'Bats on the Brink'

Conserving the Critically Endangered Seychelles Sheath-tailed Bat (*Coleura seychellensis*)

UNIVERSITY OF ABERDEEN

Aberdeen University Seychelles Expedition 2004

Final Report - May 2005

BP Conservation Programme – Grant Reference: Gold 103104

'Bats on the Brink'

Granitic Island Archipelago, Seychelles Republic, Indian Ocean.
12th June 2004 to 15th September 2004

To establish the population status, highlight and analyse possible causes for decline and compile a species recovery action plan for the Seychelles Sheath-tailed bat (*Coleura seychellensis*).

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Aberdeen University (AU)
Nature Seychelles (NS)
Ministry of Environment and Natural Resources (MENR), Seychelles
WildLife Clubs of the Seychelles (WCS)

Final Report – May 2005

Cover photo, *Coleura seychellensis.* Mahé, Seychelles © AUSE 2004.

Questions and requests for additional data or information should be directed towards:

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Acknowledgements

Many people, organisations and institutions provided varying levels of assistance in the planning and execution of this research expedition. The order by which they appear bears no relevance to their level of help or input.

We would like to thank those who helped with the field section of the expedition, especially staff at Nature Seychelles (NS); Nirmal Jivan Shah (Chief Executive, Kirsten Henri (Projects Coordinator), Rachel Bristol (Science Coordinator) and family, Colleen Morel (Education and Awareness Coordinator) and Fabrina Mole (Assistant Administration Officer). Also, Terence Vel (Coordinator) of Wildlife Clubs of the Seychelles and the staff at the Ministry of Environment and Natural Resources Seychelles (MENR); Didier Dogley (Director General Nature and Conservation), Selby Remie (Director Conservation), Flavien Joubert (Director Pollution prevention and Control), Joseph Francois (Head of Conservation, Praslin) and Perley Constance (Conservation Officer). The staff and organisations jointly provided much information, logistical and moral support prior to and throughout the expedition. Also, Victorin Laboudalon (Independent Conservationsist) for his time and expertise during our stay on Praslin.

Also those who provided valuable support back here in the UK. Marianne Dunn (BP Conservation Programme) for her training and support and various staff and research assistants at Aberdeen University (AU).

Of course all of the organisations who were kind enough to provide us with funding to make the project a reality; The BP Conservation Programme, Carnegie Trust for Scottish Universities, AU Expedition Fund, Gilchrist Educational Trust, Gordon Foundation, Chester Zoo, British Ecological Society, AU Small Grants Fund and Paco's Restaurant, Perth.

UNIVERSITY OF ABERDEEN THE GORDON FOUNDATION Chester Zoo British Ecological Society

Not forgetting the thanks to all of the people not mentioned above, including family and friends of team members for all their advice, help and support. You know who you are!

The research team: Left to right; Denise McGowan, Andrew Blyth, Sarah Burthe, Lorraine Marshall-Ball, Louise Craig, Sinclair Laing, Laura Bambini, Tim Bradford and Rachel Bristol and Terrance Vel of Nature Seychelles (Also, but not in the photo, Project Leader Nick Downs and MENR Collaborator Perley Constance).

Executive Summary

The Sheath-tailed bat is one of only two mammals endemic to the granitic Seychelles. Historical records indicate that the bat was widespread and abundant prior to the 1970's, but that populations underwent a severe decline during the mid to late 20th century. Prior to this study it was known to occupy only two roosts, and extinction seemed likely without the implementation of conservation measures. Efforts to raise the profile of the species have been hampered by its' chronically data deficient status, meaning that coherent information is urgently required to allow the drafting of an action plan for a long-term recovery strategy. This study aimed to assess the population status and investigate the ecology of the sheath-tailed bat on the four main granitic islands of the Seychelles. Bat detector surveys were undertaken in order to assess habitat use, abundance and distribution. Five main foraging areas were located on the main island of Mahé, but no bats were located on the islands of La Digue or Praslin, the latter result indicating that the species may have become extinct on this island in the last three years. Intensive roost searches were undertaken and three roosts were located on the main island of Mahé: at Port Launay (7+ individuals), Anse Major (7+ individuals), and Baie Lazare (1+ individuals).

This study provides a data framework for implementing a long-term conservation and recovery plan for this species, and highlights deficiencies in basic ecological knowledge necessary for effective management. However, it was found that better co-operation and data circulation between local conservation organizations and government researchers would be invaluable for this species' survival. A conservation strategy and recommendations for species management is outlined.

Contents

2. Logistics & Administration

3. Fieldwork & Research

Appendices

Final Report Copies

1. Introduction

1.1. Background

The *'Bats on the Brink'* conservation project arose as a direct result of the desire of the Seychellois NGO, Nature Seychelles (NS), to initiate much required research into the ecology and population status of the endemic and critically endangered Sheath-tailed bat (*Coleura seychellensis*), aiming to culminate with suggestions for positive actions towards the conservation of this species. After initial contact and many subsequent consultations between Dr Mike Hill (NS) and Nick Downs, a team was assembled consisting of members with the relevant areas expertise. Two years after the first consultations took place, the team, logistics and methodology were finalised and a major source of funding was gratefully secured through The BP Conservation Programme. Following this support, further supplementary sources of funding were also secured and the project was ready to move onto the field stage.

Selected team members varied from ecological consultant to undergraduate student and NS employee. These varying levels of expertise lent much to the development of a coherent project and the success of its implementation in the field. It also allowed for a great deal of exchange of knowledge and expertise in all directions, to the benefit of everyone involved.

