Developing strategies for invertebrate conservation: the case for the Seychelles islands

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Abstract: Approaches to invertebrate conservation in Seychelles are reviewed. These comprise taxonomic research and Red List assessments, monitoring of populations and the status of habitats, monitoring of introduced species and research into their ecology and research into the status of pollinators. Further research is required on the effects of invasive species, identification of key pollinators and the effects of climate change. Red List assessments are given for threatened Mollusca, Orthopteroidea and Lepidoptera.

Keywords: invertebrate conservation, invasive species, pollinators, Red List assessments, taxonomy

In 2001, a meeting was held in Washington to investigate the practicalities of developing a global strategy for invertebrate conservation. This 'Invertebrate Scoping Workshop' proposed 8 main actions needed for the full integration of invertebrates in the planning and conservation assessments of the World Conservation Union (IUCN) (IUCN/SSC/CBSG 2001). To date, these have only been partially implemented due at least in part to a lack of funding. The recommendations are being implemented at a local level in Seychelles and this provides an indication of the relevance of these actions to developing conservation action.

Taxonomic Specialist Groups of IUCN's Species Survival Commission cover only a small proportion of the world's invertebrates. This has lead to a recent increase in the number of regional groups. The Seychelles islands fall within the remit of the Southern African Invertebrate Specialist Group. As the workshop's recommendations were aimed at global conservation, not all aspects are relevant to a single country.

The following is a summary of the workshop recommended outputs to address the priority issues in invertebrate conservation

1. Lack of taxonomic and conservation related knowledge
    1.1 Develop linkage and collaboration with the wider invertebrate community
    1.2 Co-ordinate taxonomic and conservation activity at individual and agency level
        1.2.1 Specialist Group chairs and members need to contact editors of

journals that publish taxonomic descriptions and encourage them to include a Red List assessment as part of descriptions/revisions/checklists.

  1.3 Generate and link reliable and accessible web-based biodiversity and status data

      1.3.1 Ensure sufficient linkage to existing key (including, if possible georeferenced specimen based) databases. This needs to be part of the functionality of SIS or coordinated through the Global Biodiversity Information Facility (GBIF).

  1.4 Influence and support relevant efforts (e.g. Global Taxonomic Initiative and GBIF) to encourage increasing current resource levels

  1.5 Facilitate identification of priority taxa of conservation concern.

      1.5.1 The Invertebrate Conservation Committee needs to coordinate efforts to target key taxa for assessing invertebrate conservation status across ecosystems.

      1.5.2 Specialist Groups should be encouraged to produce user-friendly specimen identification guides.

  1.6 SSC/IUCN needs to address the fact that species protection laws can prevent specimen collecting for scientific and conservation purposes. The ability to undertake such work is essential for obtaining reliable data on the species status.

2.   Habitat destruction

  2.1 Accurate assessment of invertebrate biodiversity loss relating to type and intensity of existing habitat destruction.

      2.1.1 Promote the implementation of accurate loss assessments

  2.2 Proactive baseline assessments for monitoring of invertebrates as related to trends and future potential habitat destruction.

      2.2.1 Promote the use of invertebrates in geographical prioritisation exercise

      2.2.2 Development and promotion of standardised international sampling methodologies

      2.2.3 Review the impact on invertebrate communities in priority habitats (e.g. caves, mangroves)

  2.3 Assessing synergistic impacts of habitat destruction with other threatening processes as agents of local and/or global extinction

      2.3.1 To highlight instances where the interplay of different impacts has resulted in exceptionally high loss of invertebrate diversity such that a discontinuity has occurred.

3.   Human resource issues

  3.1 Enhance the current information and networking mechanism so as fully to utilise the knowledge and ability of the international invertebrate community.

4. Invasive species
    4.1 To raise the consciousness of the problem
    4.2 Enhance the representation within SSC of invertebrate issues in management of invasive species
    4.3 Facilitate better information exchange about invasive invertebrate species and their effects on other species

5. Lack of awareness
    5.1 To harness information on the value of invertebrates in maintaining ecological integrity and health and to disseminate the information in popular form through print and electronic media.

6. Pollinator loss
    6.1 Quantify and characterise the problem.

7. Climate change
    7.1 Monitor fluxes in selected taxa across all ecosystems. Document and publicise these results.

8. Exploitation and sustainable use
    8.1 Identify those species that are threatened through exploitation
        8.1.1 Compile red data list of those species that are , or may be, unsustainable exploited
    8.2 Review the inappropriate use of CITES higher taxon listing where it relates to "trade" (movement) in scientific specimens and facilitating trade where it has a conservation benefit.
    8.3 Review the conservation value, economic viability and enforcement implications attached to popular invertebrate farming activities.

Actions carried out in Seychelles in relation to these outputs are:

1.   Taxonomy and Red Listing
Through the work of the Indian Ocean Biodiversity Assessment 2000-2005 (IOBA) of the Nature Protection Trust of Seychelles (NPTS) a world-wide network of taxonomists has been developed primarily to ensure the identification of all material from Seychelles (action 1.1). The outputs of the IOBA comprise individual taxonomic revisions, the publication of monographs and the development of a biodiversity database. Database linkage is being developed by the Africa Environment Information Network (action 1.3.1). The monographic series on the Seychelles fauna, scheduled for launch in 2005 is aimed at providing user-friendly specimen identification guides (action 1.5.2).
Red List assessments are being provided by the monographic series (with some assessments published separately). The recent establishment of a Red List focal point in the Seychelles Ministry of Environment provides a coordinated approach

to the development of a national Red List and the assessments from the IOBA will be contributed to the national listing process. The Red List assessments available to date comprise the Lepidoptera, Orthopteroidea and Molluscs (Appendix I).

