Rediscovering the neglected insects of Mauritius:

Building in-country capacity

Sarah Donovan & Saoud Motala, 26th April 2006

Darwin Initiative

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 annual report number (1,2,3..)	*1 April 2005 to 31 March 2006* *Annual report number 3*
Project website	*In development*
Author(s), date	*Sarah Donovan, Saoud Motala, 26th April 2006*

2. Project Background

Much of the biodiversity in Mauritius is endemic but the population statuses of some taxa are 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 London. The three month research project used specimens collected in Mauritius, incorporating field ecology and taxonomy (using morphology and molecular techniques).

(ii) Include a baseline study to create an inventory of extant invertebrates. Firstly, a review of historic literature was undertaken to determine the current knowledge-base. Secondly, a sampling programme was devised and carried out in island areas largely cleared of introduced predators (rats, shrews, tenrecs, toads etc.) and mainland locations on Mauritius and Rodrigues. Specimens collected are in

the process of being sorted and identified to an appropriate taxonomic level with additional support from UK scientists.

(iii) Include two workshops on insect sampling and ecosystem function. To expand awareness and expertise within MWF partner organisations, workshops will be held in September 2006 incorporating sampling methods, basic identification of key groups and the importance of insects in ecosystems.

(iv) Prepare an exit-strategy document. A review of specimens collected during the study and assessment of their conservation significance 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 by Linton Winder. 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 7 – Sampling and sorting

The systematic sampling has been completed according to the agreed sampling programme. The initial sorting of the specimens arising from the quantitative sampling into beetles (Coleoptera) and non-beetles is now completed. In all we have processed 1,721 beetles and an estimated > 10,000 non-beetle specimens.

The project benefited from the visit of Mr. Clive Turner who, in collaboration with Saoud Motala and Zayd Jhumka, surveyed the aquatic Coleoptera fauna of Mauritius and Rodrigues. The findings from this study will be very useful and yield complementary data within our project on many invertebrates, and particularly aquatic beetles.

Additionally, we were able to survey Agalega Island using qualitative techniques (light trapping, direct searching and pitfall trapping and baiting for two days).

Milestone 8 – Specimen identification

The beetles collected from the qualitative sampling are being classified into Recognizable Taxonomic Units (RTUs) and is still ongoing. To date, we have already identified 70 RTUs.

Reference material from a pilot study in Brise Fer has been sent from the NHM to facilitate the identification process. In addition, S. Motala and Z. Jhumka are currently visiting the local collections housed at the MSIRI and The Mauritius Institute to further the identification of the beetle RTUs.

MWF is currently in the process of purchasing two taxonomic CD ROMs (Beetles of the World; Beetle larvae of the World both by CSIRO Entomology) to aid the identification process.

Milestone 9 – Database design and production

The design of the database is ongoing, since it is partly dependent on the type and amount of data arising from the identification of the RTUs (see above).

Project's achievements during the last year

The quantitative sampling was successfully carried out by S. Motala and Z. Jhumka, together with additional, ongoing qualitative sampling (Table 1).

	Brise Fer		Vallee de		Ile aux	Round	Grand	Cascades
	CMA	Nr. CMA	l'Est	Magenta	Aigrettes	Island	Montagne	St Louis
Pitfall traps	20	20	20	20	20	20	20	20
Winkler (litter)	20	20	20	20	20	20	20	20
FIT	2	2	–	2	2	2	2	2
Light trapping	1	-	-	-	-	-	–	–
Malaise	-	-	-	-	-	-	1	1
Direct searching	1	-	-	-	-	-	–	–
Canopy	–	–	–	–	–	–	1	1

Table 1. Sampling of seven sites in Mauritius and Rodrigues. CMA – conservation management area, FIT – flight intercept trap.

This sampling generated a large number of specimens (~12,000). We have already sorted our focal group – beetles – from the rest (Table 2), and now have over 1,700 beetles to identify. Initially, we are sorting to family, and then to a higher taxonomic resolution. To aid this, the Natural History Museum has sent out reference material, identified from preliminary sampling before the project began.

Site	Technique	No. beetles
Anse Quitor	Pitfall trap	31
Brise Fer	Pitfall trap	87
Brise Fer NCMA	Pitfall trap	104
Grande Montagne	Pitfall trap	14
Ile aux Aigrettes	Pitfall trap	100
Magenta	Pitfall trap	25
Round Island	Pitfall trap	50
Vallee de l'Est	Pitfall trap	60
Anse Quitor	Winkler	101
Brise Fer	Winkler	774
Grande Montagne	Winkler	16
Ile aux Aigrettes	Winkler	52
Magenta	Winkler	85
Round Island	Winkler	71
Vallee de l'Est	Winkler	151

Table 2. Number of beetle specimens collected from quantitative sampling of seven sites.

A broad outline for the workshop has been planned, with specialists from the UK having been invited to train local stakeholders in practical taxonomic and identification skills for core invertebrate groups, including beetles, spiders and termites. Advance notice of this workshop has been sent to our stakeholders, together with a summary of progress on this project. Saoud Motala has been in informal but regular contact with the stakeholders to keep them abreast of developments.

Finally, the review of historic literature was submitted to and accepted by the journal 'Biodiversity and Conservation'.

Difficulties and steps taken to overcome them

Logistics: Transport organization proved to be a challenging task since planned visits had to be changed at the last minute on numerous occasions due to unavailability of vehicles. We did not have a particular vehicle assigned to the project. This was especially problematic because the quantitative sampling is heavily reliant on pre-planned dates. However, we adapted to the situation and re-planned our work accordingly and we were able to complete the quantitative sampling successfully.

