

Appendix 9: Insects Sub-group Report

HONG KONG TERRESTRIAL AND FRESHWATER INSECTS

STATUS, TRENDS, RED LISTING & RECOMMENDATIONS

AUGUST 2014

EXECUTIVE SUMMARY

Hong Kong insect biodiversity is at present poorly known, despite the fact that this is the most diverse group of multicellular organisms on the planet.

Our knowledge of the status of the local insect fauna is limited to a few insect taxonomic groups (butterflies & moths, dragonflies & damselflies, mayflies, caddisflies, ants, partially beetles, partially aculeate wasp taxa) and in consequence only a few insect taxa have been assessed locally. Knowledge of population trends is minimal.

However, over 2400 species of moth, 240 butterflies, 115 dragonflies & damselflies, 180 ants, 70 mosquitoes, 40 termites, and over 150 aculeate Wasps have been recorded locally, as well as hundreds of beetles and smaller numbers of mayflies, caddisflies and stick insects. Some of these insects are endemic to Hong Kong and many species either entirely new to science or to the territory are discovered every year. An assessment conducted by the authors on a fraction of these Hong Kong species has revealed that 29 out of 46 moths, eight out of 10 aculeate wasps and three out of 104 dragonflies assessed qualified for threatened status (Critically Endangered, Endangered and Vulnerable) as defined by IUCN.

The ecology of these insects is diverse and understanding this is important to conserving the biota as a whole. A particular need is to study those that perform important known ecological services such as pollination, seed dispersal, nutrient recycling and soil turnover, and to gain a better understanding of their functional role within food webs.

Many threats endanger local insects, notably habitat destruction as a consequence of development (particularly in Country Park enclaves and feng shui woods, known to harbour a great many species); pollution and channelisation of our water courses; and invasive species. This is not to mention global warming for which the impacts are little understood but could well be very significant.

In consequence it is a recommendation of the authors that:

- Generic action plans be drawn up and enacted for all species of known conservation concern.
- Resources are made available in order to define and conduct species-oriented surveys covering at minimum moths, beetles, aculeate wasps and bees, ants, caddisflies, mayflies, true (dipteran) flies, in association with habitat and micro-habitat analysis not only to determine species at risk) but also to identify the trends and threats affecting assemblages as a whole.
- Resources are made available to define and conduct on medium- to long-term monitoring programmes on selected taxa/habitats so as to enhance knowledge of the population trends and factors that may be driving them.
- Research is needed to enhance understanding of the functional role of insects in terrestrial ecosystems, as this will provide a means of allowing prediction of the ecosystem-level effects of declines and loss of populations of particular species or functional groups.

1. INTRODUCTION

Insects are among the most diverse of all life forms, representing around 50% of the total recorded species (Gullan, 1998). As an example, the number of arthropod species estimated in tropical forests totals 6.1 million (Hamilton *et al.*, 2013; Basset *et al.*, 2012). Of 1,302,000 species described worldwide (Zhang, 2013), approximately 950,000 are insects.

Hong Kong supports an estimated 33,000 invertebrate species of which some 16,000 are insects (Dudgeon & Corlett 2004).

In addition insects have great ecological importance. They allow nutrient recycling through organic matter degradation and soil turnover; plant pollination and dispersal; and maintenance of plant and animal community composition and structure, by consuming plants and other animals, and as major components of food chains.

As such any Biodiversity Action Plan should pay particular attention to insects and other invertebrates to be representative.

However, due to the sheer numbers of species, taxonomic problems, and the resources required to survey and identify invertebrates, most remain under-studied, under-identified and under-represented in the scientific literature generally.

The present report is the result of a coordinated effort between several specialists of various insect taxa represented in Hong Kong.

It aims at presenting a partial summary of our present knowledge (or lack of it) of the terrestrial insect fauna of Hong Kong. No attempt has been made here to synthesise the fragmented and/or in-existent information on other invertebrate groups although their ecological importance cannot be underestimated.

The individuals that have contributed are listed below along with the taxon that they represent.

- Roger Kendrick: Lepidoptera (moths)
- Graham Reels: Odonata
- John Fellowes: Hymenoptera, Formicidae
- Christophe Barthélémy: Hymenoptera, Aculeata (except Formicidae).
- James Young: Lepidoptera (butterflies)

2. STATUS

Only a few taxonomic groups are well studied locally; these are dragonflies, butterflies (moths included), phasmids and some aculeate wasps. Beetles, despite recent effort, remain largely unknown, although this order represents over 60% of all described insect species and over 400 species of rove beetles alone are known from Hong Kong. Mollusca (land snails) have received some study in the past but the available information is neither up-to-date or comprehensive.

Our knowledge of other orders is patchy and the following are lacking data adequate for status assessment:

- Diptera
- Hemiptera (Auchenorrhyncha, Heteroptera and Sternorrhyncha) and Psocoptera
- Megaloptera and Neuroptera
- Mantodea, Blattodea, Isoptera, Dermaptera, Orthoptera
- Collembola.
- Hymenoptera: Parasitica.

Due to the limited taxonomic knowledge locally (and even globally) for many of these orders it is unlikely that in the medium term great progress will be made in terms of species identification, biology, ecology and understanding conservation importance. For pragmatic reasons it seems more appropriate to concentrate resources on the few orders where local knowledge exists in the hope these give an indication of the wider biota.

2.1 Moths - Roger Kendrick

2.1.1 Species Richness

Moths comprise the vast majority of the order Lepidoptera, with some 160,000 described species (and a similar number thought to be undescribed) globally. In Hong Kong, there are known to be around 2,400 species, with a further 1,500 to 2,000 estimated to occur, subject to surveys other than light-trapping being undertaken in a comprehensive manner. Most moth species currently known from Hong Kong are nocturnal or crepuscular; however, in Hong Kong there are at least as many diurnal moth species as there are butterfly species. It is suspected that many moth species yet to be documented in Hong Kong are small and primarily diurnal as adults, thus easily overlooked by even the most dedicated naturalists. Moths have been surveyed using light traps in Hong Kong since the 1960s, though little data has been published or written up that refers to population ecology. Lists of species have been published on at least three occasions (So, 1967; Lee & Winney, 1982; Kendrick, 2004), with a thorough list also compiled by Kendrick (2002) as part of his PhD thesis, though the taxonomy and nomenclature of these lists is now outdated and in need of revision. There have been several hundreds of species added to the list since 2004, with an updated list in preparation, based on the "Hong Kong Moths Recording Database" [HKMRD] maintained by C & R Wildlife (Kendrick, *pers. comm.*). Species new to science found in Hong Kong continue to be described; with at least 10 papers published post 1999 recording 20 newly described species, almost all endemic, to Hong Kong. There are some 70 moth species currently only known from Hong Kong, about 3% of the total moth fauna here.

2.1.2 Ecology

With one exception, all of the native species that are of conservation concern have no life history data published. Almost all moth species are herbivorous in the larval stages, whereas adult moths of most families feed on liquid resources, primarily nectar, as well as fruit juice, water ("mud-puddling"), sap, lachrymal fluid, blood (one species in Hong Kong) and ammonium compounds in vertebrate dung. Many of the adult moths that seek out nectar also act as pollinators for plants and thus provide valuable ecosystem function [ABT 14] (and services to humanity by pollinating fruit and vegetable crops). An estimated 10% of Hong Kong's moth species have some life-history data published, although this pertains mostly to well-known and globally widespread species that impact upon agricultural or horticultural produce.