The field stage commenced in the middle of June 2004, and with an extension of an extra four weeks in the field, it ended in late September 2004. All of the team members left for the field together and began by establishing themselves and initiating contact with all of the relevant Seychellois organisations in order to get the most out of the project. Due to the various personal commitments of the team members, individuals left the field at various stages throughout this phase. These departures were all planned and responsibility for co-ordinating fieldwork was simply passed along a pre-determined line of co-ordinators, selected according to their experience and expertise.

Once all of the fieldwork was concluded, energies focused on more desk based research, data and sample analyses. Given the variety of aspects within this project, each was dealt with by those team members with the relevant expertise to obtain the best outcomes, and to share the workload. This stage is now also coming to an end and much of the team's work to date is set out in this Final Report.

The Final Report is an attempt to convey as much information about the project as is possible in a single accessible format, both for the benefit of funding bodies and other interested parties. Initially it provides details of the individual team members, collaborative organisation involved and a few notes on the logistics of the project and the budget and accounts to date. It then moves onto the hard science of the project, with an introduction of the current knowledge surrounding *C. seychellensis,* the project's aims and the field methods, analysed results, etc., each in defined sections. It draws to an end with the project's outputs, research conclusions and the very important Species Action Plan. Within the Appendices are also included standardised methods and sample data collection sheets for future monitoring work.

A CD containing a digital copy (portable digital format) of this report is contained within the final page of this report (*Final Report Copies, CD: Digital Copy of Final Report*, page 75). It is supplied in the hope that this document becomes more accessible to all who require it, without the associated environmental and financial costs of copying such a large volume. Please feel free to share and copy this CD as is required, bearing in mind it still conforms to all copyrights of the original document.

1.2. Maps of Seychelles Archipelago

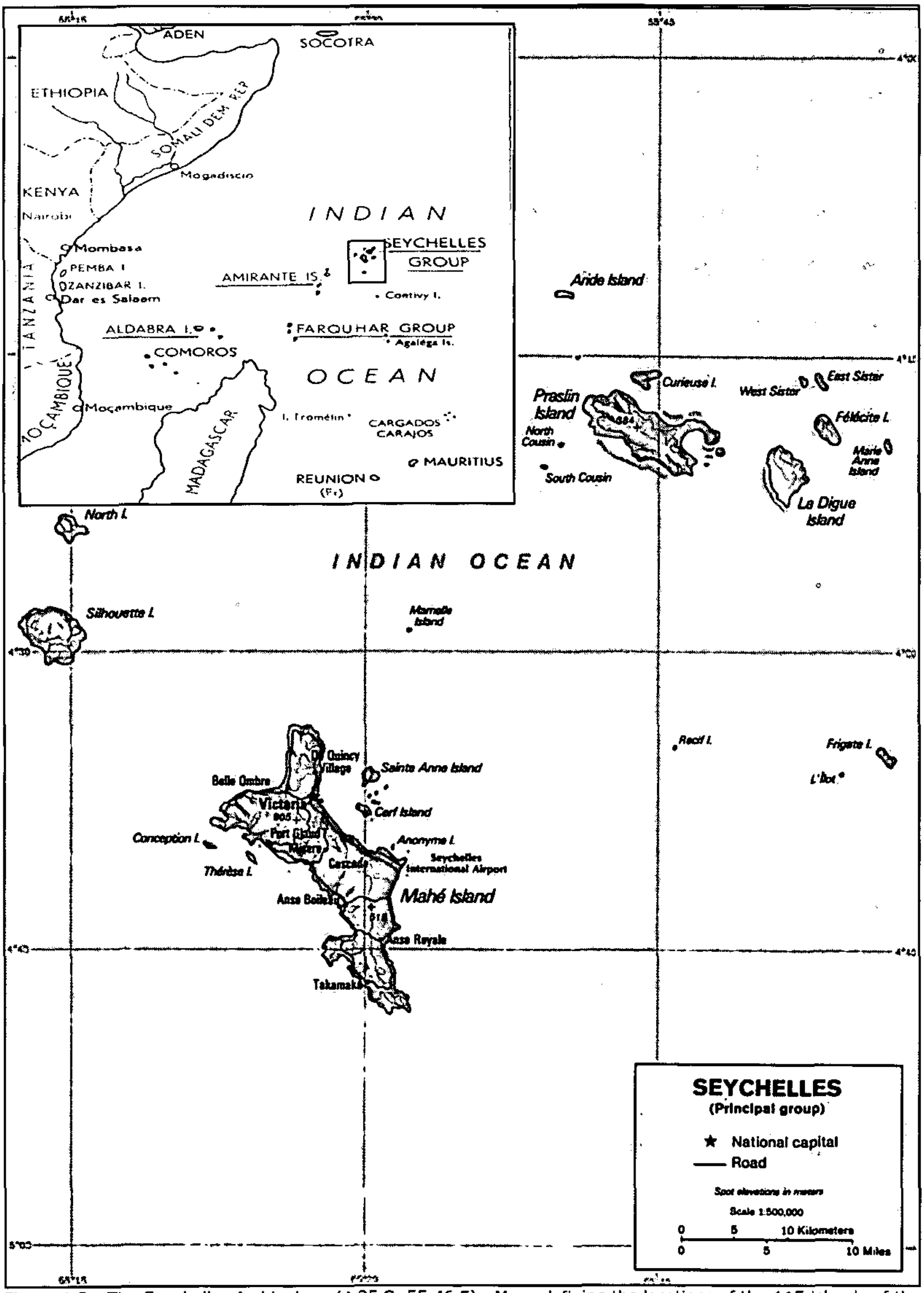

Figure 1.2: The Seychelles Archipelago (4 35 S, 55 46 E). Maps defining the locations of the 115 islands of the Seychelles within the Indian Ocean, and relative to each other. The main group consists of four granitic islands at the north of the archipelago; Mahé, Praslin, La Digue and Silhouette.