Specimens sorting: A large amount of material was generated by the quantitative sampling. The sorting of the beetles from non-beetles took considerably longer than expected given the very small size of the specimens (most < 5 mm) and the large amount of mud in the samples. However, this task has been successfully completed

Specimen identification: The lack of a suitable reference collection in Mauritius hampers the identification process for the beetles. The identification work carried out at the NHM highlights the specific problems of beetle identification on Mauritius, as it is characterised by an unusual dominance of particular groups (Curculionoidea, Tenebrionoidea, Cucujoidea Hydrophiloidea), displaying both a high level of endemism and undescribed taxa (for fuller details see interim report from the NHM in appendix 2). However, the identification work is being greatly helped though the reference material sent over from the NHM and access to local collections at the MSIRI and The Mauritius Institute.

Project enhancement

Additional sampling and training

Funding was gained from the University of Plymouth for an additional sampling and training trip by a specialist in aquatic beetles, Clive Turner (Dec 2005). Two MWF staff, S. Motala and Z. Jhumka, were trained in specialist sampling techniques for this diverse group of beetles, along with associated taxonomic techniques. This trip also generated additional, non-Coleoptera specimens. This material will be identified in the UK, and reference material will be sent back to Mauritius for incorporation into local collections (MWF and MSIRI). Fuller details are in appendix 3.

Timetable for next reporting period

May 06	**WORKSHOP PROJECT PLANNING (Milestone 10).** Invitations sent to delegates. Questionnaire sent to those with prior experience to customise advanced programme. Project planning of workshop completed.
Sep 06	**STRATEGIC REVIEW AND FUTURE FUNDING (Milestone 11).** Publication of MWF Insect Conservation Strategy (authored by S. Motala and S. Donovan). Future-funders identified and application submitted.
Sep 06	**INSECT CONSERVATION WORKSHOP (Milestone 12).** Training completed.

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

Number of workshops. We will be having one workshop, but split into two parts. The first is for undergraduates and will cover basic sampling techniques and invertebrate sorting. The second will be at a higher level, for the stakeholders, and will cover the more advanced taxonomy and identification skills required for any successful invertebrate conservation work with the stakeholder organisations.

Conservation aspect of project. It is not possible, for the majority of invertebrates, to select just one species for conservation work. Therefore, the aim of this project is to identify locations that provide the most suitable habitat for the widest range of endemic invertebrate species. This explains the emphasis on the biodiversity aspect of the project. Through careful selection of sites, we will be in a position to advise MWF of the suitability of their 'conservation management areas' (CMAs) for successful invertebrate conservation. Early indications (e.g. NHM report) show that the CMAs are indeed successful in maintaining populations of endemic invertebrates, though these patterns are likely to vary widely between CMAs of differing habitat types and histories.

6. Partnerships

The links between MWF and the NHM have remained strong, and are crucial to the success of this project. A large number of specimens have arisen from the sampling programme, and without input from the NHM, both through provision of reference material and expertise, the identifications will have to be done to a much coarser taxonomic resolution. The stakeholder organisations are kept informed of progress, both informally, and via report updates and their responses are incorporated into the work plan.

7. Impact and Sustainability

MWF has a high profile as a conservation organization within Mauritius, and S. Motala has been instrumental in publicising the project within the country and has already given two radio interviews (Radio1 and Mauritius College of the Air) to talk about the importance of the project. Updates of the project are also disseminated to all the partners of MWF through the MWF Newsletter. In addition, a web page detailing the findings of the project will be available shortly. The exit strategy is embedded in the final 6 months of the project.

8. Outputs, Outcomes and Dissemination

13B, reference collections. After discussion with stakeholder organisations, it has been decided to lodge the reference collections with MWF and MSIRI only, as these institutes have the facilities and procedures in place to curate such collections. If appropriate, surplus material will be given to the University of Mauritius, as a teaching aid.

12A, insect survey database. This database is still being built, as it is an iterative process together with the insect identifications. The sorting and identification work is proceeding more slowly than anticipated due to the high volume of material generated by the sampling programme.

15A, *press release*. This will coincide with the production of a working knowledge base and we are currently investigating the best way to make it available via the MWF website.

Dissemination of outputs. The MWF website will have a linked page detailing the invertebrate conservation programme, which will remain active after the DI funding ends.

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

Code No.	Description	Year 1 Total	Year 2 Total	Year 3 Total	Year 4 Total	TOTAL
13B	Species reference collections to be enhanced.			1		1
12A	Computer based database to be established and handed to host country.			0		0
15A	National press releases in host country			0		0

Table 2: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Paper (accepted)	The terrestrial arthropods of Mauritius: a neglected conservation target Motala, S.; Krell, F.T.; Mungroo, Y. & Donovan, S.E.	Biodiversity and Conservation	n/a	n/a

9. Project Expenditure

Table 3: Project expenditure <u>during the reporting period</u> (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

This is the final stage of the project and the funding allocated for 2005/2006 covers the period from April 2005 to September 2006 (ie, 17 months). Therefore, the remaining £6,230 will go towards the costs of the workshop in September 2006.

10. Monitoring, Evaluation and Lessons

Regular communication between the UK and Mauritius by email and monthly telephone calls have served to monitor and evaluate progress. Saoud Motala has sent updates on the sampling programme which has comprised the major part of this year's work. The data generated by this forms the basis for evaluating the status of Mauritian invertebrates. A potential problem was identified early on, in that a large quantity of material has been collected, and the quality of this data is tied to a fine taxonomic resolution, which may be difficult to achieve. We are working around this through provision of reference material from the NHM, by collaboration with taxonomists, and through the adoption of a stratified approach to the identications. However, it is extending this part of the project. Future work should aim at a more realistic time-frame for identification work.

