Rediscovering the neglected insects of Mauritius:

Building in-country capacity

Sarah Donovan, 26th April 2005

Darwin Initiative for the Survival of Species

Annual Report

1. Darwin Project Information

Project Ref. Number	*162/12/005*
Project Title	*Rediscovering the neglected insects of Mauritius*
Country(ies)	*Mauritius*
UK Contractor	*University of Plymouth*
Partner Organisation(s)	Mauritius*: Mauritian Wildlife Foundation (MWF), MSIRI, Mauritius Institute, University of Mauritius.* UK*: The Natural History Museum (NHM)*
Darwin Grant Value	*£51,491*
Start/End dates	*1 October 2003 to 30 September 2006*
Reporting period (1 Apr 200x to 31 Mar 200y) and report number (1,2,3..)	*1 April 2004 to 31 March 2005* *Annual report number 2*
Project website	*In development (please see report)*
Author(s), date	*Sarah Donovan, Saoud Motala, 26th April 2005*

2. Project Background

Much of the biodiversity in Mauritius is endemic but the population status of some taxa is virtually unknown. Knowledge relating to native insects is extremely limited, as few studies have been conducted since the 1960s. Management of key ecosystems and strategies to preserve native endemic insects is hindered by the lack of entomological expertise within Mauritian conservation organisations.

This project will build essential in-country capacity in entomology and includes the following components: (i) training to build institutional capacity; (ii) research to improve the information base on a neglected group of species; (iii) development of awareness of insect conservation into decision-making for habitat management.

3. Project Purpose and Outputs

This project will:

(i) Provide training to develop institutional capacity. This was initially achieved by a member of MWF, Mr Saoud Motala, attending the *Advanced Methods in Taxonomy and Biodiversity* MSc based at the NHM in conjunction with Imperial College. The three month research project used specimens collected in Mauritius, incorporating field ecology and taxonomy (using morphological and molecular techniques).

(ii) Include a baseline study to create an inventory of extant invertebrates. Firstly, a review of historic literature will be undertaken to determine the current knowledge-base. Secondly, a sampling programme will be devised and undertaken in island areas largely cleared of introduced predators (rats, shrews, tenrecs, toads etc.) and mainland locations on Mauritius and Rodrigues. Specimens collected will be catalogued and identified to an appropriate taxonomic level with additional support from UK scientists.

(iii) Include a workshop on insect sampling and ecosystem function. To expand awareness and expertise within MWF partner organisations a workshop will be held incorporating sampling methods, basic identification and the importance of insects in ecosystems.

(iv) Prepare an exit-strategy document. A review of specimens collected during the study and the assessment of ecosystem services provided will enable the preparation of a strategy document to develop insect conservation expertise and integrate knowledge into the wider conservation remit of MWF. The project will leave a legacy by embedding expertise within the NGO and thus facilitate the development of long-term biodiversity conservation.

We have not modified the proposed operational plan. Please see appendix 1 for logical framework.

4. Progress

History

This project was developed in collaboration with the University of Plymouth and the Mauritian Wildlife Foundation (MWF) following a Royal Society study visit. It was clear from this visit that the potential for insect conservation and its integration into the wider remit of MWF was severely limited by:

(i) Lack of in-country capacity;

(ii) Little knowledge of the current population status of native and introduced species;

(iii) The complete lack of systematic sampling programmes to monitor the population status of insects of conservation interest.

Progress against agreed baseline timetable

Milestone 1 – MSc Application

Completed previous year.

Milestone 2– Preliminary sampling

Completed previous year.

Milestone 3 – Attendance and completion of MSc

Saoud Motala, a Mauritian citizen working for MWF, successfully completed his MSc in Advanced Methods in Taxonomy and Biodiversity (Natural History Museum & Imperial College). He achieved a distinction and completed a thesis titled *'Evolution and conservation of the dodo's dung beetles'*.

Milestone 4 – Historic Literature Review

Review of entomological information pertinent to this project has been completed. The review will be submitted to the journal 'Biodiversity and Conservation', co-authored by S. Motala (MWF), S.E. Donovan (UoP) & Y. Mungroo (MWF).

Milestone 5 – Development of Sampling Programme

We have completed the development of the sampling protocol for the study (Appendix 2). Zayd Jhumka, a Mauritian citizen is being trained by MWF under the direct supervision of S. Motala to assist in the sampling work.