1.3. Project Team

1.3.1. UK Team

Project Development

Nick Downs, PhD (31) British

Nick graduated with an Honours in Biology/Geography (1995, Leeds) and went on to complete an MSc in fly population dynamics (1996, Leicester) and a PhD in bat habitat use (2001, Aberdeen). Currently he's a Consultant Ecologist (Cresswell Associates). Together with Dr Mike Hill (formerly of NS), Nick was the originator of this project. As a highly motivated, expert bat ecologist he provided the necessary practical skills and theoretical knowledge required of Project Leader. This was Nick's first expedition and due to work commitments was only able to spend two weeks in the field, during which time he helped establish the project, train team members and meet with local counterparts.
n.downs@abdn.ac.uk

Secretary & Communications

Laura Bambini, BSc (25) Finnish

Laura's completing a BSc Honours in Zoology (Aberdeen) and hopes to study for an MSc in October. She's gained prior experience conducting bat detector surveys during summer field work (2003, Aberdeen). Laura was involved with the planning and fieldwork stages of this project and was responsible for field communications to UK sponsors. She was also involved with the community education and was one of three team members to spend four extra weeks in the field. She has also taken the lead in writing our first article currently being submitted for publication.
u07lb@abdn.ac.uk

Treasurer

Sinclair Laing, BSc (30) British

Another graduate, Sinclair has a BSc Honours in Tropical Environmental Science (2004, Aberdeen). Now an Honorary Research Assistant (Aberdeen), he's planning to commence an MSc in Biodiversity and Conservation (Leeds). He was Expedition Society President (2003, Aberdeen) and has previously taken part in several research expeditions to the tropics, including one he led to the Peruvian Amazon (2003). Sinclair was involved with the later fundraising for this expedition, logistics, fieldwork and liaisons with local counterparts. He has also led the compiling of this report and plans to return to the Seychelles.
sinclairlaing@hotmail.com

Logistics

Lorraine Marshall-Ball, PhD (27) British

Lorraine graduated with a 1st Class Honours in Zoology (2000, Aberdeen) and went on to complete a PhD (2003, St Andrew's). She is now a Reserves Ecologist (RSPB). Lorraine took part in a previous BP sponsored conservation project, aiming to produce a bat field guide (2001, Madagascar) and as a result gained much knowledge of bat ecology and field survey techniques. She was involved with this project from the outset and helped to formulate the methodological protocols, aided the training of team members, liaised with local counterparts and lent her experience in analytical modelling to the the project's data.
lorraine_mb@hotmail.com

Safety & Medical

Sarah Burthe, PhD (29) British

After completing a 1st Class Honours in Zoology (2000, Aberdeen), Sarah has gone on to PhD research with the Population Research Ecology Group (Liverpool). Sarah gained prior bat field research experience when assisting with Nick Downs' Phd (2000) and also during three months researching bat roost preferences in Bialowieza Forest (2001, Poland). Sarah benefited the project with a variety of field and analytical skills, was involved with liasing with local counterparts and has been leading the writing and animation for the projects children's book, *'Boris the Bat'*. First aid trained.
burthe@liverpool.ac.uk

Community Education

Louise Craig, BSc (22) British

Louise graduated with a 1st Class Honours in Biology (2004, Aberdeen) and is planning to start an MRes in Science of the Environment (Lancaster). Previously she has demonstrated a keen interest in bat conservation and co-led an expedition to Sepilok Forest Reserve, to survey bat biodiversity (2003, Borneo). As such Louise lent her field experience and knowledge of bat survey techniques and ecology to this expedition. She was also very involved with liasing with and training Seychellois counterparts as she was with every aspect of the expedition. She was another team member to spend an extra month in the field.
louigie99@yahoo.co.uk

Community Education II

Denise McGowan BSc, (25) Irish.

Having also completing her BSc Honours in Zoology (2004, Aberdeen) Denise is now volunteering on the St. Lucian Iguana Conservation Project (Durrell Wildlife Conservation Trust). Denise was one of three team members who previously took part in an expedition to Sepilok Forest Reserve, to research bat biodiversity (2003, Borneo). She was one of our team members involved with the community education aspect of the project as well being one of the three team members to spend an extra month in the field gathering further ecological data and discovering another roosting site for this bat.
denisemcgowan24@yahoo.ie

Field Assistant

Andrew Blyth, BSc (23) British

Also a Zoology Honours graduate (2004, Aberdeen), Andy is now nearing the completion of a six month internship (World Land Trust). Andy took part in an expedition to Sepilok Forest Reserve, where he gained experience in bat field research (2003, Borneo). He provided logistical support throughout this project and was involved in writing the children's book, *'Boris the Bat'*, soon to be published and distributed throughout the Seychelles. He will also be travelling to the Society for Conservation Biology's annual conference in Brasilia (2005) to present the findings of our research.
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Field Assistant II

Timothy Bradford, BSc (22) British

Another Honours Zoology graduate (2004, Aberdeen), Tim is now working in Satrosphere (Aberdeen), an educational centre for teaching youth about the world around them through science. Tim also carried out transect bat detector surveys and also computer bat sound analysis during paid summer fieldwork (2003, Aberdeen). As well as being involved with this project's fieldwork, Tim's understanding of bat sound analysis provided the field phase of this project with a clearer understanding of the ecological requirements of this bat.
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1.3.2. Seychellois Collaborators

