e) A centre for academic and post-graduate work used by local and foreign universities for their post-graduate students in the past, such as Dr. Jason Weintraub from Cornell University who spent more than a year at PBF.
f) Hosting of butterfly conferences and giving talks to schools and other institutions have been past contributions of P.B.F.

The last major component of PBF is professional consultancy – PBF has, for example, acted as a consultancy firm for a Malaysian public listed housing development company (SP Setia) to enhance their housing project with a recreated butterfly habitat. I will elaborate on this later.

International Association of Butterfly Exhibitors (IABE)

When live butterfly exhibition has become a widespread and popular activity in the west, their governments begin to set up new rules to regulate such activity. But people involved in the industry begin to feel that their activity is being gradually over-regulated and in 2002 they officially formed an international body to unite all the people involved into one voice and use this to represent the industry to have dialogue with governments. This association has members from U.S.A., Canada Central and South America, Europe, Africa and Asia. They initiate conferences such as ICBES (International Conference of Butterfly Exhibitors and Suppliers) and ECBES (European Conference of Butterfly Exhibitors and Suppliers). This kind of conference has been in existence since 1997 when the 1st conference was hosted in Costa Rica.

This industry is now so well regulated especially in U.S.A. that it enjoys very smooth procedure in the regular import of live invertebrates and butterfly pupae into U.S.A and Canada whereby import permits are issued to those qualified individual establishments on a yearly or 3 yearly basis.

Influence on Local Communities

Through the joint effort of local councils, private sectors and butterfly house operators, many communal activities can be created. For an example the exterior walls of many local residents' homes in Bordano, a small town in North Italy near Venice have been colourfully painted with beautiful art work of butterfly murals. Such trend has now spread to Sayn, a small town near Koblenz in Germany. Other than beautifying the towns, the trend also helps to spread the message of love for butterflies.

Figure 13.1. Butterfly wall mural in Sayn, Koblenz, Germany

In the East, like Malaysia, as mentioned earlier, a leading private housing development company has pioneered in a new concept by incorporating a recreated butterfly habitat into their new residential housing project known as Setia Eco Park and invested also in a butterfly conservatory to enhance the educational value for the residents' young generation.

Penang Butterfly Farm, as their consultant, has followed their development progress since 2004 and has apparently succeeded up to this stage whereby the host plants for more than 20 selected species of local butterflies identified at the nearby Forest Reserve have thrived very well and the on going propagation work has been on schedule. Butterflies have started to appear and we are hopeful that we will achieve our objective of a sustainable environment with significant colonies of butterflies flying around this Eco Park in foreseeable future. But eventually the maturing process of the ecological balance will determine the end result, particularly in relation to predation and diseases of these re-introduced butterflies.

Conclusions

Since education in Nature Conservation through "Butterflies" has been widely promoted in the west and so far not much has been publicized in the Asian Region, the same should be given some importance especially when the economic and industrial development is currently the hottest in the world and this is inevitably creating much greater pressure on the imbalance between progress and nature conservation. In view of this, zoos and nature-related institutions should be more aware of this new trend and look to the west especially in terms of the introduction and implementation of some new regulations to simplify the legal movement and import-export procedure of live materials.

In this way, new concepts of butterfly houses and insect zoos will be popularised for the good of education, promotion of nature awareness and environmental sustainability and hopefully in the long run will help in the conservation of butterflies in the Asian Region.

Citation:

Goh, D. 2007. Roles of butterfly farms and breeding for conservation of Lepidoptera. In Kendrick, R.C. (ed.) *Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006*. pp. 101-107. Kadoorie Farm & Botanic Garden, Hong Kong.

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BUTTERFLY GARDENING AND BUTTERFLY WATCHING AS CONSERVATION STRATEGIES FOR HABITAT PROTECTION

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Abstract

A brief summary of the habitats found in the Philippines is given. The change in forest cover in the last century is very significant, with some 90% forest lost. Losses have been caused by commercial logging, slash & burn, urbanisation, commercial agriculture and poor governance. Butterfly losses are reviewed; causes of loss are habitat (i.e. forest) loss, indiscriminate use of pesticides, habitat fragmentation and unsustainable collecting for trade. The roles of butterflies in the Philippines are assessed, and found to be much the same as elsewhere, i.e. ecological (pollination, as food for predators, herbivory and occasional predation); environmental (monitors of habitat health) and intrinsic appeal in human culture. Human uses are explored – sustainable trade uses include butterfly houses, releases, specimens (from farmed sources) and ranching. Key conservation measures that need to be implemented relate to habitat conservation and increasing awareness, some methods to achieve these measures include ecotourism, political lobbying and religious lobbying.

Citation:

Robledo, L. 2007. Butterfly gardening and butterfly watching as conservation strategies for habitat protection [abstract]. In Kendrick, R.C. (ed.) *Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006*. p. 109. Kadoorie Farm & Botanic Garden, Hong Kong.

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15

COLLABORATION AMONG GOVERNMENT, GREEN GROUPS AND VILLAGERS: A KEY COMPONENT CONTRIBUTING TO THE REAL SUCCESS OF FUNG YUEN BUTTERFLY CONSERVATION PROJECT

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Abstract

Granted with ~HK$1.7 million to conduct "A pilot scheme of management agreement on the private land with high conservation value at Fung Yuen Valley Site of Special Scientific Interest in Tai Po", collaboration and communication reflected the significance in gaining widespread support from the authorities, green groups and local villagers. Through habitat conservation, species conservation and education, the Project is achieved.

To pave a good start in habitat conservation, early discussion with local villagers, understanding their willingness and getting them realize their importance in this Project do not only save our Association against future local objections but also advanced us to gain authority supports and appreciation. Agreed with them, 173,900ft^2 are under the Agreement. Without KFBG's generous donation on their quality tree seedlings, tree plantation could hardly be achieved.

Butterfly survey by Hong Kong Lepidopterists' Society, bird survey by Hong Kong Bird Watching Society and tree survey by the Chinese University of Hong Kong contributed a solid scientific foundation to prove our achievement in species conservation.

To actualize sustainable conservation, species and habitat conservation workshops, targeting students and general public, are launched. With their support, threatening larva and pupas are always given to our nursery for immediate care until they are emerged.

EDITORS NOTE

What follows is an abridged notes version of the powerpoint presentation given, as prepared by the author with assistance from the editor, rather than a formally written paper.

A Brief History of Fung Yuen

Geographical attraction:

Fung Yuen is a sheltered, southfacing valley with moderate (by Hong Kong standards) weather. It contains a mixture of habitats, with streams, secondary forest, fung shui woods and diverse agricultural land including market gardening and orchards.

High Butterfly Species Diversity:

Between 2003 and 2006, 170 butterfly species, about 70% of the total number that occur in Hong Kong, have been recorded at Fung Yuen, including about 50 species infrequently or rarely seen Hong Kong, including Common Birdwing *Troides helena* and White Dragontail *Lamproptera curius*. These species require *Aristolochia tagala* & *Illigera celebica* respectively for larval stage survival.

Prioritized sites for enhanced conservation

Fung Yuen ranked 4th (Source: New Nature Conservation Policy leaflet)

Challenges since 1980s:

Most threats revolve around habitat loss:

Villagers sold farmlands for residential development & abandon farmland because:

- Development of Tai Po New Town and development of the nearby industrial estate brought in much higher short term revenue from sale of land;
- Land reclamation;
- Decline of agriculture industry - low income;
- Increased cost of living and inflation;
- Economic restructuring;
- Emigration leading to abandonment of land.

Actualizing Butterfly Conservation at Fung Yuen

TPEA, green group involvement

- Resume plantation and weeding to attract butterfly to lay eggs and live;
- Rent private land from villagers for management;

- Co-ordinate volunteers to undertake field work and site management work;
- Gain government and other green groups' recognition;
- Apply funding to enhance infrastructure and education materials.

Difficulties encountered by TPEA

- Villagers were sceptical of green groups intentions;
- low land rental costs, no letting incentive;
- Disturbance to village life;
- Financing the conservation site;
- Manpower;
- Infrastructure;
- Transportation.

Some of these difficulties were overcome through Education and Consensus Building on Butterfly Conservation by:

- Initiating a call for butterfly salvation:
- TPEA defended butterfly larva capturing;
- TPEA discussed with villagers, raised their awareness on the seriousness of illegal butterfly larva capturing;
- Villagers actively request TPEA to "do something" upon this issue;
- Elicit the establishment of Fung Yuen Butterfly Reserve.

Recognition and Supports of Local Villagers:

Facts:

- Realize Fung Yuen Valley is zoned as SSSI;
- No market value, hard to sell;
- Cannot make a living on agriculture.

Recognition:

- TPEA positive image in local area, reference obtainable
- Indigenous local villager found the TPEA
- Maintaining their "backyard/garden" in good order resulted in a better living environment
- Eco-tourism increased the number of visitors and reduced threats from theft;
- Trust our objectives, low rental fee;
- Vital role in land rental - land owners living overseas;

Supports from other green groups

- Kadoorie Farm & Botanic Garden provided seedlings;
- Hong Kong Bird Watching Society undertook bird surveys;
- Hong Kong Lepidopterists' Society undertook butterfly surveys;
- Green Power provided assistance with publication of educational materials

Support from the government

A pilot "Management Agreement on the Private Land with High Conservation Value at Fung Yuen Valley Site of Special Scientific Interest in Tai Po, Hong Kong":

- A one year agreement, from November 2005 to November 2006;
- HK$1,734,630 funding to undertake the conservation management objectives of the site;
- Aim: through management agreement made among
  - i) the NGO,
  - ii) funding body and
  - iii) land owners, to maintain and enhance the ecological value of the private land at Fung Yuen Valley.