As of 2005, the editorial policy of *Phelsuma* is that all future taxonomic and inventory papers concerning species not assessed for the Red List should include Red List assessment as far as practical (action 1.2.1).

The distribution and population assessments provided by the IOBA will allow prioritisation of taxa of conservation concern (action 1.5.1).

Research agenda: Continuation of ongoing taxonomic revisions.

Action requirements: Continuation of ongoing taxonomic revisions and Red Listing.

2. **Habitat destruction**

The IOBA provides baseline data for the status of most invertebrate species, trends in status can be detected for a small number of taxa and these are being evaluated as part of the Red Listing process (action 2.1.1). The methods used by the IOBA are standard and appropriate for use by diverse professional and amateur researchers, as such this represents the development of standardised monitoring protocols (action 2.2.2). In addition monitoring methods have been developed for the giant tenebrionid beetle *Pulposipus herculeanus* (Gerlach 2005a), snails and diurnal hawkmoths (Appendix II).

To date, no reviews have been carried out on the status of invertebrates in the priority habitats, (action 2.2.3). In Seychelles, these represent freshwater marshes, mangroves and high forest. Priority conservation sites in the granitic islands have been identified by the IOBA in terms of animal diversity, plant diversity and the distribution of threatened species (GERLACH 2003a). This is being further refined by the development of a Seychelles biodiversity atlas.

Research agenda: Monitoring of priority taxa and habitats.

Action requirements: Evaluation of the status of invertebrates in priority habitats using the biodiversity data collected by the IOBA.

3. **Human resource issues**

Although there is a considerable volume of invertebrate knowledge in Seychelles, there remains a problem of insufficient use of appropriate human resources in the country. Accordingly, action 3.1 remains inadequately addressed. Currently a significant proportion of conservation projects employ overseas staff for invertebrate work and fail to support existing Seychelles expertise.

Action requirements: Existing capacity in Seychelles for invertebrate research and conservation should be more effectively deployed. This is a matter of capacity utilisation and not capacity building.

4. **Invasive species**

There is a high degree of awareness of the importance of invasive species in Seychelles (action 4.1) with the issue being highlighted in all status reviews and

workshops and the formulation of an Invasive Alien Species National Committee. The issue has mainly been highlighted with reference to habitat change and the impacts of introduced mammals on bird populations. The publication of the first invasive species list will be a first step in improving information exchange about all invasive species (action 4.3). Only limited research has been carried out on the impacts of invasive invertebrate species (e.g. the carnivorous snail *Euglandina rosea* (Say, 1840) and the crazy ant *Anoplolepis gracilipes* (Smith, 1857) – Haines & Haines 1979, Gerlach 1999, 2001, 2004, 2005b). More work is also required on the impact of invasive alien plants on the endemic invertebrate fauna.

Research agenda:

Distribution - the distribution of notable invasive species of all taxa needs to be monitored, and specific research carried out into their impacts.

Ecology– although almost all literature considers invasive species to be a problem for conservation, there are situations where introduced species become established as keystone species. In Seychelles, such a case has been identified with the cockroaches *Pycnoscelus indicus* (Fabricius) and *P. surinamensis* Linnaeus. These form a major part of the invertebrate biomass on the sea-bird islands of Aride, Cousin and Cousine and are the main components of the diet of the Endangered Seychelles magpie robin *Copsychus seychellarum* Newton, 1867 (Samways 2000; Le Maitre 2002). Removal of these introduced species, even if feasible, would have major negative impacts on the magpie robin. Similar dependence on invasive species has been identified in the Seychelles bee hawkmoth *Cephonodes tamsi* Griveaud, 1960 which is currently dependent on the invasive weed *Lantana camara* as its main nectar source (Gerlach 2000).

Research should concentrate on invasive predators and parasites, and plants, that are likely to have significant impacts on habitats, and which can be realistically controlled or locally eradicated.

Action requirements: where practical invasive species should be controlled before becoming problematic. This could be achieved for the snail *Euglandina rosea* through manual collection. Generally the preservation of diverse, dynamic habitats should minimise problems of invasion. Removal of invasive plants has been highly successful on the small and contained island of Cousine and in small areas of Silhouette, increasing the area of occupancy for various indigenous and endemic reptiles and birds, as well as for invertebrates.

5. **Lack of awareness**

   Invertebrate conservation remains a low priority generally and their value in ecology has not been widely publicised. Further work in this area is required. Nevertheless, through major fora such as the Expanding the Ark Coalition and the IUCN Species Survival Commission's Invertebrate Conservation Committee, some progress is being made.

6. **Pollinator loss**

   This is an emerging issue in global conservation. It has not yet been addressed in

Seychelles and little research has been carried out on this topic to date, it is a major priority for the future (action 6.1).

Research agenda: Research into the identity and status of pollinators is urgently required to determine which indigenous species are the most significant pollinators and how these interact with introduced pollinators, and which plant specific pollinators are essential for the pollination of the keystone and threatened endemic plants. Only a small amount of research has so far addressed this topic (FLOATER 1995; CADBURY 2001). Other related issues that require further research are the significance and identity of seed and seedling predators and seed distributors.