2.1.3 Trends

There are very few published data upon which trends in populations of moth species in Hong Kong can be based. For hawkmoths (Sphingidae), one paper by Tennant (1992) gives some indication of population abundance of species recorded at light trap and nectaring at flowers; observations in the last decade indicate a decline of abundance of individuals of species from Sphingidae. Analysis of data held on the HKMRD also indicates that other species that were relatively abundant at light trap in the 1990s are now less frequently encountered; some markedly so. Initial analysis of HKMRD data indicates climate change is already affecting moth populations and species, causing shifts in global distribution and probably local distribution (elevationally as well as along a latitudinal gradient) and there are also changes in species phenology comparing data from the 1990s to more recent records, with more species recorded as adults from October through March and less species recorded from May through September, most likely due to increasing night time minimum temperatures.

2.1.4 Threats

In Hong Kong there are several threats that are impacting negatively upon moth species, in particular habitat loss and fragmentation of remaining suitable habitats [ABT 11] (i.e. remaining non-urban areas).

[ABT8] The "China-mark" moths (Crambidae, Acentropinae) are a group whose larvae are aquatic and are sensitive to pollution of their freshwater homes. The larvae of "footman" moths (Erebidae, Arctiinae, Lithosiini) are lichenivorous, thus are sensitive to airborne nitrogen and sulphur pollution. One under-studied area, and assumed threat, is that of light-pollution, which impacts upon populations of moths by disorienting individual moths to lights where they are preyed by other fauna during the night and the following morning. This effect is well documented elsewhere in the world (Frank, 1988) and is a known negative impact upon moth populations.

The long term effects of climate change [ABT 10] upon the local moth species is not yet fully understood, but will depend upon the ability of the species to either adapt to warmer conditions, or to change their distribution (latitudinally or elevationally) in order to maintain their existence within the abiotic thresholds that dictate their lives; in the latter scenario, should species move up an elevational gradient it should be noted that the habitat(s) upon which the moth species depend must also move uphill - and in Hong Kong there is not a long way to go up before there is no further habitat - Tai Mo Shan is only 957m tall!

[ABT 2, 3 & 4] One further local threat is the lack of any requirement to undertake nocturnal surveys for environment impact assessment - this is a major oversight in the EIA process and has the potential for enormous impact upon the ecology of Hong Kong, as Lepidoptera have such a key position in the food-web of species.

2.1.5 Knowledge Gaps

Many, especially relevant to ABT 19 - major knowledge gaps pertain to life history, distribution and population ecology of all the species of conservation concern. There are quite a few problems regarding correct identification of moth species in Hong Kong, including possible confusion species for some of the species of conservation concern. As yet there is no guide to species' identification that covers the species recorded to date, although a guide is in preparation, converting the PhD thesis of Kendrick (2002) into an illustrated guide to the moths of Hong Kong. This work has already been a decade in preparation (in a totally voluntary capacity), and is anticipated to be published by the Hong Kong Lepidopterists' Society in 2016, in time for Hong Kong's second hosting of the Asian Lepidoptera Conservation Symposium.

2.2 Odonata - Graham Reels

2.2.1 Species richness

The Odonata is a relatively small and well-studied insect order, comprising some 6,000 named species. The Hong Kong fauna currently stands at around 115 species (Tam et al. 2011), rising to about 120 if historical species records for which there are no recent confirmations are included. This compares well with the total of just over 200 Odonata species recorded by Wilson & Reels (2003) and Wilson (2005) for the far larger area of Guangxi province, the approximately 150 species in Taiwan (Yeh et al. 2006), and the approximately 170 species in Hainan (Reels & Zhang, in press), and is slightly less than half of the ca 250 species known from adjacent Guangdong (Wilson, 2014), one of the most species-rich provinces of China, with a land area more than 160x greater than that of Hong Kong. The vast majority of species known from the SAR are of Oriental provenance. Thirty Hong Kong species (nearly half of which are in the Gomphidae family) are restricted to tropical southern China, and one of these – *Leptogomphus hongkongensis* – is currently considered endemic to Hong Kong.

2.2.2 Ecology

All dragonflies are generalist predators (with the exception of the Pseudostigmatidae, a New World family of Zygoptera, species of which specialise in gleaning orb spiders from their webs), both in the larval and adult stages. The larvae are aquatic and consume freshwater invertebrates, fish fry and tadpoles as well as conspecifics. Some exceptionally large larvae, such as that of *Tetracanthagyna waterhousei*, are able to take adults of small fish species. Adult odonates are aerial predators that feed by capturing other flying insects. All lentic and lotic freshwater habitats, from phytotelmata to lakes and from tiny forest seepages to large rivers, are utilised as breeding and larval habitat by different odonate species. Many forest species are sensitive to pollution and sedimentation and require clean well-oxygenated water in order for the larvae to survive, while many species of open water habitats, notably in the cosmopolitan families Coenagrionidae and Libellulidae, are able to tolerate polluted water with high turbidity and low dissolved oxygen. Riparian habitats such as exposed boulders or vegetation provide the main habitat for adult male odonates, many of which establish breeding territories at the water's edge, but many females and immature adults forage and roost further afield and can be found many hundreds of metres from the nearest freshwater body. Two Hong Kong species, *Mortonagrion hirosei* and *Orthetrum poecilops*, are able to breed in brackish coastal mangroves and reedbeds, and are essentially restricted to these habitats.

2.2.3 Trends

Prior to the 1990s, dragonflies had only been studied sporadically in Hong Kong, commencing in the 1850s and culminating in the work of the Japanese odonatologist Syoziro Asahina in the 1960s and 1980s. Several species recorded in Hong Kong during this long period have not subsequently been recorded, but in most cases it is not possible to know whether this is due to errors of identification in the historical record or genuine local extinction. Since the early 1990s, however, there has been continuous and growing study of the local odonate fauna, beginning with the work of Keith Wilson. Two general trends can be surmised; both are related to habitat change. The drastic reduction in lowland wetlands such as active or abandoned fish ponds, rice paddies and wet vegetable fields that has occurred over the last few decades, through rapid changes in human land use, has inevitably impacted negatively on the many pond and marsh species which breed in these habitats. Similarly, lowland riverine species will have been badly affected by the unfortunate practice of channelising streams and rivers across the SAR and the stripping out of riparian vegetation along river banks. The extent of these impacts is not possible to quantify, but it is intuitively obvious that the more habitat that is lost, the worse the impacts will be. The second trend is of an ongoing recolonisation of Hong Kong by forest-associated dragonflies as the woodlands here continue to grow back and mature. Wilson (2014) argued that more than 20 large, strong-flying forest anisopterans first recorded in the SAR after 1990 were genuine new arrivals (as opposed to having been historically overlooked), recolonising from forested areas of Guangdong due to recent forest recovery in Hong Kong after a thousand years of severe anthropogenic deforestation.

2.2.4 Threats

Habitat loss is the major threat to Hong Kong dragonflies. As noted above, this is a particular problem for species of open lowland wetlands, although many species dependent on these habitats are regionally ubiquitous and of low conservation concern. Ponds and marshes in Hong Kong tend to occur outside of Country Parks, or within Country Park Enclaves, making them particularly vulnerable. Actively farmed fish ponds are still quite abundant, particularly in the NWNT, but are of far less value as dragonfly habitat than disused ones in which rooted, submerged macrophytes and floating vegetation are established. Such ponds, which can support very diverse dragonfly assemblages, are very rare in Hong Kong. Similarly, lowland rivers with natural substrates and riparian zones are increasingly scarce as DSD continues to channelise rivers outside of the protected areas system as a flood prevention measure, leaving them habitable by only the most tolerant and ubiquitous species. The majority of forested hill streams, trickles and seeps are located in Country Parks and in consequence enjoy a degree of protection.