Milestone 6 – Project Plan Reviewed and Approved by Steering Committee

During December 2004 S. Donovan (UoP) visited MWF and in a series of meeting (and site visits) with project partners the project plan and sampling programme for remainder of the project was finalised and approved.

Project's achievements during the last year

Saoud Motala returned to Mauritius to start the in-country phase of the project, after the successful completion of his MSc. The historic literature review revealed a high level of endemism amongst many of the orders such as Coleoptera which is represented by 472 strict endemic species. This proved particularly useful in the formulation of the sampling strategy and protocol because it provided the historic status of a large proportion of the beetles against which we could compare our findings. This enabled us to evaluate the degree to which the beetle fauna (representing arthropods in general) has been invaded by exotics. Following completion of the sampling protocol (appendix 2), agreement was achieved on the plan for the remainder of the project. This programme was developed in collaboration with our Mauritian partners and after extensive consultation with NHM experts (eg. Martin Brendell, Peter Hammond, Frank Krell, Paul Eggleton). The key components of the sampling strategy are:

- Sampling at seven sites on two sampling occasions. Our sampling programme includes Conservation Management Areas (CMAs) – key sites managed by MWF.
- Location identified on islands and 'mainlands' of Mauritius and Rodrigues;
- A broad and largely quantitative programme has been adopted, using pitfall trapping, Winkler bag (for litter invertebrates), flight interception traps (FIT), Malaise traps and mist-blowing/fogging (for flying and arboreal invertebrates) augmented by casual sampling in peripheral habitats and locations.

The protocol has been distributed to all stakeholders (NPCS, MSIRI, the Mauritian Institute, University of Mauritius and MWF) who were extensively consulted. This process was facilitated by the Project Leader S. Donovan, who visited Mauritius in December 2004. This coincided with a visit by Dr John Mauremootoo, an original applicant (who has subsequently taken up a position with CABI-Africa) who also attended meetings and contributed to the planning of the work. This sampling programme has been greatly aided by the loan of equipment from the Natural History Museum.

We also identified and agreed that MSIRI will be the permanent home for the collection of Mauritian invertebrates collected during the project. MSIRI has a collection of insects of interest to the sugar cane industry and have good facilities and protocols for the long term maintenance of insect collections. MWF have provided S. Motala with a research assistant (Z. Jhumka) who is now assisting during the sampling phase of the study.

We have also made progress on the sorting and identification of samples. Material collected early in the project (Milestone 2) has been largely sorted and analysed. A particularly noteworthy finding is that termites found on Mauritius have their closest relatives in south-east Asia rather than Madagascar or Africa, which might be expected. Specifically, the sister taxon of the wood-feeding termite *Nasutitermes voeltzkowi* - one of the commonest termite species on Mauritius - is *N. matangensis*, a south east Asian species. In turn, the sister taxon of this species is *N. corniger*, a south American species. Clearly, this group of termites are efficient dispersers! Additionally, we believe there to be an undescribed genus of social wasps on Mauritius which we hope to sample.

From this early sampled material the NHM will produce a catalogue of all Mauritian beetle specimens held in the collection based on these and historical material. This resource will facilitate identification done in Mauritius, in conjunction with liaison between MWF & NHM. S. Motala is developing a website that we intend will go online in 2006 that will provide details of the project, a 'fact file' of findings, and specimens recorded with digital images which will be updated as the project develops. Digital images are being captured using the camera and microscope provided by this project. All material will be identified to order. Coleoptera (beetles) and Phasmidae (stick insects) will be identified to species.

Difficulties and steps taken to overcome them

The departure of the project leader (Dr Linton Winder, left in Nov 2004) and the original MWF collaborator (Dr John Mauremootoo, left in April 2004) have caused minor setbacks to the project. Fortunately, Dr Carl Jones (scientific director) and Yacoob Mungroo (ex entomology research scientist entomology at the Ministry of Agriculture and now Flora Conservation Manager) at MWF have coordinated work in Mauritius. At UoP, I (Dr Sarah Donovan) was an original applicant at the start of the project, and took over leadership. I have strong research links with the NHM and have used these to overcome any short term problems due to change of personnel. Both L. Winder and J. Mauremootoo have provided help and support since their respective departures. In addition, I attended the DI workshop in London in April 2005 to familiarise myself with DIs approach towards its projects. Our project is progressing well, and we have achieved all of the milestones to date. Hence, any difficulties encountered during the year have not proved problematic.