Action requirements: At present the key actions required are implementation of the research agenda. Until such time as reliable data on this issue are available, a precautionary approach should be adopted and all habitats managed to maximise natural systems.

7. Climate change

No monitoring or research relating to the impact of climate change on invertebrates has been carried out in Seychelles.

Research agenda: Monitoring should be continued or initiated using taxa selected as potential indicators of the impacts of climate change. Suitable taxa include Mollusca (monitoring ongoing – see section 2). The Seychelles giant millipede (*Sechelleptus seychellarum* (DESJARDINS, 1834)) also appears to be a good candidate as it is highly sensitive to changes in rainfall (GERLACH *et al.* 2005).

Action requirements: Implementation of the research agenda.

8. Exploitation and sustainable use

No terrestrial invertebrates are exploited in Seychelles at present. Exploited marine species include molluscs, corals, spanner crab, lobsters and sea-cucumbers. Red List assessments of marine invertebrates is required and should prioritise these exploited taxa (action 8.1.1). Similarly invertebrate farming (action 8.3) is restricted to the tiger prawns on Coetivy and the pearl farming on Praslin; the conservation implications and regulation of these need ongoing monitoring.

Research agenda: Monitoring of exploited species.

Action requirements: Maintenance of ongoing monitoring of harvest levels. Red List assessments of marine invertebrates is required, with assessment of exploited taxa being a priority.

In addition to the general aspects summarised above species-specific actions have been carried out for the larger invertebrates present on Fregate island (FERGUSON & PEARCE-KELLY 2005; GERLACH 2005A; GERLACH *et al.* 2005), specifically the Fregate island giant tenebrionid beetle *Pulposipus herculeanus* SOLIER, 1848, Seychelles giant scorpion *Chiromachus ochropus* KOCH, 1838, giant millipede *Sechelleptus seychellarum* and Fregate island snail *Pachnodus fregatensis* VAN MOL & COPPIS, 1980. These involve captive breeding, ecological research, habitat management, control of potential predators and investigation of the status of pathogens (specifically entomopathogenic fungi).

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Appendix I. Red List status of Lepidoptera, Orthopteroidea and Mollusca

The Seychelles islands have a highly diverse and phylogenetically significant endemic invertebrate fauna. The fauna of islands is widely reported to be particularly threatened in the current biodiversity crisis. Despite this there is little information

on the status of island faunas, with the exception of vertebrates. A small number of Seychelles invertebrate species have been included on the IUCN Red Lists; the 1996 (Baille & Groombridge 1996) list included the Seychelles crow butterfly *Euploea mitra* (Endangered), the butterfly *Phalanta philiberti* (Endangered), the swallowtail butterfly *Papilio phorbata nana* (Extinct), Seychelles fineliner damselfly *Teinobasis a. alluaudi* (Endangered), Seychelles giant tenebrionid beetle *Pulposipus herculeanus* (Critically Endangered) and the giant clams *Tridacna maxima* and *T. sqamosa* (conservation dependent). In 1997 the first attempt at a comprehensive listing was made with the publication of a Red Data Book for the islands (Gerlach 1997). This used the 1994 Red List Criteria and the limited distribution data available at the time, 195 invertebrate species were listed and of these two molluscs were added to the global Red List (Hilton-Taylor 2000).

The Indian Ocean Biodiversity Assessment 2000-2005 provides the first full survey of the biodiversity of the Seychelles islands. The completion of the surveys of the granitic islands in 2003 (Gerlach 2003a) allows the status of the fauna to be comprehensively assessed. Here we report on the results of the first invertebrate groups to be assessed using the new data: Mollusca, Lepidoptera and Dictyoptera.

Data for Seychelles invertebrates comprises distributions for all species but only limited data on population trends for a small number of taxa; accordingly most assessments rely on range restrictions. In the assessments tabulated below criteria D1 applies to small populations, D2 to restricted range (under 20km^2), B1abv and 2abv to restricted range with declining populations and B1biii and 2biii to restricted range with declining habitat (e.g. marsh associated species). Categories are abbreviated as follows: DD = data deficient; LC = Least Concern; VU = Vulnerable; EN = Endangered; CR = Critically Endangered.

Mollusca include a high proportion of threatened species (27%). Almost all of these are categorised as Vulnerable on the basis of restricted ranges (83%). The main additional threats are historical habitat destruction leading to population extinction (12%). 17% of Orthopteroidea are threatened, all these threatened species are Vulnerable due to restricted range. Overall 28% of Lepidoptera are threatened, with notably high levels in the Tineidae (42%), Gracillariidae (50%), Oecophoridae (30%), Momphidae (32%), Metachandidae (32%), Arctiidae (31%), Sphingidae (31%) and Nymphalidae (18%). Of these the majority are threatened by association with a threatened habitat or restricted ranges. Excluding habitat association and range restriction, high threat levels are found only in the Sphingidae (31%) and Nymphalidae (28%). It is notable that these are the largest Lepidoptera in the islands, mostly species laying eggs in a clumped pattern. These species may be vulnerable to egg or larval parasitoids and predators. In the Nymphalidae two species appear to have declined dramatically in the mid 1900s (*Euploea mitra* remaining abundant until 1959 but declining subsequently and *Phalanta philiberti* declining between 1909 and 1953, when it was last recorded). No change in probable predators (bird species) is known to have occurred in this time period but several insect parasitoids were introduced in biological control programmes. It is suspected that such introductions may have contributed to the decline in these species.