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

■ **I agree for ECTF and the Darwin Secretariat to publish the content of this section**

In this section you have the chance to let us know about outstanding achievements of your project over the year that you consider worth highlighting to ECTF and the Darwin Secretariat. This could relate to achievements already mentioned in this report, on which you would like to expand further, or achievements that were in addition to the ones planned and deserve particular attention e.g. in terms of best practice. The idea is to use this section for various promotion and dissemination purposes, including e.g. publication in the Defra Annual Report, Darwin promotion material, or on the Darwin website. As we will not be able to ask projects on an individual basis for their consent to publish the content of this section, please note the above agreement clause.

Annex 1 Report of progress and achievements against Logical Framework for Financial Year: 2005/2006

Project summary	Measurable Indicators	Progress and Achievements April 2005-Mar 2006	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 has designed and completed a sampling programme and is now sorting & identifying specimens. Additional sampling in collaboration with Clive Turner has revealed a number of significant invertebrate species. Regular briefings to stakeholders of progress of study.	*(report any lessons learned resulting from the project & highlight key actions planning for next period)*
Outputs			
1. MWF with capacity to manage and develop insect conservation strategies.	MWF staff member (S. Motala) trained using UK-based MSc. Training provided to other stakeholders.	MSc completed, with particular emphasis on Mauritian beetles.	The opportunity for overseas students to study in the UK is invaluable. S. Motala made professional links with UK scientists which have facilitated work on the

			project, and beyond.
2. Report on review of historic entomological information	Collation of material. Draft report edited by project leader.	Manuscript submitted to and accepted by journal 'Biodiversity and Conservation'	This information will now be in the public domain, making it (a) widely available and (b) highlighting the importance of invertebrates in Mauritius.
3. Baseline sampling programme designed and conducted.	Protocol developed by partners. Sampling protocol conducted.	Sampling programme successfully completed. Additional sampling achieved through collaboration with Clive Turner (see appendix).	Input from NHM aided sampling design, plus 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 projected catalogued by NHM; reference material sent out to Mauritius.	Identification of material to species may take longer than is available. A stratified approach may be taken.
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.

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Appendix 1. Logistical 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.		

The species density and composition of the Beetle fauna in leaf litter from three sites in Mauritius

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Introduction

Mauritius is classified as one of the Biodiversity hotspots in the world due to its high number of endemic species present and loss of habitat (Myers et al., 2000). Vaughan & Wiehe report in 1937that since the occupation of Mauritius in 1598 the native vegetation has been largely destroyed and a number of economic and exotic plants introduced. The decline in native forest went from 406.157 acres in 1753 to around 7000 acres (of high forest) in 1936.

The insect fauna on Mauritius is well developed, 1965 species are known from 22 orders, thereof 737 endemic species. These numbers are probably underestimates, as not all insect orders have been extensively studied. Beetles have been quite extensively studied on Mauritius and catalogues by Vinson (1956, 1958, 1960, 1962 & 1967) and more recently Gomy (2000) exist listing all known species from the area. Gomy (2000) lists 1538 species of 636 genera of Coleoptera from the Mascarene islands. Of those 979 species (63%) and 89 genera (14%) are classified as endemic.

The aim of this present study is to report on beetles found in leaf litter in different habitats on Mauritius and to see how easy it is to identify them and report on their diversity. It is also a part of a bigger survey on the invertebrate fauna of Mauritius, which is being conducted by a British-Government-funded Darwin Initiative grant lead by Dr Sarah Donovan.

Study plots and their environments

Material was collected from three sites, two on the island of Mauritius, Brise Fer and Mount Cocotte, and one on Ile aux Aigrettes, an island off the SE-coast of Mauritius in March – May 2003.

1) Brise Fer is an area of forest within the Black River Gorges National Park situated just to the east of Brise Fer Peak. This sample was collected from within what is known as the 'Old Plot' one of the Conservation Management Areas, managed by the National Parks and Conservation Services (Ministry of Agro-Industry and Fisheries), and which is almost certainly the best example of mature upland climax forest on the island, as it has been weeded from exotic species and fenced from predators for about 17-18 years (Mike Sharp, pers. comm.). The area is 19.3 hectares in size (Mungroo, 1997). The upland climax forest is restricted to a small area of about 7.5 sq. miles in isolated blocks on parts of the south-eastern plateau and the Midlands mountain range. A study done by Vaughan & Wiehe (1937) in nearby Macabé showed an annual rainfall of 3175-3556 mm and a brown, immature and highly laterized soil type with a thin cover, derived from hard impervious ferruginous lava. The forest has 4 distinct strata of woody plants. During cyclonic rains water rushes through the forest removing humus and detritus from the forest floor, which makes plant life on the forest floor so scarce. Scarcity of plant life on the forest floor is one of the most striking features of the climax forest. Light intensity on the forest floor is low, sunflecks rarely seen and no wind (Vaughan & Wiehe, 1937).

2) Mount Cocotte is situated on the edge of the south-west plateau. It has a conservation management area boundary of 0.4 hectares (Mungroo, 1997). It has a mossy forest with an annual rainfall which exceeds 4445 mm. The temperature is lower than on the Macabé

plateau and can frequently fall to 10°C in winter. Sunshine is reduced because of clouds and mist. Soil and underlying rock is very similar to those of the climax forest. It does not have the clear stratification of the climax forest and has open patches through which the sun can penetrate to the forest floor. Due to the increased light intensity, ferns are frequent on the forest floor and every available space on trunks and lower branches of woody species is home to a variety of ferns, mosses and hepatics (Vaughan & Wiehe, 1937).