Our Valuable Resources

Volunteers are critical to the success of this project. Roles undertaken by volunteers include:

Field works; electronics (computers, CCTV); designers; infrastructure; plantation; butterfly lovers; nature lovers; environmentalists.

Areas Covered & Achievements Under The Scheme

i) Site safeguard and Ecological Monitoring Program

- Daily patrol: inspect and monitor the managed areas and SSSI;
- Report cases: bush fire, war-game, damaged butterfly food plants, illegal butterfly larva capturing;
- Three independent bird surveys at Fung Yuen were carried out by the Hong Kong Bird Watching Society from December 2005;
- Until June 2006, 2 species, Pygmy wren-babbler *Pnoepyga pusilla* and Blue-winged minla *Minla cyanouraptera*, never been recorded at Fung Yuen before, were seen.

ii) Habitat Management Program

- Butterfly larval food plants and nectar plants have been cultivated in the reserve.
- Ditches were dug and fences set up to provide suitable habitat for the plants.
- Phase one of the reserve has been established. In future, more larval food plants and fruit trees will be planted in other new areas.
- Weekly habitat management volunteer program is carried out every Sunday morning.
- Four independent butterfly surveys were carried out by the Hong Kong Lepidopterists' Society, assisted by the Department of Biology, Chinese University of Hong Kong from January to April 2006.

iii) Species Conservation Program

- Butterfly nursery facilities have been set up.
- Larva facing immediate danger were placed in the nursery facilities for care.
- So far, about 30 spp., < 40 larvae have been put in the nursery facilities (see Table 15.1).

iv) Consultation / Community Development / Conservational Education and Publicity Program

- As at Aug 2006, >50 workshops (>1,000 participants) have been arranged. Approximately 83% of the participants were students.
- Educational and publicity materials (such as leaflet, butterfly identification card, worksheet for workshops) have been produced.
- Website on the pilot Management Agreement project has been set up at www.fungyuen.org for public viewing.

Table 15.1.
Life cycle data from larvae placed in nursery care at Fung Yuen
(n.r. = no data recorded)

Species	egg (days)	larva (days)	pupa (days)
Odontoptilum angulatum Chestnut Angle	n.r.	8	10
Graphium doson Common Jay	3	14	n.r.
Papilio helenus Red Helen	3	19	14
Papilio demoleus Lime Butterfly	5	28	7
Papilio protenor Spangle	5	15	10
Papilio polytes Common Mormon	5	12	11
Papilio memnon Great Mormon	5	10	7
Troides helena Common Birdwing	11	33	22
Tajuria maculata Spotted Royal	n.r.	n.r.	14
Ariadne ariadne Angled Castor	2	6	5

Citation:

Yau, W.K., Li, S.W. & Wong, L.H. 2007. Collaboration among government, green groups and villagers: a key component contributing to the real success of Fung Yuen Butterfly Conservation Project [abstract & presentation notes]. In Kendrick, R.C. (ed.) *Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006*. pp. 111-116. Kadoorie Farm & Botanic Garden, Hong Kong.

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A DECADE OF BUTTERFLY GARDENING AT KADOORIE FARM & BOTANIC GARDEN: RAISING CONSERVATION AWARENESS THROUGH EDUCATION

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Abstract

Kadoorie Farm & Botanic Garden (KFBG) has had an operational outdoor butterfly garden since 1995. The garden serves several purposes, the primary objective being educational. KFBG set out to inform visitors about the butterflies of Hong Kong, their habitat requirements and conservation needs, through the use of display boards and panels, and to make the experience of being in an open setting with butterflies free to come and go of their own choosing a memorable one for visitors. To this extent, the butterfly garden has been a success, as measured by comments from visitors.

Since the Butterfly Garden started in 1995, there have been several phases of planting garden design management implemented. These are outlined in the presentation.

Currently, a management plan is being prepared, so as to better evaluate how well the butterfly garden is maintained, to elucidate what measures can be taken to improve the butterfly garden's impact upon visitors and to further enhance conservation of the butterfly and moth populations at KFBG.

Introduction

The Butterfly Garden at KFBG was established in 1995. It was formerly the site of a macadamia grove on the slopes of Kwun Yum Shan and proposed as a butterfly garden in 1993, with the permission of Sir Horace Kadoorie, who realised that the growing of macadamia trees was less beneficial to wildlife conservation than the planting of suitable nectar and larval hostplants, in spite of his partiality to macadamia nuts. The site covers about 0.25 ha between 336m and 356 m above sea level and is currently enclosed by secondary forest on two sides, regenerating forest on a third and a permaculture style agroforestry plot above.

The butterfly garden is multi-purpose, being a focus for the rich diversity of Lepidoptera in Hong Kong and an outdoor educational resource that allows KFBG to increase visitors' awareness of butterflies with respect to the habitat requirements and conservation needs of butterflies and moths. This is achieved in part with the aid of interpretative display boards and panels

The open-air setting of the garden gives it free access for butterflies, as was the original intention, when in 1995 the Butterfly Garden became the first unenclosed butterfly garden in Hong Kong open to the public. Since then, KFBG has monitored the success of this project by recording the diversity of butterflies and moths that utilise the garden (it is possible to record 50 or more butterfly species in one day), and by asking visitors to KFBG to rank their most popular area of KFBG in a questionnaire (2005 data), in which it was found the Butterfly Garden was the most popular attraction in the upper half of KFBG (see Figure 16.1).

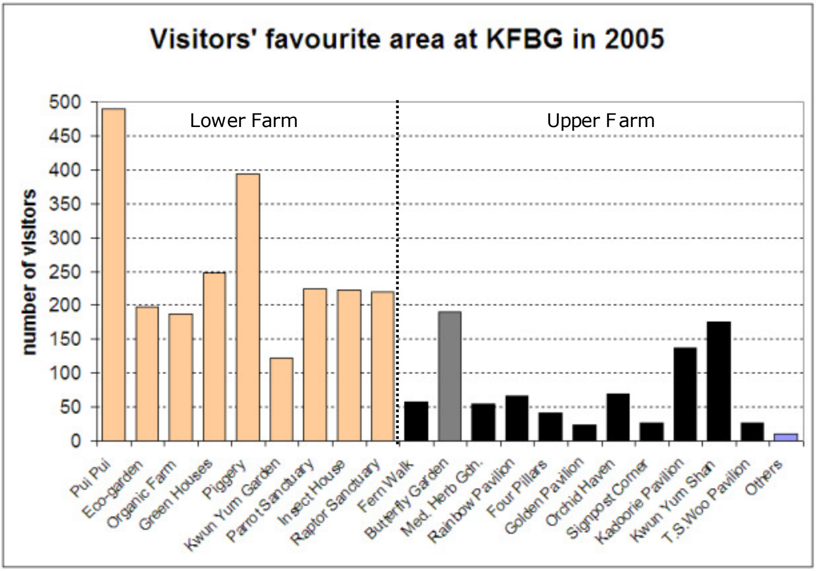

Figure 16.1.
Most popular areas in 2005 of Kadoorie Farm & Botanic Garden, as determined by visitor questionnaire; the Butterfly Garden, with 190 votes, was the most popular of the Upper Farm's attractions.

Programme Development

Several phases of planting garden design and management implemented since 1995.

Currently, a management plan is being developed, so as to

(1) Better evaluate how well the butterfly garden is maintained;

(2) Elucidate what measures can be taken to improve the butterfly garden's impact upon visitors, and;

(3) Further enhance conservation of the butterfly and moth populations at KFBG by placing more emphasis on foodplants, particularly for rare species.

The written framework of this plan started in 2001 and is now reviewed annually to monitor the progress of work on the Butterfly Garden. The focus is on the planting regime management, with review work to assess how effective the planting is by undertaking monitoring of the butterfly nectaring behaviour. Additional management incorporates the educational displays and signage in the Butterfly Garden.

Management Plan highlights

Starting in 1995, the main management points were:

(1) *Nectar plants for butterflies & education*; no major consideration was given to where the plants were sourced or to any potential problems of planting exotic species. Initially, the main nectar sources were *Lantana camara*, *Duranta erecta*, *Agapanthus africanus* and *Asclepias curassavica*, along with a host of annuals planted out on a regular basis; all these plants were selected for their known attraction to butterflies and tolerance of the Hong Kong climate.

(2) *Organic growing methods*; this minimises the impact of using pesticides and herbicides upon insects that are susceptible to poison!

(3) *Few larval host plants*; the initial focus was to get butterflies to visit the garden to fuel up on the nectar and provide visitors with the opportunity to see butterflies close up.

(4) *Unfenced against wild animals*

(5) *High labour for maintenance*; as a result of the damage from mammals and the reliance on non-natives and annuals, the labour required to keep the Butterfly Garden attractive to butterflies and visitors was high and demanding on resources, both fiscal and physical.