Table 1. Threatened Orthopteroidea of Seychelles. Globally threatened species in bold type

	Status	Islands[1]	Extent of occurrence (km²)	Area of occupancy (km²)	Records[2] 1892	Records[2] 1905-10	Records[2] 1975-2005	Restricted association	Seychelles Red List
ORTHOPTERA									
	ACRIDIDAE								
Catantops a. axillaris	Africa	1	6	6.0		+	+	coastal	Vu (D2)
	GRYLLIDAE								
Gryllapterus tometosus	Endemic	2	25000	15.0	+	+	++	>500m	Vu (B2)
Malgasia sp.	?	1	5.0	12.5			++	coastal	Vu (B2)
Seychellesia nitidula	Endemic	1	10.0	10.0		+	+	>300m	Vu (D2)
	MOGOPLISTIDAE								
Arachnocephalus mevedevi	Endemic	1	11.7	11.7			+	coastal	Vu (D2)
Ectatoderus aldabrae	Endemic	1	11.7	11.7			+	coastal	Vu (D2)
Ornebius stenus	Endemic	1	11.7	11.7		+	+	coastal	Vu (D2)
	MYRMECOPHILIDAE								
Myrmecophilus microscopicus	Endemic	1	2.7	2.7			+	lowland	Vu (D2)
Myrmecophilus seychellensis	? Comoros	3	300	4.0			+	lowland	Vu (D2)
	TETRIGIDAE								
Ocytettix nymphula	Endemic	1	5.0	5.0		+	+	>400m	Vu (D2)
Ocytettix pupulus	Endemic	1	5.0	5.0		+	+	>400m	Vu (D2)
DICTYOPTERA									
	BLATTELLIDAE								
Balta crassivenosa	Endemic	1	5.0	5.0	-	3	-	high marsh	Vu (B2)
Delosia ornata	Endemic	1	3.9	3.9	-		-	coastal	Vu (B2)
Hololeptoblatta pandanicola	Endemic	1	3.0	3.0	-	16	-	high marsh	Vu (B2)
Margatteoidea dmoana	Endemic	1	3.9	3.9	-	5	-	coastal	Vu (B2)
Theganopteryx scotti	Endemic	1	2.7	2.7	-	1	-	lowland	Vu (B2)
	NOCTICOLIDAE								
Nocticola gerlachi	Endemic	2	800	10.0	-	-	+	open grass	Vu (D2)
	POLYPHAGIDAE								
Holocompsa pusilla	Endemic	1	5.0	5.0	-	1	-	high forest	Vu (D2)
DERMAPTERA									
	ANISOLABIDIDAE								
Antisolabis scotti	Endemic	1	5	5.0	-	+	++	high forest	Vu (B2)
Antisolabis seychellensis	Endemic		5	5.0	-	-	+	high forest	Vu (B2)
	SPONGIPHORIDAE								
Chaetolabia fryeri	Endemic	1	15	15.0	-	++	++	high forest	Vu (B2)
Chaetospania gardineri	Endemic	2	300	15.0	-	++	++	palm bases	Vu (B2)

1. Islands – number of islands occupied. 2 – numbers of individuals in collections or present but not quantified or only observed (+)

Table 2. Threatened Lepidoptera of Seychelles (columns as Table 1), globally threatened species in bold type.

Table (taxonomic list of Lepidoptera families, Seychelles). Data columns rotated on the page.