2.2.5 Knowledge gaps

The Odonata is probably the most thoroughly known insect order in Hong Kong. Since 1995 there have been excellent field guides available for identification of the local fauna. However, detailed studies of the life histories and specific habitat requirements of the majority of species are lacking. Local distributional data are incomplete for many rare and potentially threatened species.

2.3 Ants - John Fellowes

2.3.1 Species Richness

Around 13,000 ant species are recorded worldwide (antbase.org: http://osuc.biosci.ohio-state.edu/hymenoptera/tsa.sppcount?the_taxon=Formicidae). In Hong Kong, ants were being collected and described from the 1850s onward (Smith, 1858), but most of our knowledge stems from extensive surveys during the early to mid-1990s, which distinguished around 180 species in about 70 genera (the higher taxonomy is constantly advancing). Of these, around 90 have been identified, with reasonable confidence, to a named species.

In general the smaller species are more likely to have been under-recorded, while some genera, such as *Pheidole*, have species almost impossible to distinguish based on the (most numerous) minor worker caste and have been under-recorded. It is likely that Hong Kong has well over 200 species, with older lowland forests particularly species-rich.

Since 2000 there has been very little active fieldwork on Hong Kong ants; however the arrival at HKU of myrmecologist Benoit Guenard in September 2014 may provide an opportunity to revive this work.

2.3.2 Ecology

Fellowes (1996) conducted work elucidating habitat associations of Hong Kong ants, which were subsequently given context by a series of surveys in South China (John Fellowes/Kadoorie Farm & Botanic Garden, various reports and unpublished). As a result we know something about the forest-dependence of local species, and their elevational ranges: in the 1990s most tropical taxa were confined to lower elevations (below about 500 m) locally. Some forest-dependent taxa are confined to the best- and most continuously-forested parts of Hong Kong, such as the northern Tai Mo Shan forests and Shing Mun.

Past work also gives some indication of the ecological roles of ant species, as predators, scavengers and consumers of plant exudates (Fellowes & Dudgeon 2004). Work elsewhere indicates this is of substantial ecological and socio-economic importance. Being, along with termites, the most abundant of insects (Wilson 1990), the ecosystem services they contribute are significant (e.g. Way and Khoo 1992; Folgarait 1998; Underwood & Fisher 2006). Ants are ubiquitous, occupy a variety of niches in a wide variety of terrestrial ecosystems and affect ecosystem functions at multiple levels of organization. Due to their static colonial mode their community influence is potentially greater than more mobile or ephemeral animal taxa.

Their direct role in pollination is thought to be minor, though they can affect pollination by nectar theft, flower consumption, antibiotic reduction of pollen viability, predation on or deterrence of pollinators, and conversely by preying on other predators of pollinators. Ants can be seed predators but also seed dispersers; up to one in three of the world's plants appear to have some adaptation to ant dispersal (Lengyel et al. 2010). They are of great importance in plant protection, and have been used in orchard biological control in the South China region for millennia. Ants are also important prey for a number of vertebrate species; notably they comprise most of the diet of HK's most globally-threatened mammal, the Chinese Pangolin (CR).

2.3.3 Trends

There is no population data on Hong Kong's native ants. The main basis for inferring trends is the changes in habitat, coupled with knowledge of habitat affiliation. Declines in feng shui wood and other relatively mature forest patches are of greatest concern, coupled with ecological degradation in the intervening matrix and the known spread of invasive species, such as *Solenopsis invicta*.

2.3.4 Threats

Habitat loss and fragmentation of remaining suitable habitats [**ABT 11**] (i.e. remaining non-urban areas) is perhaps the greatest threat to ants in Hong Kong and the region. A major additional threat is the associated spread of invasive species, particularly non-native ants such as *Solenopsis invicta* which builds up huge colonies and can transform local insect communities. These do not typically penetrate closed-canopy forests so their impact on forest ants is indirect, though small forest patches can be penetrated. Other invasive species such as *Wasmannia auropunctata* (Little Fire Ant), not yet established in tropical Asia, pose a greater risk in this regard. *Solenopsis invicta* has been implicated in the recent breeding failure of stilts in Inner Deep Bay, though this is unconfirmed; similar impacts are recorded elsewhere (Riecke et al. 2014).

Climate change [**ABT 10**] is likely already impacting ant populations, though evidence is scarce. The highest known latitudinal and elevational limits were recorded by Fellowes (2006) and it is likely that climate change is already affecting these in unmeasured ways – in particular by making exposed (south- or east-facing) habitats more inhospitable to forest-associated species.

Isolated populations of rare species may also face difficulties, as the effective population size is determined by the number of breeding queens – potentially rather small in restricted forest species. Where feng shui woods are disturbed, as in the gathering of leaf litter and dead wood, the effect is deleterious to the ant community and other litter- or wood-dependent species, as well as their predators.

[**ABT 2, 3 & 4**] Like most invertebrates ants have not been addressed in the EIA process, with a few exceptions during the 1990s when local expertise was available. As such there has been little in the way of a mechanism to prevent loss in ant biodiversity from development.

2.3.5 Knowledge Gaps

Much of the existing information on HK ants is unpublished, and requires update and publication.

While about half of the recorded Hong Kong species have been named, it is generally the unidentified species which are likely to be of greatest conservation concern. Taxonomic attention to these is a pressing need, particularly in the case of point-endemics which could become extinct if their populations are lost.

Information is needed as to the ecological impact of known invasive ants such as *Solenopsis invicta* and *Pheidole megacephala*. For others, such as *Anoplolepis gracilipes*, the native range is unknown, and there is a need for genetic study across its range. If alien, it is one of the most invasive species in Hong Kong and Southeast Asia.

Globally one in three plant species are thought to be dependent on ants for seed dispersal, especially in forest herbaceous plants. Studies exploring this locally would be valuable; one genus important in North America is *Aphaenogaster*, which has a few species patchily distributed in Hong Kong forests.

A study on Chinese Pangolin diet would be valuable, to ascertain how selective and therefore habitat-specific their needs may be.

2.4 Aculeates Hymenoptera (except ants) - Christophe Barthélémy

2.4.1 Species richness

The Hymenoptera is a large order of the insects, to date over 100,000 species have been described and possibly contain over 250,000 species worldwide (Gauld, 1996). The sub-division Aculeata of Apocrita contains approximately 73,200 worldwide species described to date including approximately 15,000 ants. Locally we have recorded about 154 named species (excluding ants).

We have monitored since 2004 the local aculeate fauna. Paratypes specimens have been collected since then and are deposited in our personal collection. The Hong Kong fauna has only started to be assessed recently and no comprehensive and historical data exists for the local species

The records so far are summarised in **Table 1**. Are excluded from this table all Formicidae, Chrysididae and Drynidae.

Table 1. Recorded species of Aculeata in Hong Kong.

Super Family	Family	ID'd Species	%
Vespoidea	Vespidae	49	31.8
	Mutillidae	2	1.3
	Pompilidae	12	7.8
	Scolidae	8	5.2
	Tiphiidae	1	0.6
	TOTAL VESPOIDEA		72
Apoïd Wasps	Ampulicidae	3	1.9
	Crabronidae	34	22.1
	Sphecidae	14	9.1
	TOTAL APOID WASPS	51	33.1
Apoïds	Apidae	14	9.1
	Colletidae	1	0.6
	Halictidae	7	4.5
	Megachilidae	9	5.8
	TOTAL APOIDEA	31	20.1
TOTAL		154	100.0

It is important to note that:

- The **Pompilidae** are under-represented in terms of identified species due to the lack of a modern comprehensive revision of this family and numerous taxonomic issues within the family

generating identifications difficulties. The author has upward 20 species deposited in his collection.