Nature Seychelles Collaborator

Rachel Bristol, New Zealander

Rachel's area of expertise lies with birds, having conducted field work and research in New Zealand, Hawaii and Mauritius. She then joined Nature Seychelles (1999) and was Seabird Coordinator for one year. She is now Science Coordinator and has been involved with this project from its outset. She showed unrelenting motivation in aiding with project development, logistics and fundraising and fieldwork. She and Nature Seychelles also plan to be further involved through long-term monitoring actions alongside other organisations in the Seychelles.
science@nature.sc

MENR Collaborator

Perley Constance, Seychellois

Perley is a Conservation Officer with the Ministry of Environment and Natural Resources (MENR) at the Seychelles Government. As Conservation Officer, he has been previously involved with the monitoring of this bat and acted as a very willing and able field assistant during the later stages of the field phase of this project on Mahé. Although already trained in bat survey techniques, he was given further training and hopes to be involved in future monitoring work undertaken between Nature Seychelles and the MENR.
perleyconstance@hotmail.com

WildLife Clubs Seychelles Collaborator

Terrance Vel, Seychellois

Terrance is Coordinator for the Wildlife Clubs of the Seychelles, a dynamic not-for-profit NGO working to improve conservation education throughout the Seychelles schooling system. Terrance helped tirelessly with plant identification and habitat surveys during the earlier stages of the field phase of the expedition and accompanied the team on research trips to both Praslin and La Digue. As our collaborator with the Wildlife Clubs, he helped to coordinate the community education aspect of this project.
wcs@nature.sc

1.4. Collaborative Organisations

1.4.1. Nature Seychelles (NS)

NS is BirdLife International's partner organization within the Seychelles. A local not-for-profit association, they are currently the largest independent environment organisation within the Seychelles. NS is involved in a suite of activities including species and habit conservation, monitoring, research, island restoration, eco-tourism, education & awareness and advocacy. It has a multi-stakeholder and result-oriented approach through its programs, as well working with other organisations such as the Wildlife Clubs of Seychelles, Ministry of Environment and Ministry of Education. The primary objective of Nature Seychelles is to improve the conservation of biodiversity through scientific, management, educational and training programmes.

Nature Seychellles were the main driving force behind originating this project. From the outset they have provided the project and its team with information, logistical, financial and manpower support. They are also incorporating plans into their work programmes to continue with long-term monitoring and conservation of *Coleura seychellensis*.

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1.4.2. Wildlife Clubs of the Seychelles (WCS)

The Wildlife clubs of Seychelles is a registered non-profit making organisation dedicated to promoting conservation through environmental education. They provide resources and support for a nation-wide network of wildlife clubs, most of which are based in schools. Wildlife clubs are run by Teachers and community volunteers, and are involved in activities such as conservation projects, recycling, creativity, hiking, snorkelling and camping.

The Wildlife Clubs of the Seychelles was involved with the team's work during our time in the Seychelles. Both in the provision of field assistance and local expertise and through allowing us to provide training and education relating to *Coleura seychellensis* to the club's leaders.

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1.4.3. Ministry of the Environment and Natural Resources, Seychelles (MENR)

The Seychelles is a biodiversity hotspot and as such has obligations to make efforts towards the conservation of its unique environments, flora and fauna. Most government actions towards this aim are taken through the MENR. The MENR were heavily involved with this project, regularly liasing with the project's team and providing the project with information, logistical and funding support. All information gained as a result of this project is to be shared with MENR and they plan to continue the project's work, and their own, through continued long-term monitoring and conservation of *Coleura seychellensis*.

Vision: At the Dawn of the 21st century it is the vision of the people of Seychelles that the second generation Environment Management plan, EMPS 2000-2010, will serve as a flexible, yet robust, vehicle for continued improvement of proactive environmental management excellence, so that by the year 2010 the Seychelles will be firmly established globally as a committed leader in sustainable development.

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Ministry of Environment Seychelles

1.4.4. School of Biological Sciences, University of Aberdeen (AU)

The School of Biological Sciences at the University of Aberdeen consists of several faculties, all of which have a positive history in encouraging its students and research staff to organise and participate in research expeditions, both within the UK and abroad.

Staff within the School were very supportive of this research expedition and displayed this support with references, advice and by providing full access to university facilities for the purposes of literature based research and analysis of samples.

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2. Logistics & Administration

Below are a few notes on the logistics of the expedition relating to the time spent on Mahé, La Digue and Praslin, along with any problems encountered and subsequent necessary changes made.

2.1. Accommodation

On Mahé the team's accommodation was in a nine-bed bungalow on the north point of the island and was organised and paid for with the kind financial support of Nature Seychelles (NS), the projects main collaborators. Rachel Bristol, Science Coordinator Director of NS also provided accommodation on La Digue at her family home, again free of charge. Accommodation on the island of Praslin was provided free of charge by the Conservation section of the MENR at one of their staff houses. With all of this support, the budgeted field costs of the expedition were reduced, allowing much needed funds to be diverted to previously unplanned areas of fieldwork.

2.2. Transport

Transporting the team and equipment around the main island of Mahé was predominantly achieved by using a leased minibus, again organised and paid for by NS. Due to the topography of the granitic islands of the Seychelles, most of the road networks are located along the coastal outskirts of the islands, with a few that dissect the mountains that dominate the inland areas. All of the roads tend to be narrow, steep and winding, and as a result, traversing the island on a daily basis for fieldwork was a long and slow procedure that hampered progress. Driving was shared between three designated drivers to portion the work.