Status		Islands	Extent of occurrence (km²)	Area of occupancy (km²)	Recorded 1892-1910	Recorded 1956-60	Recorded 1968-2005	Restricted association	Seychelles Red List
TINEIDAE									
Endemic	*Afrocelestis lochaga*	2	300	22.1	1	-	2	marsh	EN (B2abiii)
Endemic	*Amphixystis crobylora*	1	10	10	-	-	1	high forest	VU (D2)
Endemic	*Amphixystis cyanodesma*	1	300	10	2	-	-	high forest	CR (B1abv,2abv)
Endemic	*Amphixystis ensifera*	2	300	172	9	-	-	high forest	VU (D2)
Endemic	*Amphixystis fricata*	3	300	172	13	-	-	high forest	EN (B1abv,2abv)
Endemic	*Amphixystis ichnora*	3	300	100	23	-	3	marsh	EN (B1abv,2abv)
Endemic	*Amphixystis lactiflua*	1	-	-	-	14	-	-	EN (B2abii)
Endemic	*Amphixystis nephalia*	1	152.5	152.5	1	1	-	coastal	EN (B1abv,2abv)
Endemic	*Amphixystis polystrigella*	1	300	172	17	1	-	high forest	EN (B1abv,2abv)
Endemic	*Amphixystis photinula*	1	300	4.6	-	-	-	coastal	VU (D2)
Endemic	*Amphixystis rorida*	5	300	200	1	5	5	bat guano	EN (B1abv,2abv)
Endemic	*Amphixystis roseostrigella*	1	175	20	-	-	-	high forest	VU (B2)
Cosmopolitan	*Crypsithyrodes concolorella*	2	900	20	29	-	1	marsh	
Cosmopolitan	*Erechthias calypta*	5	4.6	4.6	-	-	-	-	EN (B1abv,2abv)
Endemic	*Erechthias methodica*	2	152.5	152.5	-	1	2	coastal	EN (B1abv,2abv)
Endemic	*Erechthias molynta*	1	300	20	6	1	-	coastal	EN (B1abv,2abv)
Endemic	*Erechthias palaeplaga*	4	0.01	0.01	-	-	-	mid-altitude	CR (B1abv,2abv)
Endemic	*Erechthias trichodora*	2	175	175	6	-	-	high-altitude	EN (B1abv,2abv)
Pantropical	*Opogona florea*	4	1625	20	28	9	1	-	EN (B1abv,2abv)
Endemic	*Opogona heliogramma*	2	300	175	3	-	-	high forest	EN (B1abv,2abv)
Endemic	*Opogona sacchari*	1	10	10	3	-	1	high forest	VU (D2)
Endemic	*Tinea coronata*								
GRACILLARIIDAE									
Endemic	*Acrocercops angelica*	2	600	47.5	1	5	-	coastal	EN (B1abv,2abv)
Endemic	*Caloptilia tyranniella*	1	4.6	4.6	-	2	-	coastal	VU (D2)
Endemic	*Cuphodes luxuriosa*	2	300	172	9	-	-	coastal	EN (B1abv,2abv)
Endemic	*Cuphodes tridora*	2	132.6	152.6	1	15	1	mid-altitude	EN (B1abv,2abv)
OECOPHORIDAE									
Endemic	*Anachastis digitata*							coastal	
Endemic	*Bigotianella menaiella*	1	10	10	1	16	-	high forest	VU (B2)
Endemic	*Bigotianella simpsoniella*	1	4.6	4.6	-	5	-	coastal	VU (D2)
Endemic	*Bigotianella toulnefortiaecoletla*	1	4.6	4.6	2	6	-	coastal	VU (D2)
Endemic	*Chrysistis syrtopa*	2	20	20	2	-	1	coastal	VU (D2)
Endemic	*Cophomantella cubiculata*	1	-	-	-	17	-	high forest	VU (D2)
Endemic	*Pachnistis fulvocapitella*	2	152.5	152.5	1	-	-	high marsh	CR (B1abv,2abv)
Endemic	*Paraclada tricapna*	1	0.3	0.3	-	-	-	marsh	EN (B1abiii)
Endemic	*Stathmopoda glyphanobola*							coastal	VU (D2)
BLASTOBASIDAE									
Endemic	*Blastobasis intrepida*	1	152.5	152.5	1	11	-	-	EN (B1abv,2abv)
GELECHIIDAE									
Endemic	*Apocritica chromatica*	1	20	20	1	19	2	-	VU (D2)
Asia	*Helcystogramma effera*	2	300	172	1	19	-	-	EN (B1abv,2abv)
Endemic	*Thiotricha subtenuis*	2	2000	159.4	-	13	-	coastal	EN (B1abv,2abv)
MOMPHIDAE									

Species	Distribution	n						Habitat	IUCN status
Ascalenia isotveta	Endemic	2	300	172.5	1	16	2	marsh	EN (B2abiii)
Cosmopteryx flavofasciata	Palaeotropical	4	80000	311	6	28	-	coastal	EN (B1abv,2abv)
Cosmopteryx mimetis	Asia	1	152.5	152.5	-	7	-	high forest	VU (D2)
Lymnaecia superharpalea	Endemic	2	4.6	4.6	33	7	-	coastal	EN (B1abv,2abv)
Stagmatophora agris	Endemic	2	300	155.5	33	10	-	-	EN (B1abv,2abv)
METACHANDIDAE									
Metachanda coetivyella	Endemic	1	1.5	1.5	-	7	-	coastal	VU (B2)
Metachanda columnata	Endemic				3	-	-	high forest	VU (D2)
Metachanda crypsitricha	Endemic	2	300	172.5	83	10	1	high marsh	EN (B1abv,2abv)
Metachanda glaciata	Endemic				1	-	-	high mash	CR (B1abv,2abv)
Metachanda hydrula	Endemic				-	-	1	marsh	-
Metachanda noctivaga	Endemic	1	20	20	-	11	-	coast	EN (B2abiii)
Metachanda plumbaginella	Endemic		152.5	152.5	-		-		EN (B1abv,2abv)
EPERMENIIDAE									
Epermenia roza	Asia	1	20	20	1	-	-	VU plant	VU (D2)
HELIODINIDAE									
Heliodines roblatis	Endemic	2	300	172.5	22	1	-	-	EN (B1abv,2abv)
EPICROCISIDAE									
Epicrocis	Endemic	5	240	3.2	-	-	5	*Pisonia* forest	VU (D2)
Achyra massalis	Palaeotropical	9	800	168.3	26	25	-	coastal	EN (B1abv,2abv)
Ancylosis niveicostella	Asia	2	4.6	4.6	22	2	-	lowland	EN (B1abv,2abv)
Cadarena pudoraria	Palaeotropical	4	1625	175.5	>9	5	-	lowland	EN (B1abv,2abv)
Cnaphalocrocis trapezalis	Palaeotropical	2	2000	158.4	3	11	-	-	EN (B1abv,2abv)
Crocidolomia pavohana	Palaeotropical	6	300	152.5	22	7	-	coastal	EN (B1abv,2abv)
Epanheudes nigropunctata	Madagascar	2	152.5	152.5	-	10	-	lowland	EN (B1abv,2abv)
Glaucocharis muscella	Endemic	4	3700	201.5	33	30	-	lowland	EN (B1abv,2abv)
Noorda blitealis	Asia	4	1.3	0.01	5	16	-	VU plant	EN (B1abv,2abv)
Eurrhyparodes tricoloralis	Palaeotropical	2	0.01	0.01	13	27	-	lowland	VU (D2)
Haritalodes derogata	Asia	3	1625	155.2	17	3	-	coastal	EN (B1abv,2abv)
Herpetogramma licarsisalis	Pantropical	3	152.5	172.5	-	6	-	lowland	EN (B1abv,2abv)
Herpetogramma phaeopteralis	Asia	2	300	172.5	-	33	2	-	EN (B1abv,2abv)
Lamprosema clathralis	Endemic	4	300	1.3	5	14	-	coastal	VU (B2)
Lamprosema delhommealis	Asia	2	1.5	1.5	-	13	-	coastal	VU (B2)
Limnaea ablactis	Endemic		152.5	152.5	5	29	-	coastal	EN (B1abv,1abv)
Pleuroptya sabinusalis	Palaeotropical	3	80000	310.9	9		-	lowland	EN (B1abv,2abv)
Ptyobathra tregularis	Endemic								
Pycnarmon diaphana	Asia								
Pyralis manihotalis	Palaeotropical								
Stenochora sericea	Afro-Malagasy								
CHOREUTIDAE									
Anthophila gratiosa	Endemic	1	1.4	1.4	1	1	-	coastal	VU (B2)
Anthophila quincyella	Endemic	1	4.6	4.6	-	-	-	coastal	VU (B2)
TORTRICIDAE									
Cryptophlebia caeca	Endemic					+	-	coastal	VU (D2)
Oethreutes conchopleura	Endemic	1	4.6	4.6	1	-	-	high marsh	CR (B1abiii,2abiii)
Oethreutes hygrantis	Endemic				-	-	-	high forest	VU (D2)
ARCTIIDAE									
Argina astraea	Palaeotropical	3	304	174.5	12	32	1	lowland	EN (B1abv,2abv)
Utetheisa subfusca	Endemic		30	30	4	1	-	?	VU (B2)
Mahensia seychellarum	Asia				8	-	-	coastal	VU (B2)
Utetheisa lotrix	Palaeotropical		2.2	2.2	-	1	-	coastal	VU (D2)
Utetheisa pulchella									
NOCTUIDAE									
Acontia zelleri	Africa, India	1	11.8	11.7	2	-	-	coastal	VU (B2)
Agrotis longidentifera microtica	Endemic				3	-	-	coastal	VU (B2)