3) Ile aux Aigrettes is an island off the south-east coast of Mauritius, it is 25 hectares in size (Mungroo, 1997). It has a natural ebony forest with a low canopy and the ground is limestone with thin poorly developed soils.

Methods

Sampling

Fifteen quadrats (1 m x 1 m) were located at 7 m intervals along a 100 m line transect, with eight on one side and seven on the other. All quadrats were within 5 m of the transect line. Quadrats located on major obstacles such as fallen logs were relocated to neighbouring positions. All litter (leaves, twigs etc.) and loose surface soil (to a depth of 1-2 cm) from each 1 m^2 quadrat was quickly scraped-up with gloved hands. The litter and soil was placed in a sieve (10 mm^2 mesh size) and shaken vigorously for two to three min. Decayed twigs were broken-up by hand and put into the sieve. The material passing through the sieve was then stored in a cloth bag for transportation. Because the efficiency of sieving is reduced if the litter is wet, quadrat samples were not collected within 24 h of heavy rain, or within 4 h of light rain. At the laboratory the sieved material was loaded into Winkler bags. The Winkler bags were hung in a position sheltered from wind and rain but with good air circulation. The collecting bottles (containing 80% ethanol) were removed after 72 h, and all the beetles were removed from the samples and mounted.

Identification work

Beetles were sorted into families and identified to species level (where possible). Once the beetles had been sorted into family units and divided into morphospecies, they were compared with known species from Mauritius using as a guide a checklist of Coleoptera from the Mascarene archipelago (Gomy, 2000). To confirm identification to family, generic or species level , material from the beetle collection at the Natural History Museum, London (NHM), was used in addition to taxonomic keys for groups where available and by enlisting the help of specialists at the NHM. Where it proved impossible to identify to species level, beetles were left as morphospecies and assigned to genera, or where genera could not be identified to subfamily or family.

Analyses

The beetle species-level data was analysed for both species density (using rarefaction due to unequal sampling effort per quadrat) and composition (using principal components analysis [PCA]). For the PCA the species abundances were log transformed prior to analysis.

Results

Taxonomic work

The material comprised 473 specimens, which were identified to 59 species (and morphospecies) in 42 genera, 22 families and 8 superfamilies. Although a recent

checklist was available, it proved quite hard to identify beetles definitively to species and only 10 morphospecies (17%) were successfully identified, with another 10 "provisionally" assigned to species (17%) subject to verification by a specialist. Those morphospecies which could not be assigned to species level were identified to generic level where possible (25 morphospecies, 42%) and subfamily or family level (14 morphospecies, 24%). The highest number of specimens and genera in any superfamily from all sites were Curculionoidea (see table 1).

Table 1. Number of species and specimens per superfamily per site. (BF = Brise Fer, IAA = Ile aux Aigrettes, MC = Mount Cocotte)

Total no of	BF species	BF specim.	IAA species	IAA specim.	MC species	MC specim.
Caraboidea	0	0	1	2	1	1
Hydrophiloidea	1	1	0	0	1	37
Staphylinoidea	5	8	1	1	2	3
Scarabaeoidea	2	5	0	0	0	0
Bostrichoidea	0	0	0	0	1	1
Cucujoidea	4	41	0	0	1	10
Tenebrionoidea	5	50	1	2	3	4
Curculionoidea	20	124	7	29	12	154
	37	229	10	34	21	210

The beetle collection at the NHM proved invaluable in helping to identify specimens to species level, but unfortunately it has not got a complete collection of species known from Mauritius. The expertise of the curatorial staff and taxonomic visitors at the NHM, who were more than willing to help, was also crucial in the identification work.

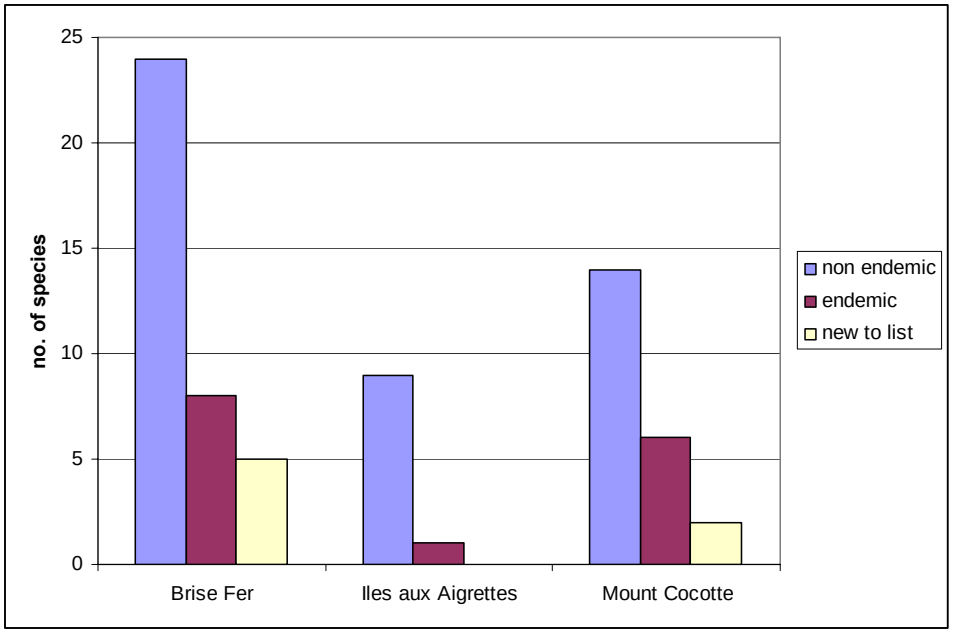

Figure 1. Number of non-endemic species, endemic species/species from endemic genera and species new to Gomy (2000) list per sample site.