Transport on the island of Praslin was kindly provided free of charge by the Conservation Section of the MENR, in one of their staff vehicles. Thanks to their close collaboration, we were able to access all areas of the island required for our research.

There are no roads or transport to speak of on La Digue, so all movement was on foot; again, a long and slow procedure.

2.3. Local Expertise

The staff of NS and the MENR provided much field and research assistance. NS and the MENR helped with local expertise, providing details of their research to date and the present understanding of the species' status, along with identifications of botanical samples and help in gaining much needed publicity. Both organisations also provided personnel for fieldwork and remote video monitoring equipment for use within the roosts.

2.4. Complications

2.4.1. Silhouette

Unfortunately a visit to the island of Silhouette was not possible due to the failure of long and complicated negotiations to come to mutually agreeable arrangements between government organisations and NGOs within reasonable time. Silhouette is host to the largest known roosting colony of *C. seychellensis* and study upon this island would have been of immense benefit to the outcomes of this project. Not being able to gain access to this island was a great blow to the team and the project.

2.4.2. Remote roost monitoring

Video-monitoring

Two remote video systems, which had previously been successfully used by both NS and the MENR in monitoring the nest sites of rare endemic birds such as the Seychelles scops owl (*Otis insularis*), were made available for our use (see *Appendix C*, page 74). It was hoped to use these systems to monitor the bat activity around the roost access points whilst minimizing disturbance and manpower effort. However, due to a combination of problems (sourcing the correct video tapes, an inability to distinguish bat presence clearly due to inadequate infra-red lights, and multiple roost exits in two of the three known roosts), it was decided observers should monitor roost access points instead.

In the future, it is hoped that use of a higher specification camera system (such as a laser or thermal imaging device) would allow more detailed information, such as bat numbers and/or behavioural observations to be made at roosting sites.

Automatic bat activity recording

Two automatic bat activity recording stations were made available from the University of Aberdeen. These stations consisted of a heterodyne bat detector attached to a computer downloadable logger through an ac/dc converter (see *Appendix D*, page75).

This system allows the logging of levels bat activity and activity patterns, without the requirement for a constant presence of personnel, reducing both costs and manpower effort. It also provides data that is immediately available. When several such systems are deployed on the same night comparable estimates of bat activity (measured as 'bat-active minutes') can be obtained with great efficiency, allowing bat habitat preference to be determined. They can also be used within roosts to determine activity patterns and roost faithfulness.

A major drawback is that these stations can also record other sources of ultrasound and require an adequate power source; the latter being a problem in the Seychelles. Quiet ultrasound noises (such as those made by leaves rustling in a light breeze) can be rejected via the use of a threshold setting on the ac/dc converter. However, louder ultrasound noises (such as those made by heavy rain or crickets) will be recorded. Therefore, in the Seychelles, these stations are only suitable for recording bat activity within enclosed spaces that will be free from ultrasonic interference (such as inside roosts). However, failures of battery equipment in the field and inability to obtain further batteries rendered these stations unreliable for use within the Seychelles.

2.5. Project Extention

The most obvious gain to the project was due to the generous help and support provided by our Seychellois collaborators, NS and the MENR. Kind financial assistance with accommodation and transport costs (along with manpower support) resulted in a reduction of the planned budget, leading to a decision for a four week extension to the field phase of the project. Three team members stayed to obtain much additional ecological data and conclude roost searches, ending with the discovery of the third roost in the south of the island.

2.6. Collaboration

Thanks to our close collaborations, ongoing monitoring of this species has been discussed between all relevant parties. The MENR have established, and are responsible for hosting a database into which all data pertaining to the species will be entered. The three main conservation organisations within the Seychelles, NS, MENR and Nature Protection Trust of the Seychelles (NTPS), are establishing a Memorandum of Understanding (MoU) that will see open access of their data for the benefit of all parties concerned.

Sample field data collection sheets (see *Appendix B*, page 73) and preliminary conservation and monitoring recommendations have also been produced by the project and deposited with the MENR for use in the interim (see *Appendix A*, page 71), until this Final Report and its recommendations were disseminated.

2.7. Budget and accounts

The project's budget underwent significant changes throughout the duration of the expedition. With unexpected changes to; the number of team members, levels of funding secured, financial support from associated organisations, and the planned itinerary, actual spending did not closely match that originally proposed.

Some costs (i.e. food) were over-budgeted; however, these remaining funds were redirected on under-budgeted and unexpected costs (i.e. equipment and fuel, respectively). The Aberdeen University Expedition Fund was kind enough to support the project with an extra £800 and NS and the MENR Seychelles were kind enough to cover all costs for accommodation and vehicle hire, saving the expedition substantial funds. The decision was made to divert some of these extra funds to extend the field phase of the project for a further four weeks.

There currently remains £3,373.84 in the expedition's accounts. Included in this figure are projected costs for one team member to produce and present a poster at the Society for Conservation Biology's annual conference Brasilia, July 2005. Not included in this figure are planned expenditure to cover Final Report distribution, presenting a paper at the BCT's annual conference, 2nd-4th September 2005, publication and distribution of the children's book, '*Borris the Bat, Trouble in Paradise*' and follow up projects (see *Future work*, pages 58 & 59 for further details). All of these costs remain as yet unbudgeted.

Table 2.7: *'Bats on the Brink'* proposed budget with actual spending and difference. Funds remaining are £3,373.84, as opposed to the figure of £3,368.67 stated below. This discrepancy is due to variations in the bank's base exchange rate obtained, in comparison to the single rate used in the calculations below (SR9.1 to £1).