Project enhancement

This project is being enhanced in a number of ways:

1. Application for Leverhulme funding.

We have applied for a Leverhulme funded PhD; 'The current range and population status of the Mauritius cuckoo-shrike (*Coracina typica*) and an evaluation of its invertebrate prey'. The cuckoo shrike is an insectivorous bird and we have selected this topic because it demonstrates the importance of entomology in the wider remit of MWF.

2. Application for NERC funding

Dr Frank Krell (NHM) is applying for funding (NERC) to use the museum's synoptic equipment to photograph all of the NHM's Mauritian beetle specimens. During our assessment of historic information we discovered that 1,480 beetle specimens from Jean Vinson's (an entomologist active in the 1950s and 1960s) Mauritian collection that was deposited at the NHM. This will enhance the new material we collect and allow us to assess how many species are still extant.

3. Application for Seale-Hayne Educational Trust and the Rufford Foundation

S. Donovan has applied to these organisations to support a visit by a specialist in aquatic Coleoptera (Clive Turner). This will provide us with an additional opportunity to develop in-country expertise. The aim is that he will travel to Mauritius in July 2005 to train S. Motala and Z. Jhumka in specialist sampling techniques, and in identification.

Timetable for next reporting period

Aug 05	**SAMPLING AND SORTING (milestone 7).** Field sampling completed at the seven selected sites (islands and mainland of Mauritius and Rodrigues). Specimens sorted and preserved.
Feb 06	**SPECIMEN IDENTIFICATION (milestone 8).** Specimens catalogued and identified to an appropriate taxonomic level. Species identified as either endemic or newly reported for selected taxa prioritised.
Apr 06	**DATABASE DESIGN AND PRODUCTION (milestone 9).** Design and build of database completed. Information included: distribution (endemic, native, exotic); ecosystem function at appropriate taxonomic level identified; extent (abundance at each sampling location). CD-ROM distributed to partner organisations.

5. Actions taken in response to previous reviews (if applicable)

Number of workshops and their scope. We are planning one workshop in this relatively small project, aimed at two levels of expertise. It is scheduled for the end of the project so as to maximise the inclusion of all of the results, and any actions arising from these results. It is envisaged that invertebrate conservation work in Mauritius will continue beyond the end of the Darwin Initiative project, as the necessary expertise will then be embedded within MWF. Therefore, we consider that the workshop is scheduled for the correct time.

Entomological scope. The entomological scope has been defined more clearly, now that the sampling protocol has been devised. We are focussing primarily on beetles because: (a) we should be able to compare our data with historical data; (b) we stand a good chance of identifying to species because collections and keys exist; (c) beetles cover a wide range of life history types, and so can accurately reflect changes to habitats, both positive (in CMAs) and negative (through loss of habitat).

Involvement with stakeholder organisations. The primary stakeholder in this project, aside from MWF is MSIRI, who hold the best entomological collection on Mauritius. We are developing close links with this institute, both through meetings (e.g. S. Motala, S. Donovan & S. Ganeshan), frequent informal discussions between S. Motala & MSIRI, and by email. They are actively supporting the project, and have allowed access to their equipment and facilities.

6. Partnerships

We have developed good links with MWF since Saoud Motala returned to work there in October 2004. Other stakeholders (e.g. Mauritius Museums, University of Mauritius, NPCS) are kept updated with progress reports, and their feedback is incorporated into future work plans. Links between the MWF, NHM and Plymouth University are also developing, with regular email contact between all three.

It is anticipated that the links between MWF and MSIRI will not only facilitate the project work, but will also lead to improved invertebrate conservation possibilities in the future.

7. Impact and Sustainability

Initial publicity regarding the project was produced at the start of the project. We anticipate that we will be able to increase interest and capacity for biodiversity at the time of the launch of our project related website. MWF has a high profile in Mauritius and we are confident that we can generate an appropriate level of publicity for our project. We have an exit strategy which is embedded in the final year of our project.

8. Post-Project Follow up Activities (max 300 words)

Not applicable.

9. Outputs, Outcomes and Dissemination

Table 1. Project Outputs (According to Standard Output Measures)

Code No.	Quantity	Description
2		Saoud Motala successfully completed UK based MSc.
20	£3,000	Microscope, digital camera and sampling equipment provided.
10		Review of entomological information to be submitted to peer-reviewed journal 'Biodiversity and Conservation' & poster presented at international conference.
6A, 6B		4 Mauritian nationals trained on one week course – Training of two nationals underway.
8	2 weeks	S. Donovan visited Mauritius Dec 2004.
10		Insect protocol designed and sent to all partners and supporters of project (see appendix 2).