There were 13 endemic species or species from endemic genera in the samples, with Brise Fer having the highest number of endemics and species new to the list (see figure 1). There were a few additions to Gomy´s 2000 checklist; confirmed new species to the list were six in total, with five being present at Brise Fer and two at Mount Cocotte. No new species were found on Ile aux Aigrettes. One species from a family new to Mauritius was identified in the sample from Brise Fer (Leiodiidae, Agathidium sp1). This number is very likely an underestimate of species new to Mauritius, as only positively identified species are counted and also in the case of endemic species, where only species positively identified or morphospecies identified to endemic genera are counted. As 42% of morphospecies are yet to be identified beyond family/subfamily level, the number of new and endemic species is likely to be higher for all sites.

Variation between sites

Brise Fer has the highest number of species, then Mount Cocotte and finally Ile aux Aigrettes has the lowest number (table 2). There is no statistically significant difference between the mean species number per m^2 between Brise Fer and Mount Cocotte, but Ile aux Aigrettes has significantly fewer species per m^2 than the other 2 sites (table 2). This pattern is also found for the standard deviations around the mean species density and for evenness (see table 1). The range of species density classes is again highest in Brise Fer and lowest in Ile aux Aigrettes, again showing a higher variability in the Brise Fer transect.

Table 2. Number of species, means, standard deviation, eveness and count variability for the three sites.

	Brise Fer	Mount Cocotte	Ile aux Aigrettes
Total no. of species	37	22	10
Mean species no. (m2)	5,7[a]	5,5[a]	1,3[b]
Standard deviation	4,4	2,1	1,2
Eveness (Berger-Parker)	0,197	0,295	0,5
Count variability (range)	13 (0-12)	7 (2-9)	4 (0-3)

Principal Components Analysis also shows that the sample with the highest variability between quadrats is Brise Fer and the least is Ile aux Aigrettess (see figure 2).

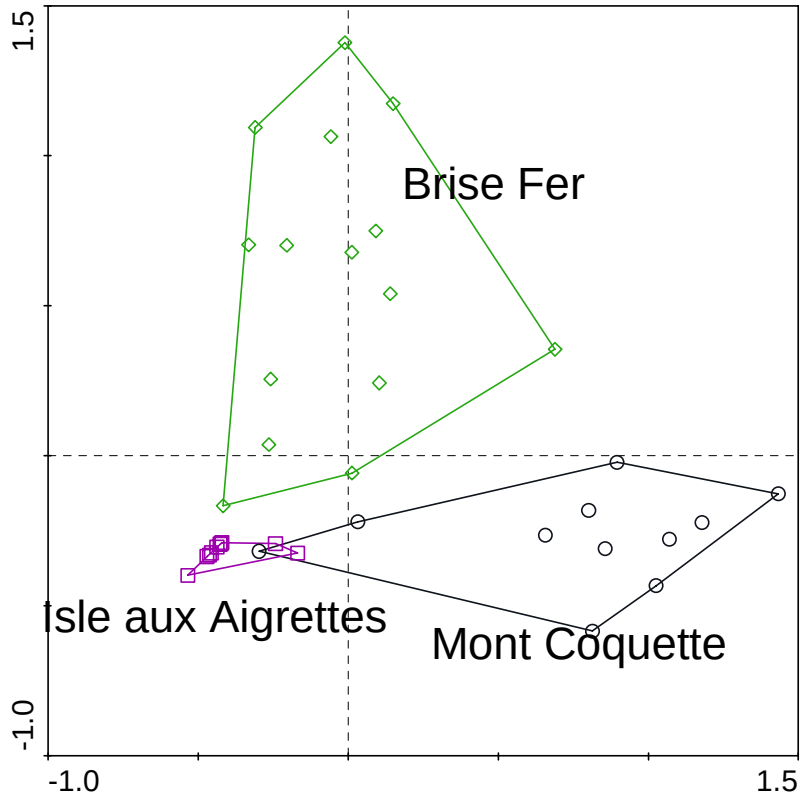

Figure 2. Principal components analysis of species and sample data.

Rarefaction was also used to assess species diversity, but that shows the Brise Fer has the highest rarefied species richness but that there is no clear difference between Mount Cocotte and Ile aux Aigrettes (Fig 3).