Since 2001; with the major review of the main project components, and increased conservation awareness amongst staff, several items were significantly altered:

(1) *More native plant spp.*; the amount of non-native species was reduced by around 70%, especially *Lantana camara*, once it was realised that particularly this species is such an invasive plant, even though it is an excellent nectar source for almost the whole year. More native plants were used to fill the gaps.

(2) *Year round schedule of different plants*; due to the removal of Lantana, and the lack of native species having such a long flowering period, a selection of species were chosen that, when combined, produced nectar throughout the year, even though each species may on its own last only a month or so. Species planted included *Ligustrum sinense* (flowering from March to May), *Pavetta hongkongensis* (flowering in May and June), *Viburnum hanceanum* (flowering in July and August) and *Schefflera heptaphylla* (flowering from late October through to early December)

(3) *Increase in number of Lepidoptera host plant species*; in an effort to increase the abundance of species considered to be of conservation concern in Hong Kong, the hostplants for some of these species were planted in and adjacent to the Butterfly Garden. Examples included: *Illigera celebica* (a native, very rare plant) to attract *Lamproptera curius* (uncommon in Hong Kong), *Asclepias curassavica* for *Danaus chrysippus* (a showy species good for education) and *Aristolochia* spp. for *Troides helena*, *T. aeacus* and *Pachliopta aristolochiae*.

(4) *Reduced labour*; the staff responsible for the maintainence of the Butterfly Garden realised that sustainable management of the garden meant that reducing the manual labour to achieve the same results of lots of butterflies being seen and people enjoying this experience. This reduction in labour also freed up staff to do other conservation work at KFBG. There were three major areas of work that resulted from this more sustainable management approach:-

   (a) More perennial plant species were used, thus reducing the daily labour requirements for potting and transplanting annual species with nectar rich flowers;

   (b) Reduced watering – many of the native plants, being better adapted to the climate than the non-native resulted in healthy plants and a reduced need to water plants in the dry season or in hot dry spells during the wet season;

(c) Fenced against animals – the fencing of the Butterfly Garden resulted in an instant reduction to almost zero damage by mammals, dramatically reducing the staff time required to maintain plants and infrastructure in the Butterfly Garden.

Education and outdoor fun

With the Butterfly Garden established and attracting plenty of butterflies, KFBG had to devise ways in which the mission of KFBG could be achieved. Increasing awareness of humans' relationship with the environment is gained in several ways, targeting specific audiences. KFBG's target groups are students, government agencies, green groups, commercial organizations and the general public. These groups are catered for in a number of ways, principally as follows: self-guided educational displays; guided tours; pot planting; "Art in Nature" activities; the KFBG Night Safari, which regularly uses the Butterfly Garden as a site for moth recording, and "Train the Trainer - Butterfly Gardening Design and Management" for groups that want to use the KFBG Butterfly Garden as a model.

Self-Guided Educational Displays consist of a series of information display panels situated in the Butterfly Garden, covering the following topics:

- General Characteristics of Insects and Butterflies;
- Lepidoptera Life Cycle;
- Difference between Moths and Butterflies;
- Nectar Plants & Larval Food Plants;
- Defence Mechanism;
- Impact of Butterflies;
- Common Butterflies;
- Rare Butterflies.

The KFBG Guided Tour (mostly given to school students) provides a Nature Walk, with either KFBG Education staff or trained volunteers giving guided interpretation to the visitors, and includes a worksheet for visitors to complete during the walk.

Planting: group events are organised by KFBG to raise potted plants and, or planting out of pot plants. Many annual species are attractive to butterflies and KFBG interpreters explain the importance of nectar plants for butterflies. Participants, mostly childrens, do planting on site, or take the plants home and start attracting butterflies on their balconies and roof tops.

Art in Nature: courses run by KFBG include “finger-tip painting”, “natural handicraft making” and “drawing”. All these courses utilise the Butterfly Garden to provide inspiration and ideas for the course participants.

Advisory Service - Butterfly Gardening:

KFBG also believes that outreach training assists the understanding and development of sustainable living that a butterfly garden can bring to people. Since the start of the Butterfly Garden, KFBG has assisted partners and other organisations to set up their own butterfly gardens, including:

1995 Ocean Park

1996 Mai Po - World Wide Fund (HK) for Nature

2005 New Life Interactive Farm (Tuen Mun)

2005 The Warehouse Teenage Club (Aberdeen)

2005 Queen’s College Old Boys’ Association Secondary School

2005-06 Fung Yuen Butterfly Reserve (Tai Po)

2006 Mui Wo Primary School (Lantau)

2006 Wildlife Habitat Enhancement Scheme

Other green organisations, and the Hong Kong Government, have not been slow to pick up on the value of butterfly gardens, and these havens of natural tranquility and vibrant colour are now well established throughout Hong Kong.

Example of Conservation Achievement:

One of the aims of the butterfly garden at KFBG is to increase the distribution and strengthen the status of rare butterflies in Hong Kong. One species with which we have already had notable success is the Birdwing, *Troides helena*. This butterfly can be seen flying at KFBG between April and October.

Its larval foodplant, *Aristolochia tagala*, a species that is often cut and removed by villagers and foresters due to its climbing nature, so much so that it is protected under Hong Kong’s legislation, has been planted around the butterfly garden (and elsewhere at KFBG) to attract the females to lay eggs.

A natural threat to *Troides helena* is a small black ant (*Crematogaster* sp.) which was noted by Farm staff predating chrysalises shortly after they are formed. The ants chew into the chrysalis and devour the contents. Protection measures taken were the removal of all the pupae that could be found from the Butterfly Garden area, and placing them in a puparium.

This conservation project has had great success: a 95% hatching rate of pupae increased the population of adults seen in 2000 through 2003 by almost 300% compared to adult numbers of 1995-1999. After this protection stopped in 2003, numbers of adults dipped in 2004 and 2005, but have been high again, with no further protection, in 2006 (unpublished data, KFBG).

Final Thoughts

The Butterfly Garden has been a success, both in terms of the number of butterfly species recorded using it as either a nectaring resource for adult butterflies or a food supply for caterpillars, or in terms of the popularity of the Butterfly Garden with human visitors to KFBG. The staff at KFBG have kept records of observations and a rudimentary set of documentation that has allowed for management of the Butterfly Garden to change in the light of better information on the needs of the butterflies, combined with better knowledge about general conservation issues relating to invasive plants, sustainable management and education methods. Recognising the need to change, update and improve, combined with effective implementation has been the key to this overall success.

Citation:

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THE MOTHS OF BORNEO ONLINE

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Abstract

An outline of the Moths of Borneo website is given, covering 13 of 15 published volumes. Target users are identified and the contents described as an electronic checklist of moths, with strategic hyperlinking, a taxonomically structured image gallery and a Boolean search facility. Ways to carry the project forward are presented, including the use of the Internet as a taxonomy tool and Web 2.0 system development opportunities. The cost of running the site in future is presented.

Introduction

The Moths of Borneo Online (MOB) - initiated by Dr Jeremy Holloway, Lim Kooi Fong and Henry S Barlow, is a web based descriptive taxonomy project on moths. The first online edition (Part 3: Superfamily Bombycoidea) was completed in 2001. Since then, 13 out of 15 volumes (a total of 18 are planned) have been fully digitized and can be accessed online via http://www.mothsofborneo.com.

Volume indices and cumulative index are prepared as each volume goes online. Volumes deal with different families and subfamilies down to species. The treatment includes taxonomic discussion and listing of foodplants. As the series is targeted at a variety of users, ranging from entomologists in tropical Asia, Lepidoptera systematists, university lecturers, school teachers and amateurs interested in the moths of the area, a user friendly navigation facility was developed to enable quick and effective browsing. Strategic placements of hyperlinks and navigation bars were also developed to enhance the interrogation process. An indexing facility has been incorporated to enable users to interrogate the database via boolean logic to obtain findings which fit their exact requirement.

This facility has proven to be an important application tool for researchers and ecologists.

Description of the MOB system

As a research centric portal, the MOB website was developed after a detailed study of user requirements. At the onset of architecture mapping and system design, the site developers (who are not trained as entomologists) had to decipher the various scientific terminologies and to develop a framework that best allows users to browse the vast body of information and at the same time be able to make cross references without losing touch with their search objective.

The system at its core is made up of four parts:

1) An electronic checklist with user friendly navigational facilities such as drop down menus and strategic hyperlinks to enable easy cross referencing between species and genus.
2) Strategic hyperlinking facility and direct placement of images of the adult and genitalia in respect of each species.
3) A searchable image gallery, organized by family, subfamily, genus and species.
4) A boolean search facility, capable of filtering search results through keyword placements

Electronic Checklist

As a one stop electronic depository, MOBOnline can be considered as the world's largest database of Bornean Lepidoptera, a high proportion of which is also relevant to South East Asia and adjacent tropical regions. It is a self-contained point of reference and is freely available on the web.

The online version is not merely an adjunct to the printed version, but has incorporated facilities, which it is hoped can be developed to provide further information relevant to the systematics of the taxa covered. At the heart of this is the Electronic Checklist (see Fig. 17.1) for each genus, complete with information on diagnosis, taxonomic notes, geographical range, habitat preference, biology and host plants information.

The Electronic Checklist also serves as a site map, and was extensively used to devise methods and processes to ensure that browsing, navigation and search engine options are developed to display accurate results.