Table 2: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Poster	Motala, S.; Krell, F.-T.; Ganeshan, S. et al. 2004. A complete beetle fauna on the web: Mauritius as a model case			
Paper (to be submitted)	Motala, S.; Donovan, S.E.& Mongroo, Y. Historic review	Biodiversity and Conservation		

10. Project Expenditure

Table 3: Project expenditure during the reporting period (Defra Financial Year 01 April to 31 March)

Item	Budget (please indicate which document you refer to if other than your project schedule)	Expenditure	Balance

11. Monitoring, Evaluation and Lessons

I took over as project leader from Dr Linton Winder in November 2004. Before he left Plymouth University, we took considerable time to discuss the way forward for the project. In December 2004 I visited Mauritius, and took the opportunity to familiarise myself with important aspects of conservation in this country, as well as meeting our partners on the project. S. Motala and I developed the sampling protocol during this time.

I am in regular and frequent contact with S. Motala, through monthly phone calls, and email in the interim periods. I also have indirect feedback on his progress through his communications with NHM staff. I developed a good working relationship with him and other project partners during my visit to Mauritius, and we have collaborated well on the review paper. My personal links with NHM have improved communication between Mauritius and MWF with great benefits to the project.

12. OPTIONAL: Outstanding achievements of your project during the reporting period (300-400 words maximum)

Annex 1 Report of progress and achievements against Logical Framework for Financial Year: 2003/2004

Project summary	Measurable Indicators	Progress and Achievements April 2003-Mar 2004	Actions required/planned for next period
Goal*:* To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • The conservation of biological diversity, • The sustainable use of its components, and • The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose *(insert original project purpose statement)* To initiate an insect conservation programme within the Republic of Mauritius, led by in-country capacity based within the Mauritian Wildlife Foundation (MWF).	*(insert original purpose level indicators)* Entomological expertise provision within MWF. The rediscovery of endemic and native species unreported since historic studies. Discovery of new species. The development of awareness of insect conservation within MWF and other conservation stakeholders.	*(report impacts and achievements resulting from the project against purpose indicators – if any)* S. Motala completed and gained a distinction in his MSc. Regular briefings to stakeholders of progress of study.	*(report any lessons learned resulting from the project & highlight key actions planning for next period)*
Outputs			
(insert original outputs – one per line) 1. MWF with capacity to manage	*(insert original output level indicators)* MWF staff member (S. Motala)	*(report completed activities and outcomes that contribute toward outputs and indicators)* MSc completed, with particular	*(report any lessons learned resulting from the project & highlight key actions planning for next period)*

and develop insect conservation strategies.	trained using UK-based MSc. Training provided to other stakeholders.	emphasis (via dissertation) on Mauritian beetles.	The opportunity for overseas students to study in the UK is invaluable. S. Motala has made professional links with UK scientists which will facilitate future work on the project, and beyond.
2. Report on review of historic entomological information.	Collation of material. Draft report edited by Project Leader.	This review is being written up and will be submitted to a peer-reviewed journal (Biodiversity and Conservation).	
3. Baseline sampling programme designed and conducted.	Protocol developed by partners. Sampling programme conducted.	Sampling protocol submitted to all partners, sampling started.	Extensive collaboration with NHM partners invaluable in designing protocol. Also loan of specialist equipment.
4. Inventory of specimens sampled.	Database construction including records of extant species with ecological function, endemism and native/alien status.	Material collected at start of project will be catalogued by NHM, and can be included in inventory, together with historical NHM specimens.	
5. Insect conservation strategy document including future-funders	Meeting of collaborators to formulate strategy. Preparation and review document	Not applicable at this stage.	

Note: Please do NOT expand rows to include activities since their completion and outcomes should be reported under the column on progress and achievements at output and purpose levels.