Income to date	Expected	Actual	Difference
BP conservation awards (gold)	9,700.00	9,667.32	-33.00
The Carnegie Trust for Scottish Universities	1,500.00	1,500.00	0.00
Aberdeen University Expedition Fund	1,000.00	1,800.00	800.00
British Ecological Society	1,000.00	1,000.00	0.00
Chester Zoo	1,000.00	1,000.00	0.00
Gordon Foundation	1,000.00	1,000.00	0.00
AU Small Grants Fund	500.00	500.00	0.00
Fundraising	500.00	285.00	-215.00
Total	**16,200.00**	**16,752.32**	**552.00**
Pre-expedition expenses			
Transport - International flights (9@£600)	5,400.00	5,134.50	265.50
Insurance, in kind from University of Aberdeen	Free	Free	0.00
Team medical kits	200.00	95.70	104.30
Administration (stationary, postage, etc.)	200.00	104.40	95.60
Research permits, in kind from Nature Seychelles	Free	Free	0.00
Vaccinations, paid for by team members	Free	Free	0.00
Equipment	800.00	1,885.54	-1,085.54
Total	**6,600.00**	**7,220.14**	**-620.14**
In the field			
Equipment	200.00	73.87	126.13
Administration (phone, bank charges, etc.)	150.00	421.36	-271.36
Food (453 people days @ £9 per day)	4,080.00	3,177.76	902.24
Household items (sanitary, kitchen, etc.)	*0.00*	*593.68*	*-593.68*
Car hire (60 days)	1,665.00	Free	0.00
Accommodation	2,925.00	542.57	2,382.43
Transport - ferry between islands	395.00	252.12	142.88
Transport costs (taxis, diesel, bus, etc.)	*0.00*	*470.22*	*-470.22*
Gifts and gratuities	*0.00*	*467.84*	*-467.84*
Total	**9,415.00**	**5,999.42**	**2,218.42**
Post expedition			
Report publications	500.00	429.70	70.30
Presentations (incl. travel and materials)	250.00	303.00	-53.00
Administration (Stationary, postage, phone, etc.)	150.00	119.43	30.57
Total	**900.00**	**852.13**	**47.87**
Other			
Contingency @ 10%	1,700.00	0.00	1,700.00
Interest	*0.00*	*22.52*	*22.52*
Total	**1,700.00**	**22.52**	**1,722.52**
Overall Totals	**18,615.00**	**14,094.21**	**3,368.67**

3. Fieldwork & Research

3.1. Introduction

Bats (Chiroptera) represent one of the most endangered mammal groups in the world, with 21% of microchiropteran bats threatened, and 23% considered near-threatened according to IUCN criteria (Hutson *et al.* 2001). The IUCN global status survey for microchiropteran bats (Hutson *et al.* 2001) highlighted the lack of even basic distribution and population status information for many species, and emphasised how important basic knowledge of species biology and ecology was for effective management and conservation. Island populations are of particular conservation concern, owing to their high levels of endemism and restricted species distributions, as well as the vulnerability of habitats to increasing human encroachment and alien species introductions (Pimm 1991, Manne *et al.* 1999).

Bats are the only native terrestrial mammals found in the Seychelles. The Republic of the Seychelles comprises of two distinct bio-geographical areas: the Granitic Seychelles consisting of four main islands and the Outer Seychelles including Aldabra (sand cays and raised atolls). Five species of bat are present, with three being endemic: the Seychelles fruit bat *Pteropus seychellensis seychellensis* (Milne Edwards 1887) (granitic islands, vulnerable), *Chaerephon pusilla* (Aldabra, vulnerable), and the sheath-tailed bat *Coleura seychellensis* (Peters 1868) (granitic islands, critical). This study focuses on *C. seychellensis*, the only microchiropteran in the granitic Seychelles (Fig. 3.1)

Figure 3.1: Photo of *Coleura seychellensis* in full flight. Picture taken just after dusk from one of the main exits at the Port Launay/Cap Ternay roost on Mahé, Seychelles.

The sheath-tailed bat is one of only two members of the *Coleura* genus, the other being *C. afra* (Peters 1852), found only in sub-Saharan Africa (Hutson *et al.* 2001). However there is some suggestion that two subspecies can be distinguished: *C. s. seychellensis* on Mahé and Praslin, and *C. s. silhouettae* on Silhouette and La Digue (Nicoll & Suttie, 1982), although this has not confirmed by genetic analysis.

Coleura seychellensis has undergone a severe and recent decline. Anecdotal reports exist detailing how this bat was very abundant throughout Mahé, especially in Port Victoria, where large numbers were documented foraging around the harbour at night (Wright, 1868, Joubert 1996). It was historically recorded as abundant and present on all four main islands (Mahé, Praslin, Silhouette, and La Digue) (Wright, 1868), but the current population has been estimated at between only 50 to 100 individuals (Rocamora, 1997), with less than 30 actually recorded. The species is now listed as critically endangered under the IUCN Red Data Book of the Globally Threatened Species of bats of the world (Hutson *et al.*, 2001). There is no information on historical or current occupation of the smaller islands in the region, where there is less human habitation (Nicoll & Suttie, 1982). Several cave roosts were documented in the past, including ones at Anse Badamier, Fond Azore and L'Amitie on Praslin; Grand Anse and Grand l'Anse on La Digue, but evidence suggests that these have been abandoned (Nicholl and Suttie 1982, Mellanby *et al.* 1997) (Figs. 3.3a-d).