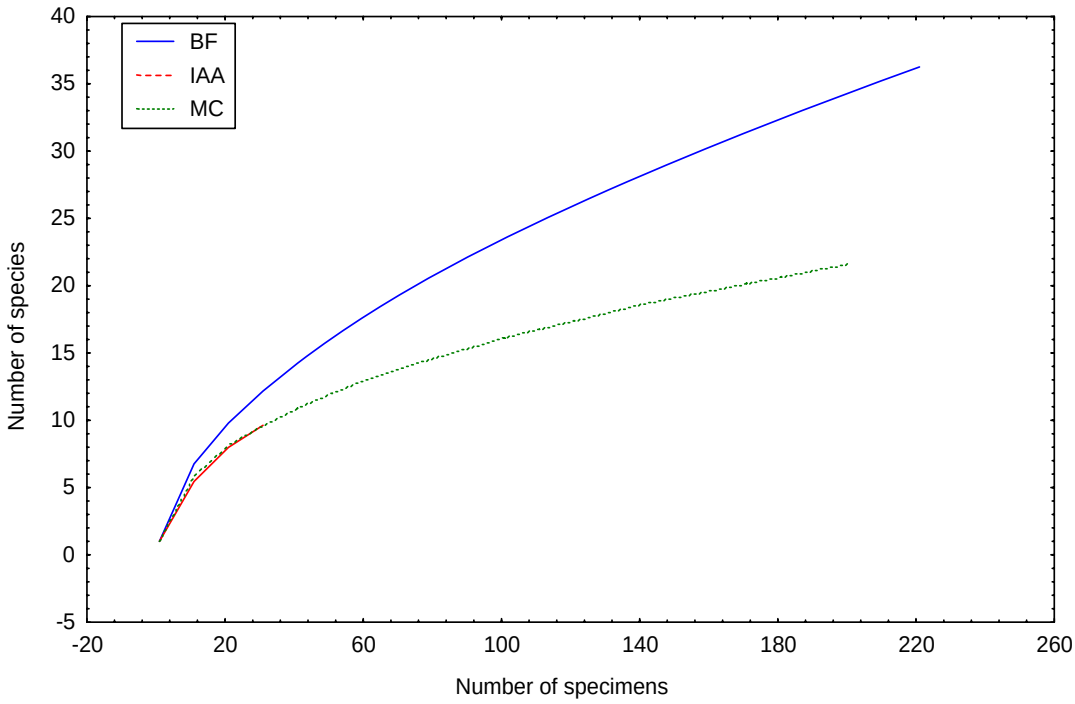

Figure 3. Rarefaction plot. BF = Brise Fer, IAA = Ile aux Aigrettess, MC = Mount Coquette.

Discussion

Species composition

As described above the highest number of species and specimens from all three sites were of Curculionoidea. The main difference in other superfamilies between sites is the abundance of Tenebrionoidea and Cucujoidea in Brise Fer, and Hydrophiloidea in Mount Cocotte (see table 1).

When comparing the results from Brise Fer to results obtained by the same collecting method from Queulat in Chile, Danum Valley in Sabah and Whitley Wood in England the striking difference is the lack of Staphylinoidea, which are abundant all the other sites. The Brise Fer sample has more Anthribidae and Scolytidae species (see figure 4). Brise Fer also has the lowest number of species (37) compared with 38 in Whitley Wood, and 45 in Queulat and 202 in Danum Valley.

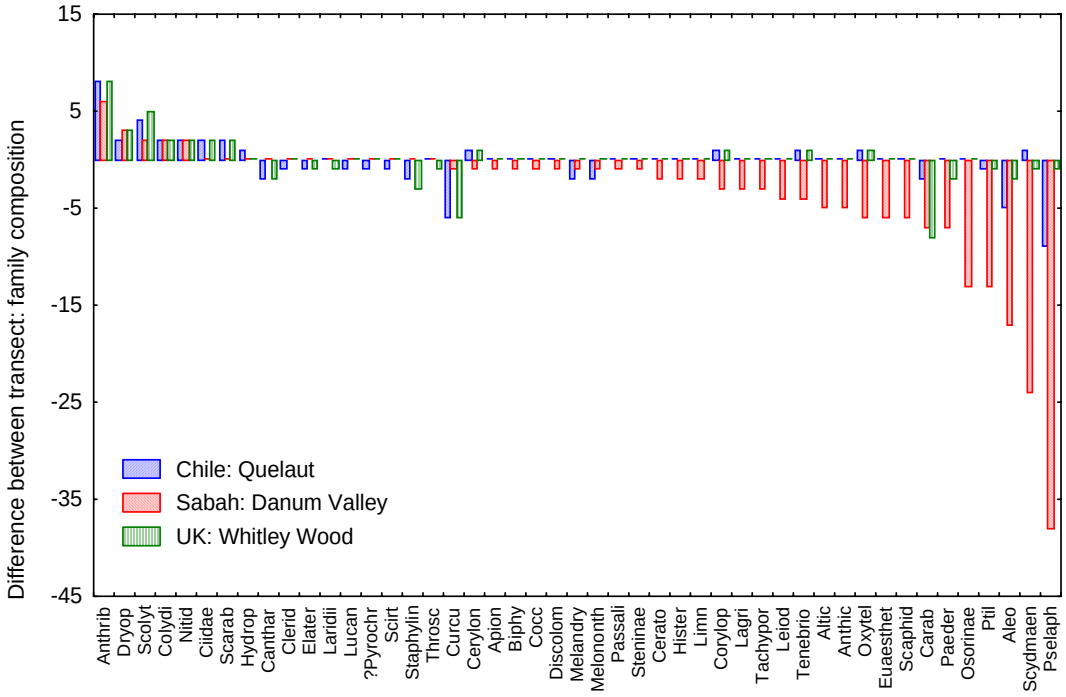

Figure 4. Comparison between beetle families found on 4 different sites. This bar polot shows the difference in family-level composition between Brise Fer in Mauritius when compared with (1) Queulat in Chile, (2) Danum Valley in Sabah and (3) Whitley Wood in England.

General comments

A study done in a tropical forest found that the number of scientist hours required to process invertebrate samples was inversely related to each groups geometric mean body length and that 50 - >80% of Coleoptera morphospecies could not be assigned to species (Lawson et al.,1998). Despite working on a fairly well known island fauna and with one of the World's best beetle collections we could only successfully assign 17% of morphospecies to species, keys were not obtainable for all taxa and in some cases even original descriptions were not descriptive/conclusive enough to securely identify specimens. The habitat (the soil/litter layer) from where the samples were collected are also poorly studied, which might contribute to the difficulty of identification. The highest number of specimens and genera from the three sites were from Curculionoidea and

despite having help from experienced taxonomists specialising in weevils, in most cases it was only possible to identify them to genera or subfamily/family.