							Habitat	Seychelles Red List
Bocana sp.	Endemic ?	1				1	VU plant	VU (B2)
Gesonia bansalis	Palaeotropical	4	1625	172.5 (20)	13	14	coastal	EN (B1abv,2abv)
Porphyrinia cf. ragusanoides	Madagascar	1	152.5	152.5	7	7	lowland	EN (B1abv,2abv)
Progonia patronghis	Asia		900	152.3	7	16	coast	EN (B1abv,2abv)
Rhesala moestalis	Palaeotropical	3		182.3	+33	23	lowland	EN (B1abv,2abv)
Spodoptera cilium	Palaeotropical							
NOLIDAE								
Celama tarzanae	Endemic	1	4.6	4.6	2	2	coastal	VU (B2)
Maceda mansueta	Asia	1	4.6	4.6	10	10	coastal	EN (B1abv,2abv)
SPHINGIDAE								
Cephonodes tamsi	Endemic	3	1625	200	1	1		CR (S1)
Macroglossum alluaudi	Endemic	2	300	172.5	1	1	lowland	VU (D1)
Nephele leighi	Madagascar	3	330	173.9	2	1	?	Extinct ?
HESPERIIDAE								
Tenga ... nosq. pekoveri						2	-	VU(B1abii,2abii)
NYMPHALIDAE								
Relonis ... Matthias	Palaeotropical	1	6.6	6.6	-	+	coastal	VU (D2)
Euploea mitra	Endemic	2	300	172.5	57	39	high forest	EN (B1abv,2abv)
Junonia rhadma	Afro-Malagasy	2	6.6	6.6	4		coastal	VU (B2)
Phalanta philiberti	Endemic		1625	-	25	1	high forest	Extinct

Table 3. Threatened Mollusca of Seychelles. Current data, with historical data in parentheses. Population and area trends since 1994. Globally threatened species in bold type.