Numerous studies have attempted to estimate sheath-tailed bat abundance and distribution, but Nicholl and Suttie (1982) produced the only published survey results. The Ministry of Environment has had a basic ongoing, monitoring program since 1992, Joubert (1996) undertook extensive surveys in 1995, and Glasgow University undertook a brief survey to assess population size in 1996 (Mellamby *et al.*, 1997) In 1997, during extensive transects on each island, only 5 to 7 bats were found on Mahé, 2 on Praslin and none on La Digue. Silhouette island has been monitored more rigorously, with 20 individuals counted in a roosting cave in 1996, 17 in 1997 and 32 in 2003 (Gerlach 2004). This roost on Silhouette and another on Mahé were the only active ones known prior to this study.

Several factors are hypothesised to have contributed to the decline of the sheath-tailed bat, including predation by Barn Owls *Tyto alba*, increased human disturbance and the destruction of habitat especially the loss of marshland. Evidence suggests that bats are mainly found on the coastal plateaus of the granitic islands, and it has been these areas which have been particularly vulnerable to increased human encroachment and loss of native vegetation and freshwater marsh (Beaver 1995). Since the 1960s, the human population in the Seychelles has undergone a rapid increase. In 1977, approximately 54 500 people lived on Mahé (376 people km^{-2}; Benedict 1984) but now approximately 80 000 people (482 people km^{-2}) live on the island (Mair and Beckley 2001). Due to the topography of the Granitic islands, most of the human population is concentrated on the coastal plains, therefore creating enormous development pressures. New housing has sprung up rapidly in the area surrounding the town of Victoria on the east coast of Mahé, and houses are being built on the hillsides along the coast. Tourism is a major source of income on the islands, with much development of coastal hotels across Mahé; and plans are currently under way to build one in the Port Launay area (Anon. pers. comm. 2004).

Reduction in insect abundance and diversity, both as a result of reduced native vegetation and due to historical/current heavy use of pesticides, has also been suggested as a cause of the sheath-tailed bat decline (Joubert 1996, Gerlach 1997). From the sparse records available, it appears that insecticide use in the Seychelles has been rather limited, focusing on species harmful to the tourism industry, such as the sandfly and *Aedes* mosquitoes. Documents on DDT use on the islands have been lost, and only one reference was found, stating it was used to a limited extent for experimental purposes (Way 1973). Some larger scale spraying occurred on Praslin pre-1977. Para-dichlorobenzene (PDCB) fumigation was carried out on coconut plantations, and other organochlorines were also used to some extent (Mathias 1971). Some banned chemicals were still on use on the islands in 1996 (Anon. 1996), and some pollution events from chemicals have occurred in local rivers and streams on Mahé. A study carried out in 1970 on the status and control of the sandfly recommended habitat alteration and insecticide spraying on the beaches where sandflies were found. The insecticides this study recommended were pyrethrum synergist and malathion (Laurence and Mathias 1970). Diazinon was also used to control the sandflies, and dieldrin was sprayed on the coconut plantations to control the *Melitomma* spp. (Way 1973). Some of the pesticides used in the Seychelles are considered to have low mammalian toxicity (e.g. pyrethrum, Morse and McNamara 2004), and the sprayings undertaken were possibly on a small scale. However, the treatments were concentrated on the coastal zone (Laurence and Mathias 1970) where the bats forage, and some of the substances used can potentially have an adverse effect on the wildlife. Russo and Jones (2003) have demonstrated pesticide use can affect bat populations, through changes in insect communities. Organochlorine pesticides are highly persistent in the environment (Dinham 1993), and the longer an animal lives the more time it has to accumulate these compounds into its tissues (Klemens *et al.* 2003). Organochlorine pesticides, including dieldrin, have been found in aquatic insect's larvae (Standley and Sweeney 1995); dieldrin is highly toxic, and disruptive to the endocrine system (summarized in Vorkamp *et al.* 2004). Organophosphorous pesticides, while less persistent, have a problem of high acute toxicity as they can potentially interfere with the immune system and cause alterations to disease resistance. Furthermore, they can cause direct damage to cell membranes, proteins and DNA; diazinon and malathion in particular have been shown to cause immunopathological effects in mice (reviewed by Galloway and Handy 2003).

There is an extremely urgent need to save the sheath-tailed bat from extinction. This study aimed to estimate abundance on the main four islands, establish basic ecological parameters, and to coordinate an ongoing monitoring and conservation strategy for the species.

3.2. Aims & objectives

1. To estimate the current population level and distribution of the Sheath-tailed bat on all of the four main granitic islands by bat detector transects and roost location.

2. To assess foraging rates and habitat use in order to better understand the bats' requirements.

3. To identify the core threats to the species and the principal reasons for the observed decline.

4. To implement an education program with Wildlife Clubs and schools of the Seychelles.

5. To outline sustainable measures to improve its' conservation status and implement an ongoing monitoring and recovery programme.