Strategic Hyperlinks

An important feature in MOB online is the extensive labyrinth of hyperlinks connecting the rich body of information to the gallery of images of species and genitalia. Such strategic development has enabled users to make quick and easy comparisons, especially in relation to images of genitalia to a particular species (see Fig. 17.2a).

A browsing facility in the guise of a dropdown menu was incorporated for each genus. The system was devised with the aim of providing search within a genus. This facility is highly advantageous when used for this purpose, compared with that of a traditional monograph. (See Fig. 17.2b)

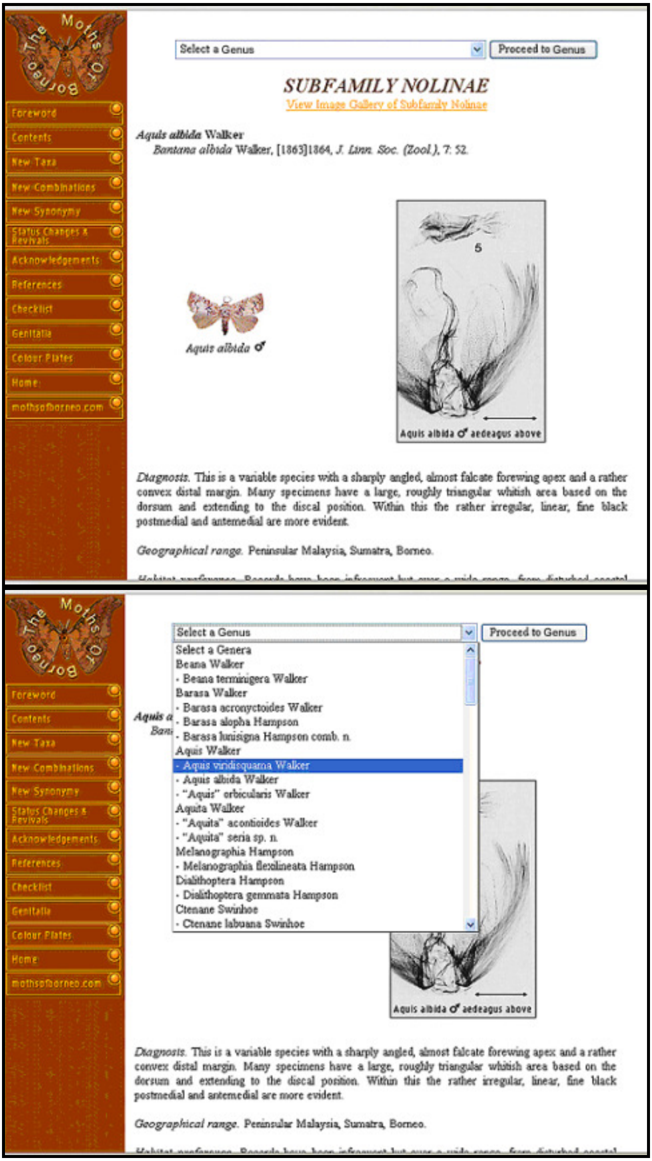
Figure 17.1: electronic checklist (screenshot taken from Part 18)

Searchable Image Gallery

One of the key features of MOB Online which differentiates it from the printed version is that all the images found within the site are hyperlinked to a body of information. The images are either linked to a specific taxon, or lead the user to a description of each species and a means of distinguishing among them. This is apparent in the colour plates for each volume (see Fig. 17.3).

Boolean Search Facility

An ongoing development of MOB Online is the establishment of an indexed database of keywords and references which will enable users to make better deductions and analysis of search results. Currently, the search engine will only enable users to place keywords within a search box, and the search result will produce a listing based upon the input of the respective keywords. The work of indexing the entire work is currently being handled by Ms. Maia Vaswani.



(a)

(b)

Figure 17.2
(a) Placements of genitalia images with species (screenshot taken from Part 18)
(b) Strategic use of dropdown menus (screenshot taken from Part 18)

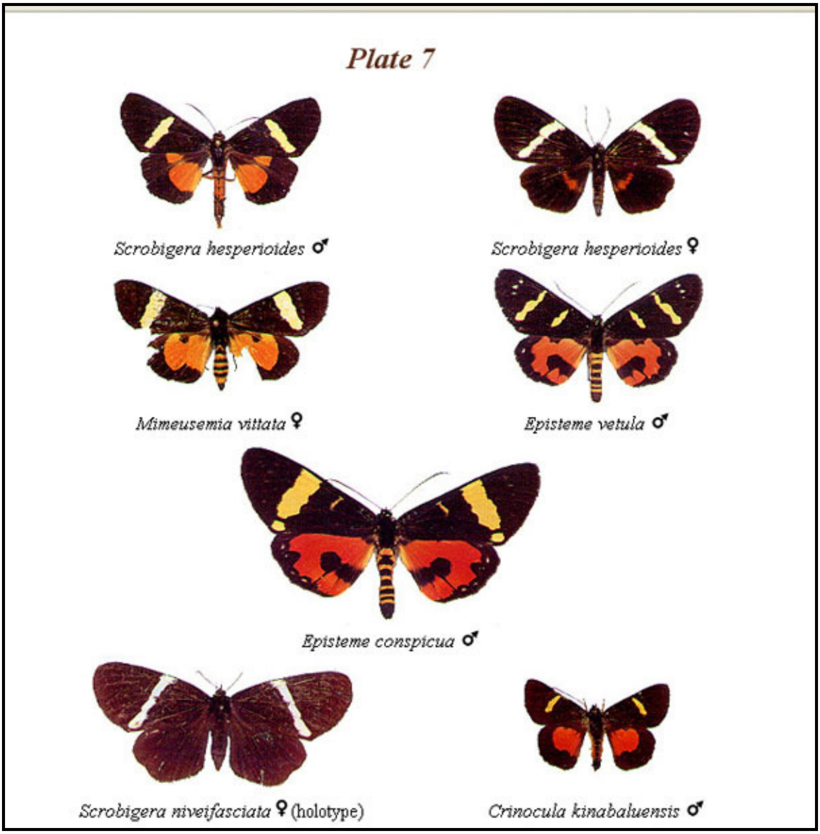


Figure 17.3:
Hyperlinked images in the colour plates (screenshot taken from Part 12)

A Virtual Museum for MOB: The Way Forward for MOB

Charles J. Godfray (2002) presented a paper on "Challenges in Taxonomy" where he argued why descriptive taxonomy is in such dire straits and offered a proposition on how it can prosper if it reinvents itself as a twenty-first-century information science. One of the key reasons identified was that "descriptive taxonomy ... lacks clearly achievable goals that are realistic and relevant" due to the monumental number of species of organism on this planet.

Godfray made an important presumption that taxonomy is "made for the web" given "its information-rich subject, often requiring copious illustrations." However, in order to use the web effectively as a platform to disseminate information and expert collaboration, he suggested that the only way "to organize the taxonomy of a particular group is to have it reside in one place and be administered by a single organization. It could be self-contained and require reference to no other sources." He calls this "distributed collaboration via unitary organization".

Currently, the Internet is undergoing a major change. From an original environment where individuals posted static information that was hard to navigate, it is growing into a new environment where people are dynamically posting information and collaborating. New search and aggregation tools are making it easier to find and contribute to the information that an individual is interested in. This shift has been described as the switch from Web 1.0 to Web 2.0. Web 2.0 promises to be the "distributed collaboration via unitary organization" as envisioned by Godfray.

Taxonomy can both use these new tools directly and also apply similar concepts by analogy. The expectation is that these new concepts will make the taxonomic community more open and will increase the speed with which new information is accumulated and disseminated. Listed below are some of the ways that taxonomic research moves from Web 1.0 to 2.0. These are not prescriptive solutions, but ideas to generate discussions on new ways by which taxonomic research can be accelerated using new communication and collaboration tools.

Examples:

· Peer-reviewed specialty journals --> Articles aggregated and ranked by search engines (Google style) or via a catalog and user review (Amazon style);

· Maintenance of static protocols in labs that are shared via reference texts -> Online sharing of protocols;

· Materials collections --> Materials registries; the Registry permits users to design, obtain, test, and annotate parts. The users who design parts do not necessarily have to be the ones who synthesize the parts. It enables anyone to post comments about any part. Eventually the Registry would like to move to a web of registries based in multiple locations to further decentralize and make the engineering of new and existing parts easier. It should probably include cross links to other online items which overlap to a greater or lesser extent in species coverage.

Ideas for Web 2.0 Application on Taxonomic Research

· Online lab notebooks: Accessible from everywhere, Searchable, Referential, Equipment-friendly: as data comes off a machine, it goes directly into notebook.

- Lab "feed": An equivalent of an RSS (Real Simple Syndication) feed of what is coming out of a lab updated daily/weekly. Results would be less finalized but might help people coordinate on projects across labs rather than just repeating each other's work in secret. The RSS news feed will also form part of the electronic refereeing system, with automated alerts for new updates.
- Live data sharing: Currently authors must keep data private until a paper is published. Regardless of whether the publishing process can be accelerated, it would be desirable if the raw data could be shared earlier while protecting the author's rights to publish papers based on the data. Is this practicable, given the enormous importance of priority in key scientific publications?
- Collaborative written works: Currently review articles written by experts in the field are the primary mechanism in which the state of a research area is evaluated. Instead, one could imagine an "expert based participatory wiki" (not entirely open to the public) to accumulate descriptive information, make amendments and update annotations
- Electronic refereeing system: This is done via the establishment of an expert community approved refereeing system to moderate input of new information or to agree on amendments or revisions. Such a platform would include the development of systematic information add-ons, with facility to automate referencing to historical literature and double checking for duplication.
- Image Search: Better imaging systems with high resolution pixels and abilities to zoom in for details and size matching (to scale). Image browsing system (for species and genitalia) with ability to add text annotations directly onto the image.