- The **Mutillidae, Scollidae and Tiphiidae** suffer the same problem than that of the Pompilidae. The author has a few (~ 3) additional non identified species in his collection.
- The **Vespidae** are well understood locally (Barthélémy *et al.* 2013) in the sub families Vespinae, Polistinae and Stenogastrinae totalling 28 species. Although we have only one record of *Ropalidia mathematica*. The eumenine are less well known and additional species may be found/identified later (~5-8).
- The **Crabronidae** are under-represented in terms of identified species due to the lack of a modern comprehensive revision of this family and numerous taxonomic issues within the family generating identifications difficulties. The author has upward 40 species deposited in his collection.
- The **Sphecidae** are well understood locally (Barthélémy. 2014), however the author has never recorded species in the genus *Chlorion* and additional species should be expected due to the known geographical range of the genus.
- The **Apoids** are under-represented in terms of identified species as taxonomic issues render identification difficult. The author has upward 40 species deposited in his collection.
- The author has recorded four species of **Drynidae** and eight species of **Chrysididae**. However due to their cryptic biology and generally very small size, it is very likely that additional species will be discovered in both families.
- **Formicidae** are excluded from the above count, but upwards of 180 species are known locally.

Locally it can be expected that over **200 species of aculeates** (excluding Formicidae) may be present. While none of the species that have been identified so far seem to be endemic, because our knowledge of the regional distribution of species is patchy it is impossible to rule out that within some families (Crabronidae, Pompilidae) the territory may host some endemic species.

A word is necessary concerning the “Parasitica” group of Hymenoptera. This taxon alone represents 90% of all Hymenoptera described to date and our knowledge of the local fauna is all but unknown. They are often represented by cryptic and very small specimens and identification is extremely complex. However, these wasps are extremely important in terms of ecology for their parasitic biology on many arthropod species. The author has upward 60 species deposited in his collection.

2.4.2Biology

All vespid and apoid wasps are carnivorous at larval stage, while the adults may feed on plant nectar and plant sap, and thus provide an important ecological service by pollinating plants and controlling plant pests through predation [**ABT 14**]. Adults may also feed on the haemolymph oozing from the sting wound of the arthropods that they hunt. Bees on the other hand feed uniquely on pollen and plant nectar (both at larval and adult stage) and perform the same ecological service than the other wasps (pollination).

The life history of some local wasps is well documented. We have published information for approximately 50 species out of the 200 that may be present locally. But by and large the biology of aculeates remains unknown and/or undescribed for the vast majority of species. Of the 10 species that have been assessed four have poorly known biology (*Ropalidia fasciata*, *Polistes rothneyi*, *Polistes strigosus* and *Calligaster himalayensis*).

2.4.3Trends

There are virtually no published data on trends of the local aculeate population and in consequence no trend assessment can be made.

One very localised study carried out by the author showed that aculeate population numbers were following a cyclical phenomenon which remains unexplained (Barthelemy, 2011).

2.4.4Threats

In Hong Kong the main threats to aculeate population resides in habitat loss and fragmentation of remaining suitable habitats [**ABT 11**] due to development particularly within the Country Park Enclaves, known to be of high species richness.

The effect of global warming [**ABT 10**] should not be under-estimated, but its impacts are as yet unknown and will depend on the ability of each species to either adapt to warmer conditions, or to change their distribution (latitudinally or elevationally) in order to maintain their existence within the abiotic thresholds that dictate their lives.

2.4.5Knowledge Gaps

There are many and important knowledge gaps pertaining to aculeates, all are relevant to **ABT 19**:

- Biology
- Population distribution, ecology and trends
- Identification and taxonomy
- Threats to populations

2. CONSERVATION ASSESSMENTS

One of the serious constraints in conservation assessments (Egoh et al. 2007) is sparse knowledge and data on the sources of ecosystem services, their ecology, dynamics and threats. The functions that support these services often depend upon particular taxa or guilds (Kremen 2005). To identify and address key priority areas under CBD it is necessary to know the precise ways in which important taxa contribute towards ecosystem processes and services, and the threats facing them. The Arthropoda are important in providing some basic essential services to mankind such as pollination (by many Hymenoptera, Diptera, Lepidoptera etc.), soil modification (by termites and ants) and pest suppression (by predatory activities of ants, mantids, spiders etc.).

3.1 Moths - Roger Kendrick

An initial list of moth species of conservation concern in Hong Kong was published in Fellowes *et al.* (2002), updated in Kendrick (2007). As part of the Hong Kong BSAP process, the species of conservation concern have been reviewed in 2013-14, with 46 species meriting immediate listing as important for conservation based on their global distribution and local threats. All of these species meet global IUCN Red List categories Vulnerable, or more endangered, based upon criteria for AOO & EOO, additionally meeting criteria based on one or more of threat to populations, degree of fragmentation and small population size (inferred). One species previously only known from Hong Kong has not been recorded since it was described in the 1850s and is thought to be extinct.

A list of these 46 species considered to be threatened with extinction in Hong Kong (and for most of these species, global extinction) is appended (Appendix 1). A further 33 species were also assessed based upon the same criteria, but not included in the HK Red List as there is currently no significant immediate threat to the known populations of these species, or their local populations are currently sufficiently robust that local red-listing is not required for the time being.

It is important to note that *Eristena sp. cf. argentata* population in HK is probably the largest anywhere in the world (Prof. Dr. Yen Shen, pers. comm.) and as such would merit to be added to a Species Action Plan.

3.2 Odonata - Graham Reels

The majority of dragonfly species occurring in Hong Kong have now been formally globally assessed for Red Listing by IUCN working groups (e.g. Mitra et al. 2010, Reels et al. 2012). Of 115 named species, 97 are listed as Least Concern. One species, *Mortonagrion Hirosei*, is Near Threatened; two are Vulnerable (*Macromia katae* and *Orthetrum poecilops*), and *Gomphidia kelloggi* is Endangered. *Cephalaeschna klotsi*, *Ophiogomphus sinicus* and *Sieboldius alexanderi* are considered Data Deficient. Eleven Hong Kong species have yet to be formally assessed. Three of these are species that have not been recorded in Hong Kong in recent times. The remaining eight are *Drepanosticta hongkongensis*, *Gynacantha japonica*, *Planaeschna skiaperipola*, *Asiagomphus hainanensis*, *Leptogomphus hongkongensis*, *Melligomphus guangdongensis*, *Idionyx victor* and *Macromidia ellenae*. Of these, all but *Gynacantha japonica* are restricted to tropical southern China, and *Leptogomphus hongkongensis* is endemic to Hong Kong.

3.3 Ants - John Fellowes

Fellowes et al. (2002) considered certain species to be of global concern (*Rotastruma stenoceps*, *Strumigenys heteropha*), regional concern (*Pachycondyla amblyops*, *Tetraponera nitida*), local concern (*Dolichoderus sibiricus*, *Pheidologeton melasolenas*, *Pyramica sauteri*), or potential regional concern (*Pristomyrmex brevispinosus*). In fact many more ant species meet such criteria; however they could not be reliably named. Examples include species of *Acanthomyrmex*, *Amblyopone*, *Aphaenogaster*, *Camponotus*, *Centromyrmex*, *Gesomyrmex* and *Polyrhachis*. None have been assessed using Red List criteria.

Singletons – species known from a single record – are problematic in conservation assessment of under-recorded taxa; Hong Kong has many of these. It is debateable whether they should be considered Critically Endangered or Data Deficient locally – in either case known populations should be protected, as their elimination could cause global extinction. Though it is a very small and possibly overlooked species, one

species described from a single specimen at Sha Lo Tung was *Acropyga septemstruma*; although this was subsequently synonymised with a species from New Guinea, *A. oceanica* (LaPolla, 2004), the adjustment was made without looking at the type specimen and seems doubtful given the great biogeographical separation between the two.