Appendix 1. Logical framework

Project summary	Measurable indicators	Means of verification	Important assumptions
Goal: To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • the conservation of biological diversity, • the sustainable use of its components, and • the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose			
To initiate an insect conservation programme within the Republic of Mauritius, led by in-country capacity based within the Mauritian Wildlife Foundation (MWF).	Entomological expertise provision within MWF.	Training of Insect Conservation Manager.	Training completed successfully.
	The rediscovery of endemic and native species unreported since historic studies. Discovery of new species.	Publication of historic review and inventory of extant species.	Programme sufficient to adequately sample extant species.
	The development of awareness of insect conservation within MWF and other conservation stakeholders.	Insect Conservation Workshop. Publication of MWF strategy document.	Conservation stakeholders incorporate new knowledge into their strategic thinking.
Outputs			
1. MWF with capacity to manage and develop insect conservation strategies.	MWF staff member trained using UK-based MSc. Training provided to other stakeholders.	Award of MSc and training of four MWF field workers. Twenty delegates trained via workshop.	Successful completion of MSc by MWF staff member.
2. Report on review of historic entomological information.	Collation of material. Draft report edited by Project Leader.	Publication of report. Distribution to stakeholders.	Availability of historic documents, particularly unpublished field notebooks.
3. Baseline sampling programme designed and conducted.	Protocol developed by partners. Sampling programme conducted.	Sample collection. Field notes and diaries.	Co-operation of stakeholders and MWF volunteers.
4. Inventory of specimens sampled.	Database construction including records of extant species with ecological function, endemism and native/alien status.	Production of CD-ROM containing database. Distribution to stakeholders & MWF press release.	Identification of specimens to appropriate taxonomic level achievable.
5. Insect conservation strategy document including future-funders.	Meeting of collaborators to formulate strategy. Preparation and review of document.	Publication and distribution of report to stakeholders. Submission of at least one future-funding application.	Success of future-funding application(s).
Activities	**Activity Milestones (Summary of Project Implementation Timetable)**		
Training	Prior to YR 1: Application for place for S. Motala on UK MSc (including English test). YR1: Attendance on NHM MSc Sep 03 to May 04; Study/completion of dissertation Jun-Aug 04.		
Research programme	YR 2: Visit by UK Project Leader to Mauritius to work with MWF staff on literature review, preparation and testing of sampling protocol; Training of participatory MWF staff; Publication of documentation (Sep-Nov 04). Field sampling and specimen sorting conducted (Dec 04 to Aug 05).		
Inventory of species	YR 3: ID specimens to appropriate taxonomic level supported by UK expertise (Sep 05 to Feb 06). Collation of information & database; Distribution of CD-ROM & press release (Mar-Apr 06).		
Strategic review & workshop	YR 3: Project planning of workshop, delegate invitation and document preparation; Authoring MWF Insect Conservation Strategy; Future-funders identified and application prepared (May-Sep 06). Insect Conservation Workshop conducted (Sep 06). Supported by UK Project Leader visit.		

Appendix 2. Sampling protocol

Darwin Initiative project: 'Rediscovering the neglected insects of Mauritius: building in-county capacity'

Sarah Donovan[1]; Saoud Motala[2]

[1] Plymouth University, Devon, UK; [2] Mauritian Wildlife Foundation, Vacoas, Mauritius

Sampling protocol; Jan – Aug 2004

There are two aims to this sampling regime. Firstly, we aim to produce as comprehensive a species list as possible of Coleoptera and Phasmids. We can compare this against historic data to establish their probable conservation status. Secondly, we can evaluate the potential of the conservation management areas in providing a refuge for native and endemic species, with a long term view towards possible relocation of vulnerable species to these refuges.

Sites: we intend to sample in seven habitats (table 1, figure 1). Each site will be comprehensively sampled (see below) at least twice in the eight-month period from January to August 2004. Where appropriate, sampling will include both unmanaged and conservation management areas.

Site	Location	Terrain	Habitat
Brise Fer	Mauritius	Mainland	Upland forest
Valle de l'Est	Mauritius	Mainland	Upland forest
Magenta	Mauritius	Mainland	Lowland forest
Ile aux Aigrettes	Mauritius	Island	Ebony forest
Round Island	Mauritius	Island	Palm forest
Grand Montagne	Rodrigues	Mainland	(±) upland forest
Cascades St Louis	Rodrigues	Mainland	(±) lowland forest

Table 1. Seven proposed sites for sampling invertebrates.

Figure 1. Maps showing location of the seven sampling sites on Rodrigues (left) and Mauritius (right).

Appendix 2. Sampling protocol

Sampling: techniques will be quantitative at the selected sites, and additional methods will provide qualitative data on invertebrate populations. We will employ a range of techniques to collect the widest ecological range of taxa. Qualitative sampling will be carried out using additional techniques, and including other locations of conservation interest (e.g. Ile aux Cocos).