Web 2.0 System Development

Once the taxonomic community agrees upon the desired protocols, it is plausible to migrate this body of information into a Web 2.0 based environment. The upgrade while, technically feasible, will still require some considerable development work (such as programming and application of various facilities such as RSS Information feeds, Web based imaging software, search optimisation, content management systems etc) to integrate tools and processes promised by the Web 2.0 environment to bring immense advantages such as:

- expert community collaboration,
- data sharing,
- vast volume of data hosting,
- more effective interrogation systems,

- dynamic cross referencing and
- the advent of a virtual curator.

For this to happen, and to protect the valuable information stored in such systems, it would be practical to look into issues like mirror site hosting and resources (and money) required to put it in place.

Costing

We estimate that costs might be as follows:

Dedicated Server co-location (mirror site, preferably outside Malaysia)

- Monthly cost (estimated market rates) – US$ 800/- per month
- Development and maintenance cost of Web 2.0 for Moth Taxonomy – US$ 4,300/- per month (for the first 12 months only). Subsequently maintenance costs are estimated at about US$200 per month.) Could this be achieved more cheaply by distance outsourcing to, for example, Bangalore?

Conclusion

The Moths of Borneo Online can be considered to be a pioneering effort to collate a vast collection of moth taxonomy in one location. Being web based, it is easily accessible to the public. Nevertheless, it is still a static platform, and performs very much as an upgraded version of the print edition. The system at present is not yet able to solve current issues plaguing those involved in the field of descriptive taxonomy, i.e. how to handle the voluminous old and new data with the limited number of experts in the field. With Web 2.0 however, the collaborative nature of the web can now be harnessed to optimize research values as well as to manage content more accurately and productively. However, the moth taxonomic community is still required to come to a consensus on what should be the accepted protocol to harness the full potential of Web 2.0 technologies. This would aid their work more effectively and in the process provide a new impetus to the crucially important task of a new generation of web based taxonomists to tackle the problems of web based taxonomy in the 21st century.

Reference:

Godfray, C.J. (2002). Challenges to taxonomy. *Nature* **417**: 17-19.

Citation:

Barlow, H.S., & Lim, K.F. 2007. The Moths of Borneo online. In Kendrick, R.C. (ed.) *Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006*. pp. 125-132. Kadoorie Farm & Botanic Garden, Hong Kong.

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18

TAXONOMIC INFORMATION ON THE INTERNET: MOTHS OF BORNEO ONLINE AS A COMPONENT OF AN INFORMATION RESOURCE ON THE BIOSYSTEMATICS AND BIODIVERSITY OF BUTTERFLIES AND MOTHS FROM THE INDO-AUSTRALIAN TROPICS

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Abstract

A summary of the Moths of Borneo [MoB] monograph series and website is presented, with an outline of the forthcoming parts given. The final product should cover about 4500 species in detail, with some information on numerous other species from neighbouring areas that are related to those in Borneo, including a few preliminary phylogenetic commentaries. Funding issues are dealt with, both for the MoB website and for possible future coordination of a regional facility that could put much of the published regional texts onto the Internet. The logistical issues are discussed, and suggestions for future collaborations are given.

Introduction

Taxonomic information for moths on the Internet has evolved in the last ten years from scratch. What advantages does the Internet have over traditional publishing methods? Well, for most people in South East Asia access to academic or institutional libraries is not possible, so providing access to taxonomic information on the Internet dramatically widens the audience that can use the information and thus raises the general profile of butterflies, moths and their taxonomy. The use of the Internet also has much less cost than traditional publication processes and is straightforward to update and correct. It also presents an opportunity to provide, through its navigation attributes, linkages between independent and often disparate information resources on Lepidoptera that have been posted on the web by diverse initiatives worldwide. This poses questions of how best to improve cohesion and compatibility within this process, to respond to user needs so that it is 'demand led' as well as 'capacity driven', yet, whilst providing an evolving, flexible and responsive forum for building and exchanging information resources, observes the protocols of the taxonomic publication process over such matters as rules of nomenclature, format, and particularly the need for dating of publication of taxonomic decisions such as those for species descriptions and generic recombinations.

Example online resources

1. Moths of Borneo

http://www.mothsofborneo.com/

The Moths of Borneo website currently does little more than provide an electronic version of the hardcopy monograph series with an entrance portal and some basic navigation facilities. The images of moths and genitalia can be more directly associated with their text entries and with congeners. Nevertheless, the facility does provide diagnoses with geographic, ecological and, where available, biological information for each species and on the genera and higher taxa to which they belong. A key feature of the current site is the easy navigation between pictures, figures, checklists and taxonomic or biogeographic information on species.

Currently, 13 of the planned 18 parts are available in hard copy and electronic format, with two further recently published hard copy ones imminent online; the remaining 3 parts are still in production, but Part 2, covering the small zygaenid fauna, will also include a revised and augmented checklist with notes that will bring the earlier parts up to date. The final product should cover about 4,500 species in detail, with some information on numerous other species from neighbouring areas that are related to those in Borneo, including a few preliminary phylogenetic commentaries.

The online version has been set up by ARBEC in Malaysia with some government funding as part of the national commitment to make available data on biodiversity in the country as part of the Convention on Biological Diversity. More recently, the project has become increasingly dependent on funding from Henry Barlow, who has also supported the generation of an accessory database to provide an index, gazetteer, and full bibliography of original description literature etc.

At some time in the not too distant future, the funding and the commitment to updating the facility will cease. Yet it is proving to be of value and interest throughout the Indo-Australian tropics and subtropics, and would no doubt continue to do so for some years to come, providing a foundation for further studies in the region. In passing, it should be noted that Hampson *et al*.'s Fauna of British India Moths series, after over a century, still provides the only really comprehensive account of the moth fauna of the Indian Subcontinent.

2. Australian Moths

http://www.ento.csiro.au/anic/moths.html

The CSIRO Entomology Department has set up a database of Australian moth specimens maintained in the Australian National Insect Collection (ANIC). Coverage is representative of the Australian fauna, rather than comprehensive. Information includes photographs of the species and detailed collecting data and taxonomic placement for each specimen. However, work on the Moths of Borneo series has shown time and again that knowledge of the Australian moth fauna is very important for establishing sound taxonomy throughout the Indo-Australian tropics, because many genera and species range right across the region.

3. Sphingidae of the Eastern Palaearctic

http://tpittaway.tripod.com/china/china.htm

Put together by Tony Pittaway and Ian Kitching, this site features a taxonomic index to species in the area covered. For each species, data coverage includes extensive life-history information, pictures, drawings of larval stages and distribution maps. It complements the next item, and both feed data into the more comprehensive one following.

4. Sphingidae of South East Asia

http://www.sphin-sea.unibas.ch/

Jan Beck and Ian Kitching have constructed a complementary site to the Sphingidae of the Eastern Palaearctic, which is taxonomically up to date. Taxonomy is not, however, the main focus, which is biogeographic. Each species distribution is analysed in detail and other information given include a photograph for each species and checklists for each island in the region.

5. CATE – Creating A Taxonomic E-science

http://www.cate-project.org/

This website is in its infancy but undergoing rapid growth offline at present. It is a joint project between major institutions responsible for significant taxonomic work and is not restricted to Lepidoptera. Its aims are: to provide unitary taxonomy; to construct protocols for web-based, reviewed taxonomic revisions; to develop a format where users can present and discuss alternative taxonomic views. At present only 'test cases' are available: the plant family Araceae and the sphingid moth genus *Acherontia*. However, the facility will eventually offer a comprehensive coverage of the Sphingidae based on years of hard work by Ian Kitching and colleagues worldwide such as Mike Allen, Ron Brechlin, the late Jean-Marie Cadiou, Tony Harman, Jean Haxaire and those involved in the previous two items.

6. GONGED – Geometridae of New Guinea Electronic Database

URL to be announced

This is another project that has only just commenced, but it aims to provide online images of all geometrid species (and their genitalia) that occur in New Guinea and adjacent islands. The work is being undertaken by the Smithsonian Institution (Scott Miller, Karolyn Darrow, David Pollock) and The Natural History Museum (the author), as a subcontract within a much larger programme on environmental health within Papua New Guinea, funded by the United National Institute of Health through the University of Utah. Geometridae are targeted as useful indicator organisms for surveys of ecosystem health. It may be possible to extend this operation to other Lepidoptera groups of indicator potential in future years.