MOLLUSCA	Islands occupied	Population estimate	Population decline	Range (km²) total	Range (km²) decline	Habitat	Seychelles Red List
Neritidae							
Neritina gagates	1	600	-	0.12	-	freshwater	Vu (B1, 2)
Neritina pulligera knorri	1	600	-	0.12	-	freshwater	Vu (B1, 2)
Neritina pulligera stumfi	2	500	-	0.10	-	freshwater	Vu (D1, 2)
Neritinia consimilis	2	600	-	0.12	-	freshwater	Vu (D1, 2)
Septaria borbonica	2	600	-	0.12	-	freshwater	Vu (D1, 2)
Viviparidae							
Paludomus ajanensis[1]	2	10?	20%	<0.01	20%	freshwater	En (D2)
Bulinidae							
Bulinus bavayi	1	5,000	-	0.01	-	freshwater	Vu (B2)
Hydrobiidae							
Moomnia willii	2		-		-	*Pandanus* axils	Vu (B2)
Vaginulidae							
Tropidophora (Ligatella) ligata	5	18,500	-	17.47	-	coastal forest	Vu (B2)
Semperula parva	8	343,800	-	18.47	-	forest	Vu (B2)
Cecilioides mauritiana		354,300	-	2.41	-	lowland	Vu (B2)
Allopeas gracile			-	4.36	-	palm forest	Vu (B2)
Edentulina dussumieri praslinus			-	2.74	-	palm forest	Vu (B2)
Edentulina dussumieri reservae		1,000	-	7.00	-		CR (B2ab(iii))
Edentulina moreleti	2	84,000	-	3.50	-	*Dracaena* axils	Vu (D2)
'Gulella' silhouettae	2	<216,000	-	2.16	-	moss forest	Vu (D2)
'Gulella' thomassetti[2]	1	<1,000	-	0.01	-	high forest	CR (B2ab(iii))
Stereostele nevilli parvidentata	1	525,800	-	18.59	-	high forest	Vu (D2)
Imperturbatia violascens	1	23,500	-	6.00	-	high forest	Vu (D2)
Silhouettia silhouettae	1	1,773,400	-	17.67	-	high forest	Vu (D2)
Careoradula perelegans	2	29,100	-	19.03	-	low forest	CR (A2a)
Conturbatia crenata[3]	1	0?	>80%	0.35	-	high forest	Vu (D2)
Priodiscus spinatus	1	64,700	-	2.16	-	high forest	Vu (D2)

Family	Species	n	Population	%	Area		Habitat	Status
Acavidae	*Priodiscus costatus*	5	8,000	–	8.00	–	high forest	Vu (D2)
	Stylodonta unidentata sobertae	1	6,960,700	–	10.84	–	marshes	Vu (D1, 2)
	Stylodonta unidentata globosa	1 (2)	1,000	–	10.39	–	forest	Vu (D2)
	Stylodonta unidentata praslina	1	700	–	7.50	–	palm forest	Vu (D1, 2)
	Stylodonta unidentata parva	1 (3)	50,000	–	5.00	–	forest	Vu (D2)
	Stylodonta studeriana	2 (3)	12,100	–	12.12	–	forest	Vu (D2)
'Chronidae'	*Nesokaliella subturritula*	1	500,000	–	8.00	–	high forest	Vu (D2)
	Nesokaliella minuta	1	8,000	–	8.00	–	high forest	Vu (D2)
	Nesokaliella intermedia	1	44,300	–	3.28	–	high forest	Vu (D2)
Euconulidae	*Louisia duponti*	1	?	–	8.00	–	lowland	Vu (D2)
Helicarionidae	*Dupontia levensoniae*	1	1,700	–	8.16	–	high forest	Vu (D2)
	Pilula mahesiana	2	3,200	–	7.16	–	high forest	Vu (D2)
Cerastidae	*Pachnodus (P.) velutinus*	1	0	–	5.00	–	moss forest	Extinct
	Pachnodus (P.) niger niger	1	5,000	–	5.00	–	high forest	Vu (D2)
	Pachnodus (P.) niger subfuscus	1	3,000	–	5.00	–	palm forest	Vu (D2)
	Pachnodus (P.) niger x velutinus	1	3,525,000	–	16.00	–	forest	Vu (D2)
	Pachnodus (P.) lionetti	1	89,700	–	17.47	–	forest	Vu (D2)
	Pachnodus (P.) becketti	1	50,500	–	6.00	–	forest	Vu (D2)
	Pachnodus (Nesiocerastus) ornatus	1	101,000	–	12.00	–	forest	Vu (D2)
	Pachnodus (N.) silhouettanus	1	46,600	–	15.31	–	forest	Vu (D2)
	Pachnodus (N.) fregatensis[3]	1	7,700	87%	2.00	–	low forest	En (A1a)
	Pachnodus (N.) kantilali	1	545,000	–	15.00	–	high forest	Vu (D2)
	Pachnodus (N.) praslinus	1	7,000	–	7.00	–	palm forest	Vu (D2)
	Pachnodus (N.) oxoniensis	1	422,800	–	3.28	–	moss forest	Vu (D2)
	Pachnodus (N.) ladiguensis	1	0	–	0	–	forest ?	Extinct
	Pachnodus (N.) curiosus	1	0	–	0	–	forest ?	Extinct

[1] GERLACH 1997; [2] GERLACH 2002; [3] GERLACH 1995a

Table 4. Summary of Tables 1-3 by family

	DD	LC	Globally threatened				Nationally threatened			
			VU	EN	CR	EX	VU	EN	CR	EX
Orthopteroidea										
Phasmoptera										
Phasmidae		6								
Orthoptera										
Acrididae	3	10					1			
Eumastacidae		1								
Gryllacrididae		2								
Gryllidae		25	2				4			
Gryllotalpidae		1								
Mogoplistidae		7					3			
Myrmecophilidae				1			2			
Phasgonuridae		5								
Tetrigidae		5	2				2			
Tettigoniidae		5								
Tridactylidae		1								
Mantoidea										
Mantidae	1	3								
Dictyoptera										
Blaberdiae	2	1								
Blattellidae	13	15	6				6			
Blattidae	1									
Nocticolidae				1			1			
Polyphagidae				1			1			
Dermaptera										
Pygidicranidae		1								
Anisolabididae			2				2			
Carcinophorinae	1									
Spongiphoridae		6	2				2			
	21	**94**	**17**	**0**	**0**	**0**	**24**	**0**	**0**	**0**
Lepidoptera										
Nepticulidae	1									
Tineidae	6	23	8	11	2		9	12	2	
Psychidae	2									
Gracillariidae	2	4	2	4			2	4		
Oecophoridae	10	8	6	1	1		6	1	1	
Blastobasidae	1	1		1				1		
Gelechidae	8	13	1	1			1	2		
Momphidae	4	9	1	3			1	5		
Metachandidae	4	11	2	3	2		2	3	2	
Scythiridae			1				1			
Copromorphidae	1									
Alucitidae		2								
Carposinidae	1									
Epermeniidae							1			
Glyphipterigidae		2								
Plutellidae		2								
Yponomeutidae	1	1								
Lyonetidae	1			1				1		
Heliodinidae				1			1			
Immidae	2									
Hyblaeidae		1								
Thyrididae	4	3								
Pyralidae	38	57	1	2			4	17		
Pterophoridae	5	7								
Choreutidae			2				2			