Endemism is known to be high in Mauritius and we found beetles belonging to endemic species or species from endemic genera being over all three sites to be 22% (13 species out of 59 morphospecies). Brise Fer had the highest number of endemic species and species new to the list, which was to be expected as it is the least disturbed of the sites and at 25 hectares the largest of the plots. In comparison Mount Cocotte is 0.4 hectares and has fewer species in total, fewer endemic species and new species. Ile aux Aigrettes had no new species and only one endemic species, but that is not surprising given its location. These numbers are due to change as material sorted to morphospecies is sent to specialists for identification.

Although there was no significant difference between the mean species number between Brise Fer and Mount Cocotte, Principal Components analysis and rarefaction make it clear that Brise Fer has the highest variability of the sites. Ile aux Aigrettes always comes out at the bottom, with significantly fewer species and a lower eveness. However, the fact that rarefaction did not show a difference between Mount Cocotte and Ile aux Aigrettes was surprising, but this could be caused by the sampling effort being lower in Ile aux Aigrettes to be comparable, as there is very little soil and litter cover on the ground.

There was not much difference in species composition between the three sites. However, when the sample from Brise Fer, which was the most diverse of the three sites is compared with sites from Chile, Sabah and England there is a definite difference in that there are considerably fewer Staphylinoidea in the Brise Fer sample. This could be because these families are normally associated with social insects and may not have got to the island. Brise Fer has more species of Anthribidae and Scolytidae than the other sites. These families are normally associated with dead wood and could perhaps have rafted to Mauritius in driftwood.

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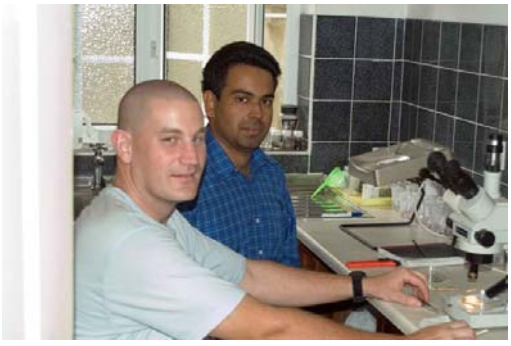
Aquatic Coleoptera in Mauritius and Rodrigues – interim report

by Clive R. Turner

Introduction

As part of the Darwin Initiative project, the islands were visited between the 3rd and 18th December 2005, just at the start of the wet season, which was slightly later than anticipated. In the 15 days available a combination of techniques were experienced and demonstrated in the variety of habitats found over the 1960km travelled on Mauritius and the single day's visit to Rodrigues. Over 70 sites with aquatic species were investigated and material examined in the laboratory was used to demonstrate genitalia dissection and essential taxonomic features. Additional terrestrially based techniques known to produce semi-aquatic species were also explored.

Training



Saoud Motala (far right) and Zayd Jhumka (above) readily attended the field sessions and exhibited great enthusiasm, interest and aptitude in the specialist techniques employed to locate aquatic and semi-aquatic Coleoptera. The water beetle bioinventory methodology (Turner in prep) was explained and demonstrated in the context of the habitats experienced. A cross-section of habitats on the islands were visited. On Mauritius this comprised of basal divisions between upland and lowland permanent still and running waters of the south, and the lowland seasonal running and still waters of the northwest and coastal fringe. The skill to recognise subhabitats within a site was experienced with the accompanying appropriate sampling techniques primarily consisting of a combination of netting, hand searching and sieving supplemented with methods of agitation and observation to maximise specimen and species extraction. In the MWF laboratory the essential skill of genitalia extraction and recognition was practiced under guidance and salient taxonomy was discussed and demonstrated with reference to the determination of material and the finer points of preservation for specialist purposes.

Preliminary results

The initial results, other than the positive results of the specialist training, must be described as extremely exciting from the taxonomic, biogeographic and biodiversity perspectives.

Several higher taxa were discovered as new to the islands. This included the tribe Bidessini (Dytiscoidea) on Rodrigues, the Heteroceridae on Mauritius and probably the Mascarene Islands, the genus *Rhantus* in the Dytiscoidea was discovered as new to Mauritius.

On a species level several endangered species considered probably extinct were rediscovered. This included *Rhantus socialis* (Dytiscoidea) and *Hydraena balfour-brownei* (Hydraenidae) on Rodrigues where they were located at new localities and the original localities investigated. The Bidessines of Rodrigues comprised of two species both new to the island. In addition a large *Dineutes* (Gyrinidae) was considered to be *aeratus* which has not been seen since the type series taken in 1873. More endangered species on Rodrigues will surely be recorded as the identification process continues.

On Mauritius there were several encounters with the endangered endemic members of the Dytiscid genus *Copelatus,* the *Rhantus* is a potential new species or a recent introduction and the Gyrinidae are hoped to produce a new species composition scenario. The Hydrophlidae were very widespread and considered to provide some interesting distributional data with respect to the several endemic species. The Heteroceridae comprised of two species, one from the upland endemic Sideroxylon forest and another for the arid areas of the north west. Several small Bidessines were captured in temporary waters and seeps.