Future coverage options

Much more could be done, and is being done, to provide a considerably wider online facility for moth and butterfly information resources as a foundation for biodiversity studies in the region. A number of other butterfly and moth faunas are presented online (see Appendix 2). There are modern hardcopy treatments of a varying number of moth families for Sumatra, Peninsular Malaysia, Thailand, Vietnam, the Philippines, Sulawesi and further into the Asian mainland, many backed by electronic databases. Hampson's volumes 1 through 4 of the Fauna of British India: Moths are now available online (see Appendix 2) and, no doubt, the relevant volumes in Seitz' Macrolepidoptera of the World series could also be scanned and made available - conceivably for these, updating to the current taxonomy could be commissioned. Linkages could be made to sites elsewhere, such as to the major Lepidoptera names database and the HOSTS hostplant database in The Natural History Museum (both URLs are listed in Appendix 2). It may be possible, copyright issues permitting, to develop electronic versions of catalogues on major groups such as Noctuidae (Poole, 1989) and Geometridae (Scoble, 1999).

More general introductory works such as Robinson *et al*. (1994) on microlepidoptera and Holloway *et al*. (2001) on the Lepidoptera might provide additional information resources, such as on key works treating genera in more detail, and keys and characterisation for higher taxa. It might also be possible to tap into global programmes such as the Tree of Life initiative or, for Geometridae, the Forum Herbulot network based in Munich (www.herbulot.de; www.geometridae.de).

Future facilitation

All this will require coordination, funding and human resources, both for development of a system of linkages and navigation between disparate products and for maintenance, the latter always much harder to sustain, whether for a monograph, a catalogue, card index or electronic database; the medium is irrelevant, but the long term commitment is critical, indeed essential.

It would make sense for any such facility to be hosted, developed and maintained within the region where the majority of stakeholders in the information is found, but could such an initiative thrive? And who would guarantee its financial foundations? Then, would there be regional agreement at a national level on the nature of such ownership? How would quality control for the taxonomic structure be assured, reflecting current consensus, or alternatives where there is disagreement? The CATE project (see above) aims to explore some of these questions.

At this point it would be gratifying if an affirmative chorus, with a barrage of constructive suggestions, were to be heard from, for example: the regional offices of GBIF (Global Biodiversity Information Facility) and GTI (Global Taxonomy Initiative); the coordinator of ASEANET, the regional LOOP (Locally Organised and Operated Partnership) of BioNET INTERNATIONAL; the Regional Biodiversity Centre in Manila; together with any government or aid agency with an interest in the objectives of this meeting. Must this always be wishful thinking, given that the stakes of the game may represent the environmental health of the planet we all share?

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Holloway, J.D., 2007. Taxonomic information on the Internet - Moths of Borneo online as a component of an information resource on the biosystematics and biodiversity of butterflies and moths in the Indo-Australian tropics. In Kendrick, R.C. (ed.) *Proceedings of the First South East Asian Lepidoptera Conservation Symposium, Hong Kong 2006*. pp. 133-137. Kadoorie Farm & Botanic Garden, Hong Kong.

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Discussion Topics

1. Light Pollution

The first discussion session looked briefly at the possibility that light pollution could be a major determining factor in the decline of moth populations.

In general, it must be said that most delegates did not feel that this issue was significant, when compared to habitat loss. However, most delegates also felt that there was very little documented work undertaken to study this issue and as such it was not realistic to comment much further without studies being undertaken.

Subsequent to this symposium, the publication by Rich & Longcore (2006) contains several chapters about the effects of night lighting on nocturnal invertebrates, all of which note that insect mortality is increased, possibly substantially, in areas with artificial lighting (Eisenbeis, 2006; Frank, 2006; Lloyd, 2006). Moth populations appear particularly vulnerable to predation by birds and bats in artificially lit areas (Frank, 2006). Eisenbeis (2006) also noted that as many butterfly larvae are nocturnal, they too are subject to increased predation by nocturnal predators in artificially lit environments in which they would normally go undetected in dark conditions.

Clearly there is a need of further work on how artificial lighting affects Lepidoptera.

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Rich, C. & Longcore, T. (eds.) *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington D.C., U.S.A.. 458 pp.

2. Species Distribution, Population and Taxonomic Information Impediments to Conservation

This discussion session served as a prepatory meeting between several key speakers for the final day workshop on Conservation Science and Research Needs (see Workshops)

3. Collecting & Trading Impact

Several delegates took up this discussion area. Not much discussion actually, as all who were present felt that the collecting of specimens was insignificant in its impact on almost all species except where species were known to be limited to very small distributions with low populations. "Farm" rearing methods could provide the collection trade with material of rare or threatened species, so as to avoid collecting from the wild. All delegates agreed that other areas, particularly the loss or degredation of habitats / ecosystems was by far the most significant impact that needs addressing

4. Internet Resources

About half the delegates attended this discussion, which followed on from the Internet themed presentations (Lim & Barlow, p125; Holloway, p133). Time was spent reviewing websites that contained taxonomic information on S.E.Asian Lepidoptera and global databases. The sites covered (plus some others that time prevented the delegates from viewing) are listed in Appendix 2.

Delegates then turned their attention to possible internet uses for SEALG, investigating webforums, Wikipedia and learning about RSS feeds for keeping abreast of new information. This matter was taken up in more detail on the last day for one of the Workshop sessions (Networking).

Site Visits

The symposium included four site visits over two afternoons, allowing delegates to glimpse a selection of the conservation initiatives that are taking place in Hong Kong with respect to butterflies and moths.

1. Kadoorie Farm & Botanic Garden

Delegates were given a guided tour of various facilities at KFBG, including the Orchid Greenhouse and the Butterfly Garden, where a small booklet guide was given to delegates. Judy Kiu (KFBG Education Department) and Joanne Loi (KFBG Flora Conservation Department) presented the Butterfly Garden's history, aims, educational and operational components, and then fielded questions. Delegates took time out to enjoy the Butterfly Garden, and compared its function to that of indoor butterfly houses. The visit expanded upon the paper of Kiu, Loi & Kendrick, presented at the symposium.

2. Fung Yuen Site of Special Scientific Interest & Butterfly Reserve

Raymond Wong of Tai Po Environmental Association led delegates on a guided tour of Fung Yuen SSSI, the Fung Yuen Butterfly Reserve and the small education centre. Aspects of site management, interaction with the local community (and their involvement), site monitoring and public use of the site were discussed. The visit expanded upon the paper of Yau, Li & Wong, presented at the symposium.

3. Tai Po Kau Special Area

Delegates were given a guided tour of the trail around the "Outdoor Study Centre" near the Tai Po Kau Special Area management centre by Roger Kendrick (KFBG Fauna Conservation Department). Work on the conservation of *Troides* spp. was compared to that undertaken at KFBG and the delegates were able to see areas where the planting of *Aristolochia tagala* had clearly benefitted the *Troides* population, with several chrysalises being observed. The conversion of the citrus grove to a nature trail and butterfly area was briefly discussed, with issues about the effect of conversion on other butterfly species being noted – as raised by the Hong Kong Lepidopterists' Society with regard to the blue butterfly *Tajura maculata* (for details please refer to http://hkls.org/news/newsSept99.htm). The presence of several mistletoe plants amongst the remaining citrus bushes was noted. Delegates were also informed of other government initiatives, such as the Shing Mun Country Park Butterfly Garden opened in 2003.

Site Visits:
Delegates enjoying afternoons at (top) Kadoorie Farm & Botanic Garden, (middle) Fung Yuen SSSI & Butterfly Reserve and (bottom) Tai Po Kau Special Area's Outdoor Study Centre (butterfly trail), and learning of the various conservation measures and actions undertaken at these sites (not just restricted to Lepidoptera); such as planting *Aristolochia* for *Troides helenus* (Birdwing Butterfly) – whose pupa / chrysalis is illustrated here.

4. Tai Po Kau Headland

Mrs. Karen Barretto (Hon. Secretary, Friends of the Earth, Hong Kong) gave a tour of the forested areas of Tai Po Kau Headland, where moth recording has underpinned efforts to upgrade the site's conservation status from Green Belt [GB] to Site of Special Scientific Interest [SSSI]. Discussion on the site's proposed conservation status upgrade at an upcoming hearing with the Town Planning Board [TPB] took precedence and provided useful insight on conservation measures available for habitat conservation in Hong Kong. The visit expanded on the paper of Barretto & Kendrick presented at the symposium.

[Editor's note: at the TPB hearing held nearly two months after the symposium, the proposal was partially agreed with, most of the area being designated "Conservation Area" – a designation that ranks between that of GB and SSSI. However, the buffer zones were rejected by the TPB. Further work is being undertaken to safeguard this special site].

Left:
Mrs. Barretto discussing conservation issues with SEALCS2006 delegates at Tai Po Kau Headland.

Right:
Apha sp. indet. near *A. subdives* (*A. floralis* group) is an undescribed moth species in the family Eupterotidae (monkey moths) that is found in well established secondary forest in Hong Kong, and is common at Tai Po Kau Headland.

Workshops

Three workshops ran over the final morning of the symposium. The topics were chosen by the delegates from a list of suggestions. About half the delegates attended the session. Brief summaries are provided here.

1. Education and Resources

Areas in which education can impact beneficially upon Lepidoptera conservation were investigated. Some possible resources that exist already to aid education were identified. Key points were as follows:

There were three main educational foci:-

I. Adult Education

Adults can be taught about Lepidoptera conservation through several avenues, including: family day events; teacher training; multiplier approach events run by environmental NGOs and adult education classes (e.g. evening classes, distance learning); scientific learning through societies and journals.

II. School Education

It would be very beneficial to have school curriculum include biology and conservation using Lepidoptera as one example of conservation issues that need to be addressed.