	DD	LC	Globally threatened				Nationally threatened			
			VU	EN	CR	EX	VU	EN	CR	EX
Tortiricidae	11	17	2		1		2		1	
Geometridae	8	17								
Uraniidae		1								
Notodontidae		1								
Lymantriidae		1								
Arctiidae	5	6	2				4	1		
Noctuidae	35	55	1				4	4		
Nolidae	8	4	1				1	1		
Sphingidae	1	8	1		1	1	2		1	1
Hesperiidae	1	4					1			
Pieridae	1	3								
Lycaenidae		6								
Nymphalidae	3	5		1		1	1	1		1
	164	**272**	**32**	**28**	**7**	**2**	**45**	**53**	**7**	**2**
Mollusca										
Neritidae							5			
Viviparidae				1				1		
Thiariidae		1								
Bulinidae							1			
Helicidae		1								
Cyathopomidae		2								
Hydromiidae			1				1			
Pomatisiidae		2								
Vaginulidae		3								
Ferussaciidae		1								
Subulinidae		4								
Tornatellidae		1								
Streptaxidae		18	4		2		4		2	
Succineidae		2								
Acavidae		4	3				3			
Punctidae		1								
Chronidae		1	2				2			
Euconulidae		2								
Helicarionidae		3	1				1			
Pupillidae		3								
Pupisoma		1								
Cerastidae		9	2	1		3	2	1		3
	0	**61**	**13**	**2**	**2**	**3**	**19**	**2**	**2**	**3**

Appendix II   Invertebrate monitoring in Seychelles

The only invertebrate population estimates carried out to date have been for terrestrial Mollusca and the day-flying hawkmoths. For molluscs, a system of random quadrats has been used over the last 15 years for both leaf-litter inhabiting and arboreal species (GERLACH 1999, 2003b). The use of randomised quadrats allows the molluscs to be studied regularly without requiring sophisticated marking of location techniques and over-sampling of small areas.

Hawkmoths have been monitored in one locality, the 16ha area of the Dauban Marsh to Pointe Ramasse Tout on Silhouette island. This comprises nine ha of open habitat and 6.25ha of woodland. In this area searches were made for active hawkmoths at several times of day to provide an estimate of the total area used by this population of moths. The majority of moths were found to be feeding on one area of *Lantana camara*. In 1999 this area was visited hourly and the number of moths of each species recorded to obtain activity patterns (Fig 1). Mark–recapture studies of 20 moths were

used to obtain population estimates based on the number of moths observed and the average time taken for moths to return to the study plants. Moths, returned to the plants after 4.5 hours (range=3-6). Numbers of moths increased throughout the day, with a maximum number in July 1999 of 22 *Cephonodes hylas*, 2 *C. tamsi* and 1 *M. alluaudi*, giving a density estimate of 352 per km^2 for *C. hylas*, 32 *C. tamsi* and 16 *Macroglossum alluaudi*. On Silhouette, there are 10km^2 of optimal habitat for the bee hawkmoths and 100km^2 for *M. alluaudi*, giving population estimates of 3520 *C. hylas*, 320 *C. tamsi* and 1600 *M. alluaudi*. Since then, the area is visited one per day in the early afternoon during the seasons when hawkmoths are observed.

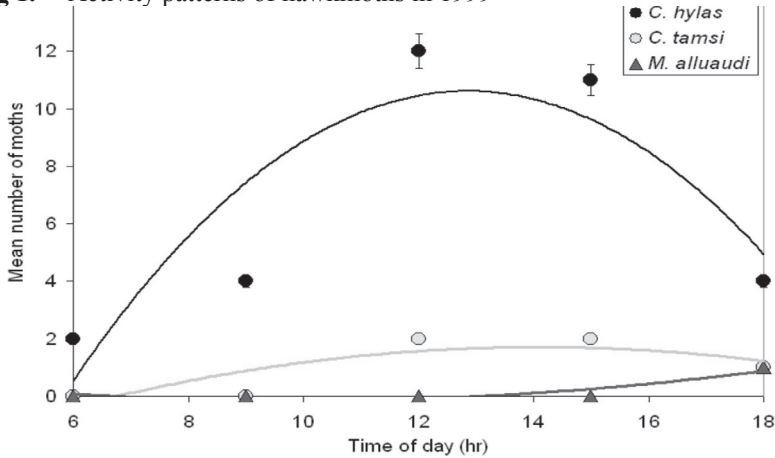**Fig 1.**   Activity patterns of hawkmoths in 1999

Fig 2.   Variation in hawkmoth numbers over time since 1998.