- Pitfall traps (quantitative). These will be set out along a 100 m transect at 10 m intervals. This method is good for collecting actively moving, ground-dwelling invertebrates. We also have systematically-collected material available from a current study on Formicidae (ants) being carried out in the Mascarenes, which will supplement our material.
- Litter (quantitative). Ten lots of $1m^2$ of leaf litter + top 1cm soil will be collected along the same 100 m transect as the pitfall traps. Invertebrates will be extracted using Winkler bags (see Appendix 1). This method is effective at recovering slow-moving, small, cryptic species. Winkler bags are preferred over Tollgren funnels as they are highly portable, can be used in the field, and do not require any light (heat) source.
- Canopy (quantitative). This will be done once at each site, using a mist-blower, although it is probable that this technique will be ineffective in areas with a low canopy (< 10 m). However, the canopy fauna is of particular significance, as it is liable to have survived more intact that the ground dwelling litter fauna. The latter has been severely negatively affected by the introduction of vertebrate predators, including tenrecs, rats, lesser Indian mongooses, Indian house shrews and toads.
- Light trapping (qualitative). This technique is effective at targeting certain invertebrate families, e.g., long-horn beetles, jewel beetles and some scarab beetles. However, it is dependent on a portable generator for it to be of any practical use.
- Aquatic habitats (qualitative). A wide taxonomic range of beetles can be found in a variety of aquatic habitats (e.g., Turner, in prep), although not all of the seven selected sites contain water. Sampling of aquatic areas, then, will be qualitative and will focus mainly on: ponds, rivers and streams (netting vegetation, rocks, gravel, sand, coarse organic detritus, trapping), water margins (hand searching, stamping and splashing, digging, sieving), madicolous habitats (hand searching, rock turning, wood turning).
- Flight intercept/Malaise traps (qualitative) (see Appendix 2). NB, Malaise traps are highly influenced by local conditions (within a few metres), so limited sampling cannot be regarded as quantitative for a particular site.

Selected taxa: all material collected will be sorted to Order. Coleoptera (beetles) and Phasmids (stick/leaf insects) will be sorted to species as far as possible. It is important to sort to this level as many arthropod groups show a greater response to habitat differences than those observed at coarser taxonomic levels (Nakamura et al. 2003).

There are many reasons for focusing attention on Coleoptera. This Order has been shown to most closely resemble the response of arthropods in general to restoration processes (Neumann, 1979; Moeed & Meads, 1985; Longcore, 2003). They are one of the most diverse groups of organisms and comprise about 20% of total arthropod diversity (Stork, 1988; 1993). They show a wide range of trophic functions (Watts & Gibbs, 2002), and so are indicative of ecosystem functions as well as species diversity. Coleoptera may be an alternative indicator assemblage to arthropods in general and provide a finer resolution of response to habitat changes. In particular, beetles - at the species level - are recommended for use in comparative biodiversity surveys of forest litter faunas (Carlton & Robinson, 1998) as they are indicative of subtle habitat changes. Preliminary studies in Mauritius indicate that beetles will provide valuable information on habitat differences (Motala, 2004; Sharp, 2004; Jhumka, 2002; Budullah, 2001)

In addition, the beetles are the one group of invertebrates that have been comprehensively surveyed within the Mascarenes (e.g. Vinson 1967), enabling a comparison to be made with the historical distribution of beetles with regard to (a) which species have decreased in numbers or disappeared, (b) what species have invaded and (c) whether any species have increased their range/numbers. Many keys exist for their identification (e.g. Williams & Cox, 2004), and the original collections are accessible, having been lodged in the Natural History Museums at London and Paris. Saoud Motala has taxonomic knowledge of this group, and there is taxonomic expertise available through contacts with the NHM, London and, for aquatic beetles, Clive Turner

(a UK based coleopterist). This gives us the best chance of being able to obtain the essential species-level identifications.

Phasmids will also be targeted as Saoud Motala has some taxonomic experience in this area. They are also useful as 'flagship' invertebrates, being relatively large and attractive. As such, they provide an umbrella for other invertebrates that provide essential ecosystem services, but may be visually unprepossessing.