III. Media

General education can be achieved through various forms of media, principally the Internet – e.g. society / NGO / institution websites and reporting of newsworthy events via television, radio and newspapers.

Ways of generating interest in education can be achieved through:

- tourist attractions (butterfly gardens, nature reserves);
- photography competitions (e.g. on-line, societies, NGOs …);
- campaigns to save habitats (not just with a Lepidoptera focus).

The main resources for Lepidoptera conservation in South East Asia were identified as places for learning (e.g. Penang Butterfly Farm, Malaysia; Kadoorie Farm & Botanic Garden, Hong Kong and Museum Zoologicum Bogoriense, Java, Indonesia); funding for conservation from corporate sources, though this is a difficult issue; the habitat as a conservation tool – in terms of management, enhancement (of degraded habitat, through site restoration) and as an outdoor classroom.

2. Scientific Conservation & Research Needs

This workshop looked to identify areas of science that are needed to improve conservation efforts for Lepidotpera in South East Asia.

Many areas were identified, outlined as follows:

- There is a need to list all lepidopterists (worldwide) working on S.E.Asian species.
- There is a need to inventory all institutions working on or with an interest in S.E.Asian Lepidoptera
- There is a need to share information freely; basic information still does not exist for most species, other than identity and locations recorded of adults. Critical data to be established includes life history and species distribution / range / population size; moths less well known, especially microlepidoptera.
- There is a decline in popularity (in academic and business circles) for research in ecology, in favour of genetic work, which is perceived as the trendy area of biology to invest business money in. Non-govermental organisations have to try and spend ever decreasing amounts of funding as effectively as possible, though the amount of work increases!
- Taxonomic impediments include insufficient people, lack of technical support in the region (need to send people to world class institutions for training); poor understanding of phenology, evolution and molecular relationships; insufficient laboratory time (cost impediments) to research these issues. Setting a standard taxonomy is a problem as much scientific literature that updates taxonomic understanding is difficult to obtain for the layperson.
- Many of these areas can be addressed with better communication, especially through the Internet, although other aspects, such as exchanges or joint research ventures would also assist.
- There remains a significant impediment to freedom of research in some countries; legal issues could be relaxed to increase ecological and taxonomic understanding. It is noted by the editor that it appears most legislation preventing improved ecological understanding occurs in countries where power is in business hands with an interest in financial gain from habitat destruction the places where improved ecological understanding would be detrimental to such business activities as agriculture, logging, commercial plantations, mining and property developers.

3. South East Asian Lepidoptera Conservation strategy: Priorities – Communications (Networking)

This workshop looked to identify areas that are needed to improve conservation efforts for Lepidoptera in South East Asia by investigating methods of effective communication between existing conservationists, with a focus on using the internet as the primary means of communication.

The key areas were identified, and are outlined as follows:

Some type of web-portal should be established and implemented to facilitate networking of all parties involved in the conservation of Lepidoptera in South East Asia. Several options are available, but it was noted that the development of "Web 2" systems in the near future would enable the scope of operations to become substantially more efficient and effective. Consequently a two phase approach was suggested.

Phase 1

The establishment of a dedicated website for SEALC Group, incorporating the following structure and features:

Communication forum; links to other organisations; listings of species (where not already available); listing of other internet resources and affiliate organisations; listing of SEALCG members, including their areas of expertise, and honorary committee; SEALCG policies and guidelines. It was proposed that five SEALCS2006 delegates be nominated as the founding committee for this site, who would maintain and oversee all aspects of the site's operation. The delegates nominated were H.Barlow, J.Beck, S.Cabigas, R.Kendrick and K.F.Lim. Issues to be addressed centred on funding and copyright.

Phase 2

Once the initial website and forum becomes established, further "Web 2 compliant" functions could be developed to make the site a truly interactive portal for investigating and documenting South East Asian Lepidotpera species, through (for example) the use of Wiki style data storage and RSS feeds to automatically inform users of updates. Users would need to input a user ID and password (as per the forum) to gain certain viewing and data input rights.

[post symposium note: the SEALCG web-forum has subsequently been established at http://sealcg.freeforums.org/ It features several access levels for members and non-members, with control being maintained by administrator rights for the nominated members, as suggested; however, at the time of publication the site is blocked by mainland Chinese authorities, thus relocation of the site, or purchasing a domain name would need to take place to ensure better access for all users].

Poster Presentations

1. A decade of butterfly gardening at Kadoorie Farm & Botanic Garden: raising conservation awareness through education.
Judy KIU, Joanne LOI & Roger C. KENDRICK

This poster provided a summary of work that has taken place since 1995 at the KFBG Butterfly Garden, with short paragraphs on butterfly recording, moth recording, conservation assessment, education through enjoyment, practical management and services to the community. These points were augmented by illustrations of key butterfly species, the garden, visitors and notable plants.

2. Lepidoptera (Butterflies) of Brunei Darussalam.
Atar TUAH & Haji Munab HASSAN

A short introductory text provided background to two maps of Brunei Darussalam illustrating the basic statutory protected areas and main habitat types. Inserted into these were photos of set butterfly specimens of key conservation concern. A table listing numbers of species found in each area was included. Key locations were also located on the second map.

3. An introduced plant induced an endemic butterfly outbreak that may threaten the survival of an endangered plant.
WU Li Wei, YEN Shen Horn & HSU Yu Feng

A short study analysing *Chilades pandava* populations and their origin, tied into the effect this species has as an herbivore utilising rare cycads in Taiwan. Illustrated with graphics showing populations' relatedness superimposed on maps of Taiwan and in the broader regional context from Taiwan to Indo-china.

Symposium Agreements & Declaration

Hong Kong Declaration on the Conservation of Lepidoptera

Recognising that terrestrial biodiversity is dominated overwhelmingly by the invertebrates, particularly insects and their relatives, and

recognising that of all the mega-diverse of insect Orders the butterflies and moths (Lepidoptera) are the best understood evolutionarily, ecologically and taxonomically, and

noting that the Lepidoptera have a special place in human perception, culture and nature appreciation,

the participants in the first South-east Asian Lepidoptera Conservation Symposium recommend as follows:

- The Lepidoptera be regarded as the **target group of choice** in any habitat assessment which includes invertebrate biodiversity;
- Conservation decision-making involving the Lepidoptera should be **evidence based** involving the best available results of scientific research;
- Conservation of the Lepidoptera, explicitly, should focus both on **individual rare, endangered or vulnerable species** (as assessed using the best available research results) **AND on entire functional assemblages** of butterflies and moths and their habitats in nature.

BARLOW, Henry S.

BECK, Jan

CABIGAS, Stanley

CHANDRA, Kailash

CHEY, Vun Khen

CHIN, Boon Tat

FRIC, Zdeněk

GOH, David

HASSAN, Haji Munab

KENDRICK, Roger C.

KITCHING, Roger L.

LI, Hou Hun

LI, See Wai

LIM, Kooi Fong

PANG, Yoke Kiew, Helen

ROBLEDO, Lydia

TUAH, Atar

WANG, Min

WONG, Lok Hung, Raymond

Signatories to the Hong Kong Convention on the Conservation of Lepidoptera present on the final afternoon's symposium session at SEALCS 2006, Hong Kong. Institutional affiliations as per Appendix 1.

Appendices

Appendix 1.

List of Delegates

BARLOW, Henry S., Mr., Malaysian Nature Society, Malaysia

BARRETTO, Ruy, Mr., Kadoorie Farm & Botanic Garden, Hong Kong, China

BECK, Jan, Dr., University Brunei Darussalam, Brunei Darussalam

*BEXELL, A. Daniel, Dr., Zoo Outreach Organisation, Coimbatore , India

CABIGAS, Stanley, Mr., Philippine Butterfly Habitat Conservation Society, Luzon, Philippines

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CHIN, Boon Tat, Mr., Penang Butterfly Farm, Penang, Malaysia

CHIN, I.M., Moni, Dr., Agriculture Fisheries & Conservation Department of the Hong Kong Special Administrative Region Government, Hong Kong, China

CHOI, Hui Wah, Sarah, Miss, Green Power, Hong Kong, China

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*HOLLOWAY, Jeremy D., Dr., The Natural History Museum, United Kingdom

HSU, Yu Feng, Frank, Prof., Department of Life Science, National Taiwan Normal University, Taiwan

KENDRICK, Roger C., Dr., Kadoorie Farm & Botanic Garden (Fauna Conservation Dept.), Hong Kong, China

KITCHING, Roger L., Prof., Australian School of Environmental Studies, Griffith University, Australia

KIU, Judy, Ms., Kadoorie Farm & Botanic Garden (Education Dept.), Hong Kong, China

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LAU, S.K., Clive, Mr., Agriculture Fisheries & Conservation Department of the Hong Kong Special Administrative Region Government, Hong Kong, China

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LI, Hou Hun, Prof., College of Life Sciences, Nankai University, Tianjin, China

LI, See Wai, Miss, Tai Po Environmental Association, Hong Kong, China

LI, Wah Hong, Byron, Mr., WWF-HK, Hong Kong, China

LIM, Kooi Fong, Mr., Malaysian Nature Society, Malaysia

LO, Philip, Mr., Hong Kong Lepidopterists' Society, Hong Kong, China

LOI, Joanne, Ms., Kadoorie Farm & Botanic Garden (Flora Conservation Dept.), Hong Kong, China