Biogeography

The Mauritian species distributions and habitat implications are discussed separately below given the disparity with Rodrigues. The biogeographical implications of the new discoveries are very exciting given there appeared to be an incomplete picture of generic and species distributions within the Mascarene islands. Réunion has been relatively well studied in terms of the aquatic Coleopteran fauna, although new discoveries are still occurring, giving the appearance that Réunion possessed a more comprehensive fauna. In fact this study has revealed already that this is not the case and that there are more interesting biogeographic scenarios to be stated. Key to this was the discovery of *Rhantus* on Mauritius and the Bidessines on Rodrigues. Without doubt there will be further progress on this issue as the study progresses.

Conservation, habitat and reserves

One important perspective of this study was to evaluate the conservation value of the current reserve network. To understand this a précis of the distribution of species and habitats is required.

Rodrigues was briefly examined and the habitats encountered considered to be in similar to their general form at the last major examination by Vinson in the 1950's to 60's. The habitats were broadly distinguished as wetter upland and direr lowland habitats. The coastal fringe often comprised of pools dug into the valley bottoms by farmers and the upland habitats primarily flowing waters with slow flowing pools. The aquatic habitats of Rodrigues were in what was considered to be extremely good condition and very worthy of conservation efforts. A contributory factor to the clearly unchanged species communities was the apparent lack of invasive amphibians and pigs as well as the relatively low human pressure.

Mauritian aquatic habitats were generally very degraded and extreme concern must be expressed for the quality of the water itself apart from the conservation issues affecting the degraded beetle communities. The islands habitats were broadly divided in to the seasonal waters of the northern lowlands and coastal fringes and the upland habitats.

The lowland habitats comprised of permanent waterways and seasonal pools, both of which have been extensively expanded through irrigation of the sugar cane fields, and subsequent ephemeral flooding of small areas. The rivers were generally in very poor condition with generally poor water beetle communities comprising of *Dineutes* and some common Hydrophilids. These waterways were generally heavily shaded by invasive vegetation; many were partially eutrophic with abundant filamentous algae and often heavily sediment loaded. Only one lowland

river was considered to represent a healthy aquatic system with a wide variety of invertebrates and one was minimally sampled because it was considered too high a health risk to continue. The temporary pools caused by irrigation overflow were a bonus habitat and proved rich in water beetle species and certainly an important resource for several endemic species. The irrigation canals were generally very poor for aquatic Coleoptera and other invertebrates but the regularly cleared margins proved a man-made refugia for the semi-aquatic species and should be considered of conservation importance and like the overflow pools probably are in little need of any more management other than monitoring provided the production of sugar cane continues and the use of pesticides does not increase dramatically.

The upland rivers suffer severely from sediment loading, alien species shading and eutrophication, as do most of the natural upland stillwaters. The upland Dytiscid communities as described by Vinson were not encountered and subsequent investigation reveals that they may still exist in the more remote gorges of the Black River Gorges National Park. Large reservoirs possessed a very poor aquatic water beetle fauna and invertebrate fauna in general however the riparian and semi-aquatic fauna was comparatively rich due to the man made, continually disturbed and fluctuating margins. In the uplands the reserves appear to possess high conservation significance by the provision of relatively disturbed water catchments.

However they still suffer from the extremely numerous invasive amphibians and probably more importantly pigs. The human impact on sedimentation is obviously apparent outside the reserves as a direct result of only 20% of the population on mains sewage and the agricultural development of deforested slopes. The Black Forest Gorges National Park initially caused a rather puzzling scenario where sedimentation and partial eutrophication was still a problem even in the upland bogs. On closer inspection and after experience of numerous habitats it appears that the pigs are responsible for churning over much of the region's surface with the result that surface runoff carries excessive sediment into the marshes and water ways that would be expected to normally maintain a healthy vegetative mass over sediment. The net result was sediment covered aquatic vegetative mass and water bodies with extremely mobile sediment, a condition that is, in the majority of cases, unsuitable for well developed and diverse aquatic communities. This difficult situation was considered to have been exacerbated through the historical planting of alien forestry, contemporary spread invasive plant species and the extremely dense populations of alien predatory amphibians.

That the national park is a refuge for endangered species of water beetle is irrefutable and it appears that the southerly flowing rivers are probably the most species rich on the island,

however a full bioinventory of the Park would be recommended with some urgency along with an assessment of the damage to the aquatic habitats.

In general terms the state of the Mauritian aquatic habitats was a matter for extreme concern not least in terms water catchment management for the human residents. Water quality biomonitoring across the island would provide a baseline for water supply standards, which are suspected to be rather low, as well as suit the conservation of the island endangered aquatic species. Water pollution was also suspected as a result of the apparent regular temperature inversion that occurred each evening bringing lowland pollution into the highlands.

Preliminary conclusions

The training was a great success and given the conservation and environmental considerations further training would be essential to maintain and develop a local skill base. The specialist skills involved in aquatic bioinventory and fundamental Coleoptera taxonomy were effectively communicated and understood.

The water beetles of Mauritius and Rodrigues were poorly understood and this study will without doubt returned data significantly rectifying this situation. The visit significantly increased the current understanding of the water beetles of the islands. Many species are internationally endangered.

A baseline of understanding of the aquatic habitats on the islands was established.

The aquatic habitats on Rodrigues are of international importance and worthy of preservation, not least because of their proximity to their original state.

The Mauritian aquatic habitats are severely degraded and many would be considered extremely difficult to restore. The primary factors in this were considered to be agricultural methods, poor sewage treatment, invasive plant species, wild pigs and alien amphibians with the supplementary issue of temperature inversion raising pollution into the water catchments.

The existing reserves probably do not adequately encompass the remnant aquatic habitats but were sufficient to provide a baseline for aquatic conservation in the islands. Management of the existing reserves could be more sensitive to the aquatic habitats, at least in water catchment corridors.