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Appendix 2. Sampling protocol

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Appendix 2. Sampling protocol

Appendix 1. Use of Winkler bags

Samples are taken at 10 m intervals along a 100m transect (totalling 10 samples) laid out in as homogeneous piece of forest as possible. Leaf litter and any loose soil is collected from 1m^2 quadrats. This litter is then sifted through a wire sieve of 1 cm^2 mesh to exclude larger elements of the litter; all material that passes through the mesh (fine debris and invertebrates) is collected into a sealable plastic bag. All material is decanted into mesh bags and hung within the Winkler bags; samples from different quadrat samples are never put together in the same Winkler bag. These samples are then hung for three days in a constant temperature (Fig 1). Ideally, this is done indoors, but may be done outside, so long as the site is dry and extremely sheltered: any movement to the Winkler bags results in debris falling into the collecting pot and makes subsequent work on the samples much more time consuming. As the litter dries, the invertebrates within it move around to find damper conditions and eventually fall out of the mesh bags into the pot at the bottom, which contains alcohol. All samples at one site should be taken within on the same day, and sampling should not be done in the rain as smaller specimens tend to stick to the litter, and also is likely to reduce the amount of specimens recovered as the litter takes longer to dry.

Fig 1. Winkler bags hanging in roof space.

Appendix 2. Sampling protocol

Appendix 2. Use of Flight Intercept Traps (FIT): setting and servicing for beetle (Coleoptera) sampling in woods and forests.

Introduction: many beetles in tree covered terrain search for specific habitats, food and for mates by flying about the area in which they live, often within 3 or 4 feet of the general ground surface. The Flight Interception Trap (FIT) breaks this flight by surprise and collects the specimens into a killing/preserving solution set in open trays positioned beneath the flight break (the interceptor). These can then be transferred to a permanent preserving fluid for removal. This particular type of large area 'window' trap was developed in 1985 (by Peter M Hammond of the Natural History Museum) and has been used for quantitative sampling of insects in both temperate and tropical forests.

The trap components:

- The interceptor. Black, synthetic net 1 x 1.25 m. There are loops at the corners and along the top and bottom for guy strings and anchorage pegs.
- The roof. Green, woven polythene 1.3 x 3.3 m. There are 8 perimeter and 2 internal eyes. Essential to prevent wash-out in rain or contamination of the trays by leaves, twigs and falling debris.
- The ground-sheet. Green, woven polythene 0.9 x 2.4 m. There are 4 perimeter eyes, at the corners, and 3 internal eyes. Essential to prevent contamination of the trays from mud-splash should it rain.
- The catchment trays. A set of 22 trays, 20 x 11 cm, is supplied with each trap.
- The ridge rope. Approx. 10 metres of 10mm synthetic rope.
- The guy lines. A ball of synthetic string is supplied.
- The staking-out pegs. If tent pegs are not supplied, pegs can be cut from the forest.
- Servicing equipment. You will need the following
    - ✓ A 2 gallon water carrier
    - ✓ A 1 litre plastic beaker with spout
    - ✓ 2 x ¼ litre screw-cap plastic bottles
    - ✓ A 140 micron strainer
    - ✓ A 10 cm plastic funnel with most of the spout removed
    - ✓ Wash bottle
    - ✓ At least 2 litres of 80% ethyl alcohol
    - ✓ 500g of chloral hydrate crystals ($CCl_3CH(OH)$ 2=165.40)
    - ✓ Old teaspoon for dispensing above **KEEP THIS AWAY FROM FOOD**
    - ✓ 1 bottle washing up liquid
    - ✓ A small pair of pointed forceps
    - ✓ Small paint brush
    - ✓ Plastic pipette
    - ✓ A supply of vials for specimens
    - ✓ Paper for labels
    - ✓ Sharp knife for cutting pegs and clearing site
    - ✓ Graphite pencils
    - ✓ A small pair of scissors.
    - ✓ Notebook
    - ✓ Plastic carrier bags are ideal for carrying all this

Choice of site. The aim is to cut across a busy insect flight path such as a man-made path through the forest or any similar natural corridor that flying insects might select; perhaps a strip of sparser herbage among the trees. There will be many options in a forest, remember the aim is to cut ACROSS the natural passage of the insects. Note, a good flight path may not look busy in day-light. It is essential to choose flat ground or level off a strip with a spade. These traps are not effective in open spaces such as the centres of clearings or the middle of deserts, or in high winds.