3.4 Aculeates Hymenoptera (except ants) - Christophe Barthélémy

No aculeates species are listed in IUCN Red List, in consequence this attempt is fraught with risks. The known biology, ecology and distribution of the majority of species in the taxon is absent/patchy and only a limited amount of historical data is available. IUCN guidelines require data that is to date generally very difficult to compile in all insects and invertebrates as a whole.

We are confronted with a vast knowledge gap globally. Locally the same could be said but systematic recording has increased of late in Hong Kong better informing our local knowledge and “reasonable” data on a species list can be put forth with Aculeata.

We have assessed 10 species using the IUCN Regional Assessment guidelines. Nine of which are in the Vespidae and one in the Apidae. The choice of these species is based on the author’s knowledge of the local fauna and is centred on those species which show scarce or problematic distribution, locally and/or globally and a summary of this assessment can be found in Appendix 3. However, by lack of resource this list has not as of yet been expanded and the author considers that at least another 50 species require proper assessment.

IUCN assessment is based on EOO and AOO, obtained through the on-line resource offered by Kew Gardens (geocat.kew.org). However, it has to be noted that while record sites are well known for Hong Kong - making the local AOO and EOO values relatively accurate the global AOO values are difficult/impossible to compile within the geographic range of the concerned species because the literature not always cites the sites of occurrence. In consequence the global AOO values are incorrect and not used for assessment.

4 RECOMMENDATIONS

4.1 Moths - Roger Kendrick

4.1.1 Action Plans

At the current time, a generic action plan for all the moth species of conservation concern (the Hong Kong Red List) should be prepared; with actions implemented to identify (i) the life histories (hence habitat needs) of, (ii) distributions of, (iii) population ecology of, and (iv) threats to all the species of conservation concern. Where necessary, immediate action should be taken to rectify / negate any threats likely to result in major decline or extinction of a species [ABT 12], or if a species is already at a low population level, action should be taken to increase the population of said species to a state where it is no longer at severe risk of extinction; such actions may include habitat protection, habitat restoration, in-situ or even ex-situ population restoration (breeding programmes). Monitoring of all species of conservation concern should be undertaken in order to establish and maintain an awareness of continuing population trends. This overall action plan should be reviewed with the review of the HKSAR BSAP and revised as necessary, including species specific action plans where and when appropriate.

4.1.2 Recommendations

- a. The suggested species be adopted in the initial Red Listing process and be reviewed thereafter at the five year review, or earlier if necessary;
- b. The generic species action plan for Hong Kong moths of conservation concern be written and enacted within the first BSAP five year period;
- c. The information gaps pertaining to the moths of conservation concern, i.e. their life history, distribution and population ecology, be addressed, with resources being made available to undertake the necessary research.

4.2 Odonata - Graham Reels

4.2.1 Red Listing

The following species should be formally assessed for the IUCN Red List: *Drepanosticta hongkongensis* (Platystictidae); *Planaeschna skiaperipola* (Aeshnidae); *Asiagomphus hainanensis*, *Leptogomphus hongkongensis*, *Melligomphus guangdongensis* (Gomphidae); *Idionyx victor*, *Macromidia ellenae* (Corduliidae). These assessments can and should be made promptly.

4.2.2 Priority species

The following should be considered priority action species: *Gomphidia kelloggi* (EN); *Macromia katae*, *Orthetrum poecilops* (VU); *Mortonagrion Hirosei* (NT); *Cephalaeschna klotsi*, *Ophiogomphus sinicus*, *Sieboldius alexanderi* (DD); *Leptogomphus hongkongensis* (endemic to Hong Kong); any other species listed in 4.2.1 which is not assessed as being of Least Concern. In addition, *Agriomorpha fusca*, although assessed as LC, is the only species in its genus and is restricted to one country (China) and thereby meets one of the sets of criteria for conservation priority species defined by the IUCN Odonata Specialist Group (Moore, 1997).

4.2.3 Species-specific conservation recommendations

During the first BSAP five-year period, species-specific conservation recommendations should be prepared for all species listed in 4.2.2, involving, where appropriate, prescriptions for study of specific habitat requirements and species distribution. In addition, a general dragonfly action plan should be drafted, focusing particularly on identifying species that, while not on the IUCN Red List, are locally rare and their Hong Kong populations potentially threatened. Monitoring of all species of conservation concern should be undertaken in order to establish and maintain an awareness of continuing population trends. This overall action plan should be reviewed with the review of the HKSAR BSAP and revised as necessary.

4.2.4 Priority sites

Wilson (1997) listed 23 key Hong Kong dragonfly sites, of which he considered eight to merit "protection and official recognition" – a recommendation which apparently fell on deaf ears. These sites were: Luk Keng, Ma Tso Lung, Shuen Wan, River Jhelum, She Shan, Sha Lo Tung, Tai Tong, Nam Chung and Wu Kau Tang. It is recommended that these unprotected sites, most of which deteriorated to some extent in the ensuing years, be reassessed and, if appropriate, re-proposed for some kind of recognition and protection. Surveys of the other 15 key dragonfly sites identified by Wilson should also be undertaken to facilitate a review of the state of Hong Kong's dragonfly fauna and evaluate any changes in status in the last two decades. These surveys should be completed within the first BSAP five-year period.

4.2.5 Funding

Adequate funding should be allocated to facilitate implementation of the recommendations given in 4.2.2, 4.2.3 and 4.2.4.

4.3 Ants - John Fellowes

- a. Following the precautionary principle, the known locations of species of concern should be protected.
- b. A pressing need is to review and update the identification of Hong Kong ants. Far greater diagnostic resources are available for this than during the 1990s, so some effort now should lead to identification of far more species, though it is likely that many will remain problematic due to errors in the Chinese literature and the likelihood of new species being present.
- c. The impact of known alien invasive species, notably *Solenopsis invicta*, should be studied as a matter of urgency so as to evaluate and monitor the threat to native invertebrates and other biota.
- d. Since Hong Kong is a major trade route an urgent priority is to greatly boost biosecurity and work with other Asian countries to minimise the risk of further spread of *S. invicta* and other highly invasive species. The author has initiated discussions on an action plan with experts from USA, Australia and China but greater Government involvement is needed for this to be effective.
- e. In view of the global significance of Hong Kong's population of Chinese Pangolin (now Critically Endangered) a study on the diet of the species would be wise, building on the anecdotal information

available to date. This suggests ants comprise the vast bulk of the diet, but it is unknown how selective pangolins are in this regard.

- f. Improved mapping of ant assemblages, using up-to-date spatial analysis tools, is important to understanding and responding to trends in ant biodiversity. While an elevational gradient has been detected in Hong Kong ants no truly Palaearctic genera have been recorded; it is unclear whether species more frequent at higher elevations do so as a result of abiotic or biotic influences. Similarly while past studies have shown variation between forests and non-forest habitats, and indicated variation between grassland slopes depending on exposure to desiccation and fire, we do not yet have a fine understanding of these patterns.

4.4 Aculeates Hymenoptera (except ants) - Christophe Barthélémy

The present knowledge gap in terms of biology and ecology of the local aculeate fauna (and all invertebrates) locally, is the single most important issue with regards to a comprehensive and accurate assessment of the local fauna. The conservation value of species can be easily overlooked in this context and a precautionary approach to creating a list of Species of Conservation Concern (SCC) should be exercised.