LUI, Tak Hang, Henry, Mr., Green Power, Hong Kong, China

*MO, Stephen, Mr., private individual, Hong Kong, China

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*PEGGIE Djunijanti, Dr., Museum Zoologi, Bogor, Java, Indonesia

REELS, Graham T., Mr., Asia Ecological Consultants Ltd, Hong Kong, China

ROBLEDO, Lydia, Mrs., Philippine Butterfly Habitat Conservation Society, Luzon, Philippines

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SMITH, Bena, Mr., WWF-HK, Hong Kong, China

*STERLING, Mark .J., Mr., British Entomological & Nat. Hist. Soc., United Kingdom

SZE, W.C., Phoebe, Miss, Agriculture Fisheries & Conservation Department of the Hong Kong Special Administrative Region Government, Hong Kong, China

TUAH, Atar, Mr., Brunei Museums Department, Brunei Darussalam

*UNIYAL, V.P., Dr., Wildlife Institute of India, Uttaranchal, India

WANG, Min, Dr., South China Agricultural University, Guangzhou, China

WONG, Lok Hung, Raymond, Mr., Tai Po Environmental Association, Hong Kong, China

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YAU, Wing Kwong, Dr., Tai Po Environmental Association, Hong Kong, China

YEN, Shen Horn, Dr., Department of Biological Sciences, National Sun Yat-Sen University, Taiwan

* - delegate unable to attend, apologies sent

Appendix 2.
Internet Resources for South East Asian Lepidoptera Conservation

- Aganaidae (snouted tigers) of South-East Asia and the Indo-Australian tropics (http://www.aganaidae.nl/)
- ASEAN Centre for Biodiversity (http://www.aseanbiodiversity.org/)
- ASEANET - The Southeast Asian Loop of BioNET International (http://www.aseanet.org/)
- Association for Tropical Lepidoptera (http://www.troplep.org/)
- Australian Moths Online (http://www.ento.csiro.au/gallery/moths/albums.php)
- BioNET-INTERNATIONAL (http://www.bionet-intl.org/opencms/opencms/index1.jsp)
- Butterflies from Chiang Mai (Thailand) (http://www.thaibugs.com/butterflies.htm)
- Butterflies of India [Flickr; invitation only posting] (http://www.flickr.com/groups/butterfliesofindia/)
- Butterflies of Kerala (India) [Flickr] (http://www.flickr.com/groups/butterfly/)
- Butterflies of North East India [Flickr] (http://www.flickr.com/groups/butterfliesofnortheast/)
- Butterfly Circle (moths too! - Singapore) (http://b-pals.com/forums/)
- ButterflyIndia [Yahoo! Groups] (http://tech.groups.yahoo.com/group/ButterflyIndia/)
- ButterflyIndia [Flickr] (http://www.flickr.com/groups/butterflyindia/)
- CATE – Creating A Taxonomic E-science (http://www.cate-project.org/)
- CITES - The Convention on International Trade in Endangered Species of Wild Fauna and Flora (http://www.cites.org/)
- Fauna of British India: Moths (vols. 1-4)
  http://www.archive.org/details/TheFaunaOfBritishIndiaIncludingCeylonAndBurmaMothsVoli
  http://www.archive.org/details/TheFaunaOfBritishIndiaIncludingCeylonAndBurmaMothsVolii
  http://www.archive.org/details/TheFaunaOfBritishIndiaIncludingCeylonAndBurmaMothsVoliii
  http://www.archive.org/details/TheFaunaOfBritishIndiaIncludingCeylonAndBurmaMothsVoliv
- Heterocera Sumatrana Society (http://www.hssev.de/)
- Hong Kong Lepidopterists' Society (http://hkls.org/)
- Hong Kong Lepidopterists' Society forum (http://www.hkls-forum.org/) (or via http://hkls.org/)
- Hong Kong Moths (http://asia.geocities.com/hkmoths/)
- Hong Kong Moths [Flickr] (http://www.flickr.com/groups/hongkongmoths/pool/)
- Hong Kong Moths [Yahoo! Groups] (http://tech.groups.yahoo.com/group/Hkmoths/)

- Hong Kong Wildlife Net (includes forums on butterflies, moths and conservation) (http://www.hkwildlife.net/)
- HOSTS (caterpillar hostplants database, The Natural History Museum, London) (http://www.nhm.ac.uk/research-curation/projects/hostplants/)
- IndianMoths [Yahoo! Groups] (http://groups.yahoo.com/group/Indianmoths/)
- Insects of Papua Indonesia (http://www.papua-insects.nl/)
- International Association of Butterfly Exhibitions (http://www.butterflyexhibitions.org/)
- IUCN The World Conservation Union (http://www.iucn.org/)
- Lepidoptera [Wikipedia] (http://en.wikipedia.org/wiki/Lepidoptera)
- LepIndex (global Lepidoptera species database, The Natural History Museum, London) (http://www.nhm.ac.uk/research-curation/projects/lepindex/)
- List of butterflies of India (http://en.wikipedia.org/wiki/List_of_butterflies_of_India)
- List of moths of India (http://en.wikipedia.org/wiki/List_of_moths_of_India)
- Nature Campus: moths [自然教育網討論區 ： 蛾] – Taiwan (http://nc.kl.edu.tw/bbs/forumdisplay.php?f=12)
- Moths from the forests of Northern Thailand (http://www.thaibugs.com/moths1.htm)
- Moths of Borneo (http://www.mothsofborneo.com/)
- Moths of India [Flickr] (http://www.flickr.com/groups/mothsofindia/)
- Moths of Japan 【みんなで作る日本産蛾類図鑑V2】 (http://www.jpmoth.org/index.html)
- Moths of Taiwan [Flickr] (http://www.flickr.com/groups/moth/)
- The Nymphalidae Systematics Group (http://nymphalidae.utu.fi/)
- Penang Butterfly Farm (http://www.butterfly-insect.com/)
- Saturniidae Research (http://www.saturnia.de/Research/Saturniidae-Research.html)
- Sphingidae of S.E.Asia (http://www.sphin-sea.unibas.ch/)
- Sphingidae of the Eastern Palaearctic (http://tpittaway.tripod.com/china/china.htm)
- United Nations Environment Programme (UNEP) (http://www.unep.org/)
- Zootaxa (Lepidoptera section) (http://www.mapress.com/zootaxa/taxa/Lepidoptera.html)

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About KFBG

Kadoorie Farm & Botanic Garden (KFBG) is situated on the northern slopes of Hong Kong's highest mountain – Tai Mo Shan (957 metres). Within KFBG are streams, woodlands, orchards and vegetable terraces – together with conservation and education facilities.

KFBG, today, is a unique public-private partnership, incorporated and designated as a conservation and education centre by Ordinance (Chapter 1156) in the Legislative Council of Hong Kong on 20th January, 1995. While KFBG is a public organisation, it is privately funded by the Kadoorie Foundation.

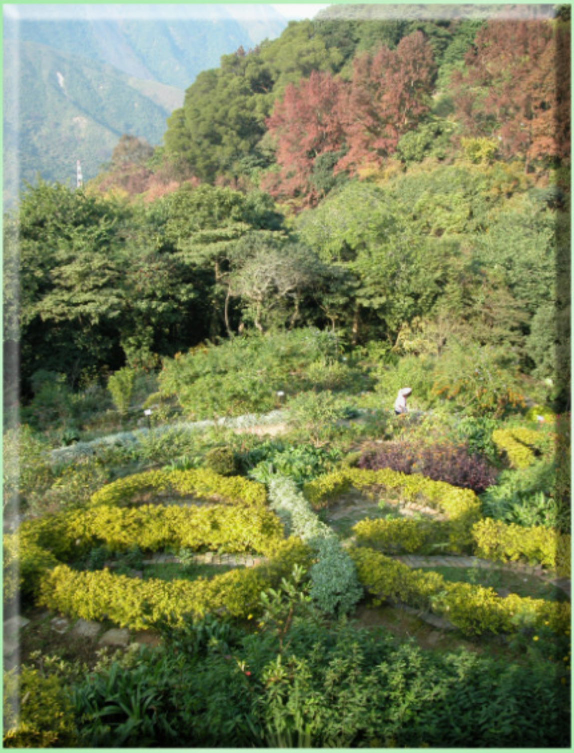
Since 1995, KFBG has focused on promoting conservation and sustainable living in Hong Kong and South China, with programmes on flora and fauna conservation and the promotion of organic agricultural practices.

KFBG's mission statement is "We exist to increase the awareness of our relationship with the environment and bring about positive change in the world through conservation and education".

KFBG's Fauna Conservation Department, which was established in 1994, promotes the conservation of animals and their habitats in Hong Kong and the region.

This book aims to provide an account of the first South East Asian Lepidoptera Conservation Symposium, which took place in Hong Kong and was hosted by Kadoorie Farm & Botanic Garden from the 4th to 8th of September 2006 at The University of Hong Kong's Kadoorie Agricultural Research Centre. Most of the presentations have been written up in full and form the bulk of this publication.

Presentations were grouped into four main themes: conservation assessment, conservation strategy, butterfly gardens & butterfly farming and internet resources, which have been reworked for this book by combining the first two themes and adding a local based Hong Kong section. Brief accounts of the other components of the symposium are added to provide a record of all the main activities.



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