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Trap erection. Establish the ridge-rope first, trying-off between two trees or posts across the chosen flight path. Tie-off on selected trees at one end and pass ridge-rope into the roof via an internal eye, pass it through the 4 loops along the upper length of the black interceptor and out of the roof via the other internal eye, and tie-off at the other tree. The ridge rope should be taut and at such a height as to allow the interceptor to be stretched out tight, flat and exactly vertical and with its bottom edge running lightly along the tops of the trays when they are placed on the ground sheet; this is done by trial and error and it must be right. The top corner loops of the intercept should be pulled out through the internal holes of the rood and tied off separately to the same trees that anchor the ridge-rope. The ridge-rope passes through these loops but by typing them separately you can more easily adjust the tension of the interceptor (refer to diagram). Tie off the corners and edges of the roof to saplings, trees, bushes or sticks to form a four-slope roof like that of a simple, rectangular, detached building.

Before pegging out the bottom edge of the intercept put down the ground sheet. This is a little longer than the intercept and should be centred under it. If a wooden plank can be acquired place this under the ground sheet as a firm, level base for the trays. Peg out the bottom of the intercept, the internal eyes in the ground sheet allow the passage of pegs securing the middle loops along the bottom of the intercept. The intercept should be tight as a drum with NO wrinkles. Remember that the bottom edge of the intercept should lightly brush the tops of the foil trays once the trap is set up. Check that the roof is tight again; trial and error in moving the guys about in inevitable in order to achieve this to operational perfection. Arrange a line of 22 trays, long axis at right angles of the intercept; the trays should be shoulder to shoulder and can be formed around the intercept pegs that pass through the ground-sheet.

Trap operation. Once the trap is up and the foil trays in place, about an inch depth of water is poured into each tray. Next add about half a teaspoon of chloral hydrate crystals to each tray – THIS IS A TOXIC CHEMICAL AND SHOULD BE HANDLED WITH RESPECT – its function is to inhibit bacterial breakdown of the insects that fall into the trays. Lastly add a few drops of washing-up liquid to each tray; this reduces surface tension and allows the specimens to sink as soon as they fall in. The trap is now up and running and can be left for 24 hours. Remember where you left it!

At the end of 24 hours each tray should contain quite a number of beetles and other insects. Using pointed forceps remove and discard any leaves, butterflies, moths, grasshoppers, large flies and wasps. Next, using forceps, remove all large beetles to a ¼ litre plastic pot which is half-filled with 80% alcohol. Now position the plastic beaker near the trays and, one by one, empty the whole contents of each tray through the 140 micron strainer. A small spout can be made by pulling out the corner of each tray. As you fill the beaker return the strained solution to the trays as you work your way along. Nearby keep the ¼ litre plastic pot and empty the strainer into it as it becomes loaded with specimens. This is best done by picking out ‘bundles’ of insects with the forceps and finishing by knocking the strainer upside down against the sawn-off funnel placed in the mouth of the ¼ litre pot. Use the wash bottle containing alcohol to rinse round the funnel. Sometimes the plastic pipette is more useful. The small paintbrush is handy for fielding small, stray specimens. Thus all the specimens caught end up in the plastic pot and the solution is safely returned to the trays for the next 24 hour run.

Before leaving the site place a pencil written data label in the pot with the specimens giving locality, date, collector etc. Once back at the base camp/hotel remove the beetles from the plastic pot to glass vials, again use the strainer and sawn-off funnel to do this. Place a duplicate of the data label in each tube used and remember to use only graphite pencil for this. Use a new set of tubes for each days samples.

Notes. Use two traps running concurrently within one notional hectare of forest. Run them for at least 7 consecutive days at each site emptying the trays preferably once a day, or at least every other day. Keep all beetles from each session as the number of individuals for each species are some of the essential data that will be studied. Recharge trays that may have lost their solution. Tighten guys and pegs that may have slackened at each visit. If you lose the chloral hydrate,

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vinegar will do mixed 1 to 4 parts water. At the end of a trap dispose of toxic tray solution by pouring into a small hole in the ground and cover. Bring left-over chloral hydrate back to UK in its original canister. Return all major parts of the FITs to the Museum. Glass vials of insets should travel as hand baggage. Your expedition should check with the host country regarding removal of insect specimens of no commercial value through their customs. The glass vials should be packed very carefully for the return journey as they are not very strong. Photograph the traps in situ if you can. Also make an on-the-site description of each trap site in a note book. The foil trays, unused glass vials and alcohol can be carefully disposed of at the end of the expedition.

Figure 1. Flight intercept trap in situ.