We recommend that the following actions be considered with regards to the local aculeate fauna (generally land invertebrates):

- a. Increase our knowledge of the local aculeate fauna by **implementing a consolidated survey and monitoring programme** (between the various stakeholders such as AFCD, NGO's and individuals) on a suite of selected taxa such as vespids, pompilids, sphecids & crabronids and all apoids (to consider, resources and local knowledge).
- b. Where necessary, immediate action should be taken to rectify / negate any threats such as habitat destruction, use of pesticides, etc.) likely to result in major decline or extinction of a species [**ABT 12**], or if a species is already at a low population level, action should be taken to increase the population of said species to a state where it is no longer at severe risk of extinction; such actions may include habitat protection, habitat restoration, in-situ or even ex-situ population restoration (breeding programmes)
- c. To **include** the following 10 species (6.5% of the locally identified species) in the **SCC** list with a review of the status of each in five years:
 - *Eustenogaster nigra*
 - *Polistes gigas*
 - *Polistes strigosus*
 - *Polistes rothneyi grahami*
 - *Ropalidia fasciata*
 - *Ropalidia marginata*
 - *Vespa mandarinia*
 - *Vespa mocsaryana*
 - *Calligaster himalayensis*
 - *Amegilla fimbriata*
- d. To treat the following species as **priority action species**:
 - *Ropalidia fasciata*
 - *Ropalidia marginata*
 - *Vespa mandarinia*
 - *Vespa mocsaryana*
 - *Calligaster himalayensis*
 - *Amegilla fimbriata*
- e. To **delineate protection zoning** for the known habitats in Hong Kong of the following species, all of which occur in and outside CP save for *C. himalayensis* that is only found in Sai Kung Country Park:
 - *Ropalidia fasciata*
 - *Ropalidia marginata*
 - *Vespa mandarinia*
 - *Vespa mocsaryana*
 - *Calligaster himalayensis*
 - *Amegilla fimbriata*

4.5 Butterflies - James Young

Four species of butterflies should be added as priority action species, these are :

- *Hasora vitta* : a cryptic species which is very vulnerable with a small population and an AOO of a couple of square kilometres.
- *Halpe paupera* : small AOO (a couple of square kilometres) and population seems decreasing; any devastating event can wipe out the whole population in HK.
- *Taractrocera maevius* : small AOO (couple of square kilometers) and any devastating event can wipe out the whole population in HK.
- *Thoressa monastyrskyi* : nowhere to be found in the whole of China though wide spread in Sai Kung.

5 CONCLUSION

While Hong Kong hosts a great many species of insects, only a few taxa have been properly assessed in terms of species richness, biology/ecology and conservation importance. This lack of knowledge stems from the incredible diversity of this group, the taxonomic difficulties encountered when trying to identify species and the lack of resources locally and globally dedicated to insects and generally invertebrates. In addition, habitat definition for insects largely differs from that of higher animals and the recognition of habitat structure in relation to insect assemblages is rather difficult to assess given our sub-tropical latitude (plant diversity) and the variability of habitat structures in Hong Kong (geology, hygrometry, topography and long history of human influence).

Our present knowledge of the local insect diversity lags behind that of plants and higher animals, and increased effort is needed to obtain not only a representative species list but also to understand the conservation importance (endemism, non-typical species, monotypical species, ecological function) of various assemblages and taxa. Resources required to achieve such knowledge are extremely important, and realistically this can be done for only a few groups such as moths, beetles (partially), wasps & bees (partially) and ants, while butterflies, dragonflies and damselflies have been quite systematically surveyed in Hong Kong.

As such it is a major recommendation of the authors that resources be made available in order to conduct species oriented surveys in association with habitat and microhabitat analysis and on the medium to long term that a monitoring programme on the selected taxa/habitat be conducted for our understanding of the population trends in relation to biotic and abiotic factors. By lack of time the authors have been unable to assess past information on some groups such as ants and some beetles (rove beetles), an exercise that still needs to be completed.

This will not only benefit our knowledge of the local insect fauna but would also allow for a better holistic approach to biodiversity assessment, as insects play an important part within the ecological food/energy web.

The sharing of data between “specialists” in these taxa is of paramount importance to obtain “reasonable” assessment and the authors note that some information remains “locked away” in government departments and has remained inaccessible to this group despite our continuous requests. If sharing is achieved without constraints it will benefit our knowledge and render assessments far more accurate and scientifically reliable.

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7 APPENDICES

Appendix 1. Table 1. Recommended list of moth species to include in Hong Kong Red List of Flora and Fauna

CAT.	Family	Species name	Species Author(s)	HK threats	HK AOO / km ²	HK EOO / km ²	Main habitat preference (adults)
				[n.b. a "location" as defined by IUCN may comprise more than one recording site if sites are within contiguous similar habitat]			
EXTINCT							
	SESIIDAE	<i>Chimaerosphesia sinensis</i>	(Walker, 1854)	no records since original description - 160 years ago	?	?	?
CRITICALLY ENDANGERED							
2	CRAMBIDAE	<i>Eristena</i> sp. nr. <i>argentata</i>	undescribed	habitat destruction (mangrove loss in Country Park [CP] enclaves)	4	?	mangrove
3	EUTELIIDAE	<i>Atacira</i> sp. nov.	undescribed	2 records, no further global distribution; 1 site unprotected (Sha Lo Tung) CP enclave	2	0	undetermined
4	GELECHIIDAE	<i>Dichomeris argentenigera</i>	Li, Zhen & Kendrick, 2010	one HK record (Wong Lung Hang, Lantau) habitat under threat of development (CP enclave site); only known from one other location globally (single record)	1	0	undetermined
5	GEOMETRIDAE	<i>Dindica hepatica</i>	Inoue, 1990	only known from type locality [TPK] with no confirmed subsequent records	1	0	2° forest
6	LIMACODIDAE	<i>Olonia zolotuhini</i>	Solovyev, Galsworthy & Kendrick, 2012	single record from Victoria Peak (outside CP), October 1991; habitat subject to pressure from property developers.	1	0	undetermined
7	OECOPHORIDAE	<i>Promalactis noviloba</i>	Wang, Kendrick & Sterling, 2009	1 record (Holotype): KISK (a supposedly protected area, though with no active conservation protection and recently subject to <i>Aquilaria</i> "theft") from 1999	1	0	undetermined
8	OECOPHORIDAE	<i>Promalactis similifulata</i>	Wang, Kendrick & Sterling, 2009	1 record (Holotype): Nam Chung (abandoned agricultural land adjacent to CP) from 2007	1	0	undetermined
9	SESIIDAE	<i>Cyanosesia ormosiae</i>	Kallies, 2011	1 record from 1 location (Ma On Shan); host trees possibly subject to "pest management" by AFCD ...	1	0	undetermined
ENDANGERED							
10	CRAMBIDAE	<i>Acropentias</i> sp. A	undescribed	small AOO/EOO; 3 records only; fragmented population, only one protected site (SSSI) one in Conservation Area [CA] zone, one in Village [V] zone)	3	?	undetermined
11	EREBIDAE	<i>Britha bilineata</i>	(Wileman, 1915)	3 HK records, 2 sites, one (Sha Lo Tung) under threat; Taiwan has main population	2	0.37	undetermined
12	GELECHIIDAE	<i>Dichomeris parvisexafurca</i>	Li, Zhen & Kendrick, 2010	5 records from 4 fragmented sites (1 Protected Area [PA] and 3 CP enclaves, one threatened); low population	4	152	undetermined

13	GEOMETRIDAE	<i>Axinoptera anticostalis</i>	Galsworthy, 1999	4 records from 2 locations (one PA, one CP enclave access route); fragmented; v. low population.	2	5.88	undetermined
14	GEOMETRIDAE	<i>Sauris victoriae</i>	Galsworthy, 1999	7 records from 3 sites (1 PA, 1 CP enclave access + "Victoria Peak") - only one post 2000 record (Chuk Yueng Road); severely fragmented; low population.	3	131	undetermined
15	NOCTUIDAE	<i>Chasmina sinuata</i>	Galsworthy, 1997	3 records from 3 locations (1 PA only, other two sites subject to property development pressure)	3	73.6	undetermined
16	OECOPHORIDAE	<i>Stereodytis brevignathus</i>	Wang & Kendrick, 2009	3 records from 2 sites (1PA, 1CA under developmental pressure)	2	0	undetermined
VULNERABLE							
17	CRAMBIDAE	<i>Palpita minuscula</i>	Inoue, 1996	17 HK records 1965-2014, though only 1 post 2007; small EOO, 5 known sites, only 2 protected	9	171	undetermined
18	EREBIDAE	<i>Bertula retracta</i>	Galsworthy, 1997	23 records, low population, fragmented; HK population is greatest global.	48	627	2° forest
19	EREBIDAE	<i>Acidon evae</i>	Lödl, 1998	70 records from 7 sites; fragmented, only 3 PAs; no post 2010 records, fluctuating population	14	308	undetermined
20	EREBIDAE	<i>Schrankia bilineata</i>	Galsworthy, 1997	12 records from 7 fragmented sites; low population;	9	343	undetermined
21	GELECHIIDAE	<i>Dichomeris anisacuminata</i>	Li & Zheng, 1996	9 records from 7 sites; only one PA; 3 village enclave sites; fragmented, low population	9	287	undetermined
22	GELECHIIDAE	<i>Dichomeris orientis</i>	Park & Hodges, 1995	10 records from 5 fragmented sites (one PA, 3 CP enclaves and one threatened V site)	6	221	undetermined
23	GEOMETRIDAE	<i>Microcalicha reelsi</i>	Sato & Galsworthy, 1998	26 records from 3 locations (CP, SSSI and private PA); 1 record since 2006	3	5.36	undetermined
24	GEOMETRIDAE	<i>Thalassodes maipoensis</i>	Galsworthy, 1997	8 confirmed records from 2 PA locations (Mai Po, Tin Shui Wai); no records post 2004; site mismanagement, pollution loading, sites' fragmented; low population; ecology unknown.	4	1.11	coastal/mangrove
25	OECOPHORIDAE	<i>Promalactis apicispinifera</i>	Wang, Kendrick & Sterling, 2009	4 records from 2 locations (one PA, one CP enclave); fragmented; v. low pop. BUT likely under-recorded due to very small size	3	2.47	undetermined
26	OECOPHORIDAE	<i>Promalactis quinilineata</i>	Wang, Kendrick & Sterling, 2009	6 records from 3 fragmented locations (1PA, 2CP enclaves, one of which is subject to planning proposal)	4	62.9	undetermined
27	OECOPHORIDAE	<i>Variacma tomentosa</i>	Wang, 2011	2 records from single site (KISK) PA at risk from trashing by illegal logging of <i>Aquilaria</i>	1	?	2° forest
28	SPHINGIDAE	<i>Cypa uniformis</i>	Mell, 1922	4 post 1990 records, 4 locations (1 developed subsequently; 1CA under developmental pressure; 1 PA under pressure from <i>Aquilaria</i> theft; 1 village)	4	77.1	undetermined

29	XYLORYCTIDAE	<i>Neospastis sinensis</i>	Bradley, 1967	25+ records from 6 locations (2 PAs; 2 CP enclaves, both at risk from development; 2 villages)	4	14	undetermined
NEAR THREATENED							
30	EREBIDAE	<i>Acidon paradoxa</i>	Hampson, 1896	60 records from 6 partly fragmented sites, 2 (Sha Lo Tung and Chuk Yeung Rd) in CP enclaves; stable but small population	13	94	undetermined
31	EREBIDAE	<i>Hypena</i> sp. A / nov. nr. <i>umbripennis</i>	undescribed	8 records from 2 sites (both PAs)	2	1.09	undetermined
32	EREBIDAE	<i>Luceria striata</i>	Galsworthy, 1997	~60 records; 8 sites, half not protected, 3 in V or enclaves; low population; fragmented.	23	546	undetermined
33	EUPTEROTIDAE	<i>Apha kantonensis</i>	Mell, 1929	170+ records; possible population decline since 1990s	32	433	undetermined
34	GELECHIIDAE	<i>Dichomeris davisii</i>	Park & Hodges, 1995	5 records from 3 sites (one CP enclave, one PA, one luxury coastal development); not threatened in Taiwan, the only other area of global distribution	3	12.9	undetermined
35	GELECHIIDAE	<i>Dichomeris hamulifera</i>	Li, Zhen & Kendrick, 2010	13 records from 6 sites (one since destroyed by development; one V, rest PAs), low population	9	326	undetermined
36	GEOMETRIDAE	<i>Sauris purpurotincta</i>	Galsworthy, 1999	15 records from 9 locations (4 PAs, one CP enclave, 3 unprotected / village, 1 golf course); low population; fragmented	10	644	undetermined
37	LIMACODIDAE	<i>Praesetora kwangtungensis</i>	Hering, 1931	3 records from 2 locations (both abandoned ag. land outside PAs near villages); very low population.	3	1.08	undetermined
38	NOCTUIDAE	<i>Belciana scorpio</i>	Galsworthy, 1997	50 records from 9 locations widely spread through HKSAR, 4 PAs, two sites in Villages, one site destroyed by property development; low population.	12	193	undetermined
39	NOCTUIDAE	<i>Athetis bispurca</i>	Galsworthy, 1997	21 records from 3 sites (2 PAs and one lost to development); fragmented sites, though seemingly reasonably stable pop at KFBG	4	35	undetermined
40	NOCTUIDAE	<i>Egira ambigua</i>	Galsworthy, 1997	10 records from 4 locations (1PA, 1 Conservation Area, 2 Village); small population but flies Jan-Feb, so likely under-recorded	5	13.4	undetermined
41	NOCTUIDAE	<i>Feliniopsis hyperythra</i>	Galsworthy, 1997	7 records from 4 locations; 2 PAs, one village site and Port Island (1993); low population	3	34.2	undetermined
42	NOCTUIDAE	<i>Feliniopsis margarita</i>	Galsworthy, 1997	14 records from 5 locations, 2 PAs 1 CP enclave (Tai Long Wan), 1 village and Victoria Peak (1990s)	7	278	undetermined

43	NOTODONTIDAE	<i>Micromelalopha albifrons</i>	Schintlmeister, 1989	15 records from 9 locations (2 PAs, 3 CP enclaves, 1 Conservation Area, 3 unprotected / village); low population; fragmented	9	329	undetermined
44	OECOPHORIDAE	<i>Promalactis lobatifera</i>	Wang, Kendrick & Sterling, 2009	30 records from 11 locations (4 PAs, 4 CP enclaves, 3 village sites); 2 of the enclave areas are subject to planning proposals	13	625	undetermined
45	OECOPHORIDAE	<i>Promalactis longiuncata</i>	Wang, Kendrick & Sterling, 2009	15 records from 5 locations (2 PAs, 1 village, 1 luxury coastal development, 1 CP enclave with planning proposal)	5	114	undetermined
46	OECOPHORIDAE	<i>Stereodytis acutidens</i>	Wang & Kendrick, 2009	46 records from 9 locations (3PAs, 1 village, 3 CP enclave, 1 SSSI, 1CA; 4 of these sites under development pressure and 1 under development; 1 site lost to development)	14	352	undetermined

Table 2. Further moth species assessed for 1st BSAP Red Listing, but not meeting local threat criteria; these species should be reviewed in the next BSAP audit.

DATA DEFICIENT							
	CRAMBIDAE	<i>Paranacoleia elegantula</i>	Du & Li, 2008	DD			undetermined
	GEOMETRIDAE	<i>Spiralisigna gloriae</i>	Galsworthy, 1999				undetermined
	NOTODONTIDAE	<i>Micromelalopha simonovi</i>	Schintlmeister, 1997				undetermined
	SESIIDAE	<i>Gaea variegata</i>	(Walker, 1864)				undetermined
	SESIIDAE	<i>Nokona semidiaphana</i>	(Zukowsky, 1929)				undetermined
LEAST CONCERNED							
	EREBIDAE	<i>Cerynea discontenta</i>	Galsworthy, 1998	90 records; no immediate overall threat			undetermined
	EREBIDAE	<i>Hyposada kadooriensis</i>	Galsworthy, 1998	40+ records, 8 mostly fragmented sites; no overall imminent threat			undetermined
	EREBIDAE	<i>Oglaa stygiana</i>	Galsworthy, 1997	60+ records, 8 mostly fragmented sites; no overall imminent threat			undetermined
	EREBIDAE	<i>Ugia purpurea</i>	Galsworthy, 1997	350+ records; no overall imminent threat despite EOO			2° forest
	EREBIDAE	<i>Lysimelia lucida</i>	Galsworthy, 1997	120+ records from 20+ sites			2° forest
	EREBIDAE	<i>Bellulia galsworthyi</i>	Fibiger, 2008	30+ records, 8 mostly fragmented sites; no overall imminent threat			undetermined
	EREBIDAE	<i>Pangrapta bicornuta</i>	Galsworthy, 1997	140+ records; no overall imminent threat despite EOO			undetermined
	EREBIDAE	<i>Pangrapta roseinotata</i>	Galsworthy, 1997	140+ records; no overall imminent threat despite EOO			undetermined
	GEOMETRIDAE	<i>Calletaera digrammata</i>	Wehrli, 1925	130+ records; 7 locations			undetermined
	GEOMETRIDAE	<i>Lophophelma calaurops</i>	(Prout, 1912)	300+ records in HK			undetermined
	GEOMETRIDAE	<i>Maxates brevicaudata</i>	Galsworthy, 1997	50 records from 9 locations (mostly PAs)			undetermined
	GEOMETRIDAE	<i>Pingasa chloroides</i>	Galsworthy, 1998	29+ records from 6+ locations (at least 4 in PAs)			undetermined

	GEOMETRIDAE	<i>Eupithecia mundiscripta</i>	(Warren, 1907)	20 records from a single location (PA: KFBG/KISK) from 200m to 570m elevation		undetermined
	GEOMETRIDAE	<i>Sigilliclystis kendricki</i>	Galsworthy, 1999	115+ records from 15+ locations		undetermined
	GRACILLARIIDAE	<i>Gibbovalva singularis</i>	Bai & Li, 2008	12 records from 3 locations (all PAs, fragmented, low population)		undetermined
	NOCTUIDAE	<i>Callopietria flavitincta</i>	Galsworthy, 1997	100+ records from 15 sites, mostly in PAs		undetermined
	NOCTUIDAE	<i>Athetis hongkongensis</i>	Galsworthy, 1997	185+ records from many locations		generalist
	NOCTUIDAE	<i>Sugitania uenoi sinovietnamica</i>	Owada & Wang, 2010	5 records from a single location (PA); flies in January at mid-elevations so likely under-recorded		undetermined
	OECOPHORIDAE	<i>Promalactis biovata</i>	Wang, Kendrick & Sterling, 2009	35 records from 11 locations (6PAs); no significant threat at the moment		undetermined
	OECOPHORIDAE	<i>Ripeacma umbellata</i>	Yuan & Wang, 2009	25 records from 15 locations		undetermined
	OECOPHORIDAE	<i>Variacma bifariafera</i>	Wang, 2011	3 records from a single location (KFBG)		2° forest
	OECOPHORIDAE	<i>Variacma hongkongensis</i>	Wang, 2011	3 records from 3 sites in single location (PA and CP enclave)		2° forest
	PYRALIDAE	<i>Coenodomus</i> sp. A / nov.	undescribed	20+ records from 14+ locations, mostly unprotected but no significant threats at present		undetermined
	PYRALIDAE	<i>Tanyethira</i> sp. A (nov.) nr. <i>duplicilinea</i>	undescribed	30+ records from 20+ locations (including CP enclaves under developmental pressure)		undetermined
	PYRALIDAE	<i>Tyndis</i> sp. A / nov.	undescribed	4 records from 2 locations (1PA, 1 GB)		undetermined
	THYRIDIDAE	<i>Hypolamprus</i> sp. nr. <i>emblicalis</i>	undescribed	30+ records from 6+ locations; none under immediate threat		undetermined
	TORTRICIDAE	<i>Cochylimorpha hapala</i>	(Diakonoff, 1984)	3 post 2000 records, all from PAs		undetermined

Appendix 2. Table 3. Recommended Aculeata species to include in Hong Kong Red List of Flora and Fauna

No.	Family	Genus	Species Author(s)	HK threats	HK AOO / km ²	HK EOO / km ²	Main habitat preference (adults)
CRITICALLY ENDANGERED							
1	Vespidae	<i>Ropalidia marginata</i>	(Lepeletier, 1836)	Recorded from only one site in a non protected area	4.00	0.00	Disused farmland
2	Vespidae	<i>Calligaster himalayensis</i>	(Cameron, 1904)	Recorded only from 2 sites in HK, both in protected areas.	8.00	0.00	Mostly unknown, secondary forest(?)
3	Apidae	<i>Amegilla fimbriata</i>	(Smith 1879)	Recorded from two sites only. Both in un-protected areas (Shatin Park and Ping Shan Chai enclave)	8.00	0.00	Disused farmland, mostly unknown
ENDANGERED							
4	Vespidae	<i>Vespa mandarinia</i>	Smith 1852	3 records, all on the outlying Islands, Lamma and Lantau, in non protected areas.	12.00	0.00	Not known
5	Vespidae	<i>Polistes rothneyi</i>	van der Vecht, 1968	Many records in non-protected areas, rare in most country parks	68.00	240.00	Active or disused farmland
6	Vespidae	<i>Ropalidia fasciata</i>	(Fabricius, 1804)	Recorded from very few sites in Hong Kong. One major population in Kam Tin MTRC wetlands.	12.00	1.00	Over water bodies, nest affixed to water plants
VULNERABLE							
7	Vespidae	<i>Eustenogaster nigra</i>	Saito and Nguyen, 2006	23 records. Marshland, riparian band destruction, many sites of occurrence in CP enclaves.	60.00	662.00	Reproduction and life cycles habitats: Dark & humid sites, in and around wetlands, close to streams (Saito et al., 2006. Barthelemy, 2009 & 2010), old agricultural land is a habitat of choice. Shallow water bodies are essential for breeding as male and female hover over them (pers. obs.).
8	Vespidae	<i>Polistes strigosus</i>	Bequaert, 1940	Recorded from 14 sites, mostly in non-protected areas (Village and agricultural land)	52.00	350.00	Abandoned or active orchards.
NEAR THREATENED							
9	Vespidae	<i>Polistes gigas</i>	(Kirby, 1826)	48 Records, in non protected areas but also CP enclaves	156.00	806.00	Variable and oportunist.
DATA DEFICIENT							
10	Vespidae	<i>Vespa mocsaryana</i>	du Buysson, 1905	1 record in Hong Kong in an urban area.	4.00	0.00	Healthy Forest