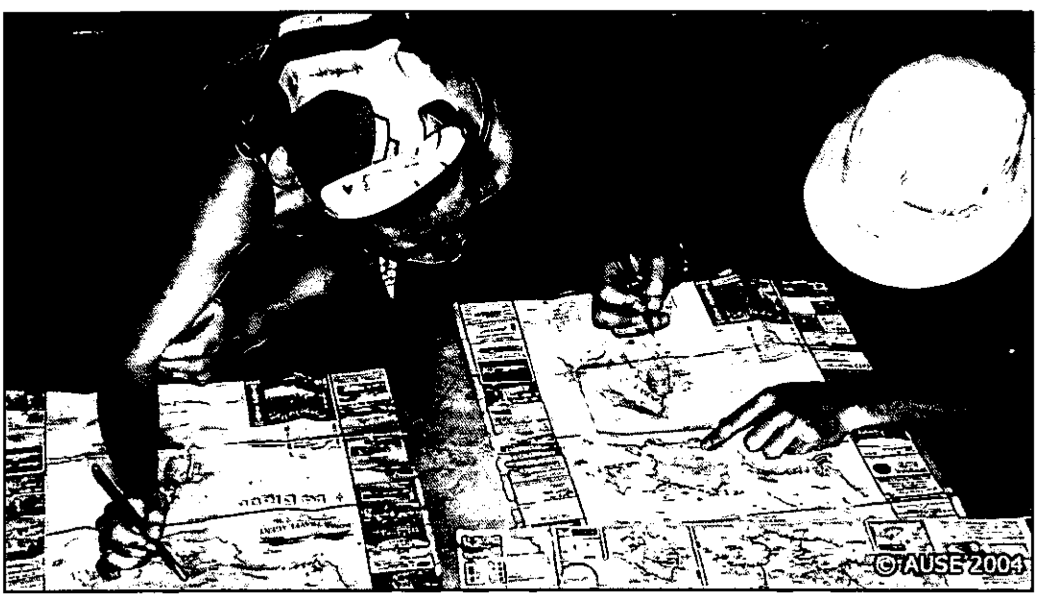


Figure 3.2: Working hard to achieve the expedition's aims. Two team members plotting and recording transect locations and bat occurrences across the 3 islands under study.

3.3. Maps of the Grantic Seychelles

3.3.1. La Digue

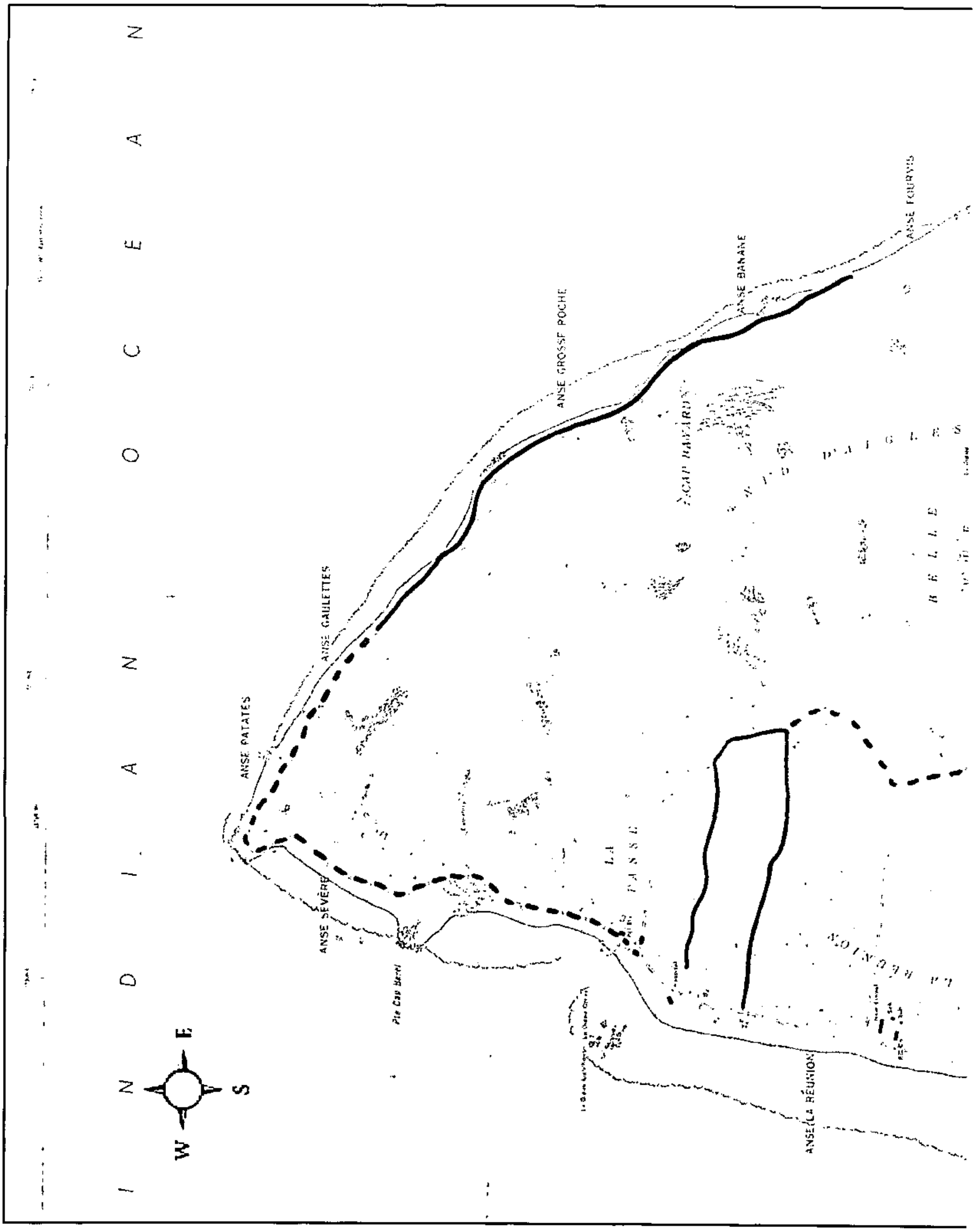
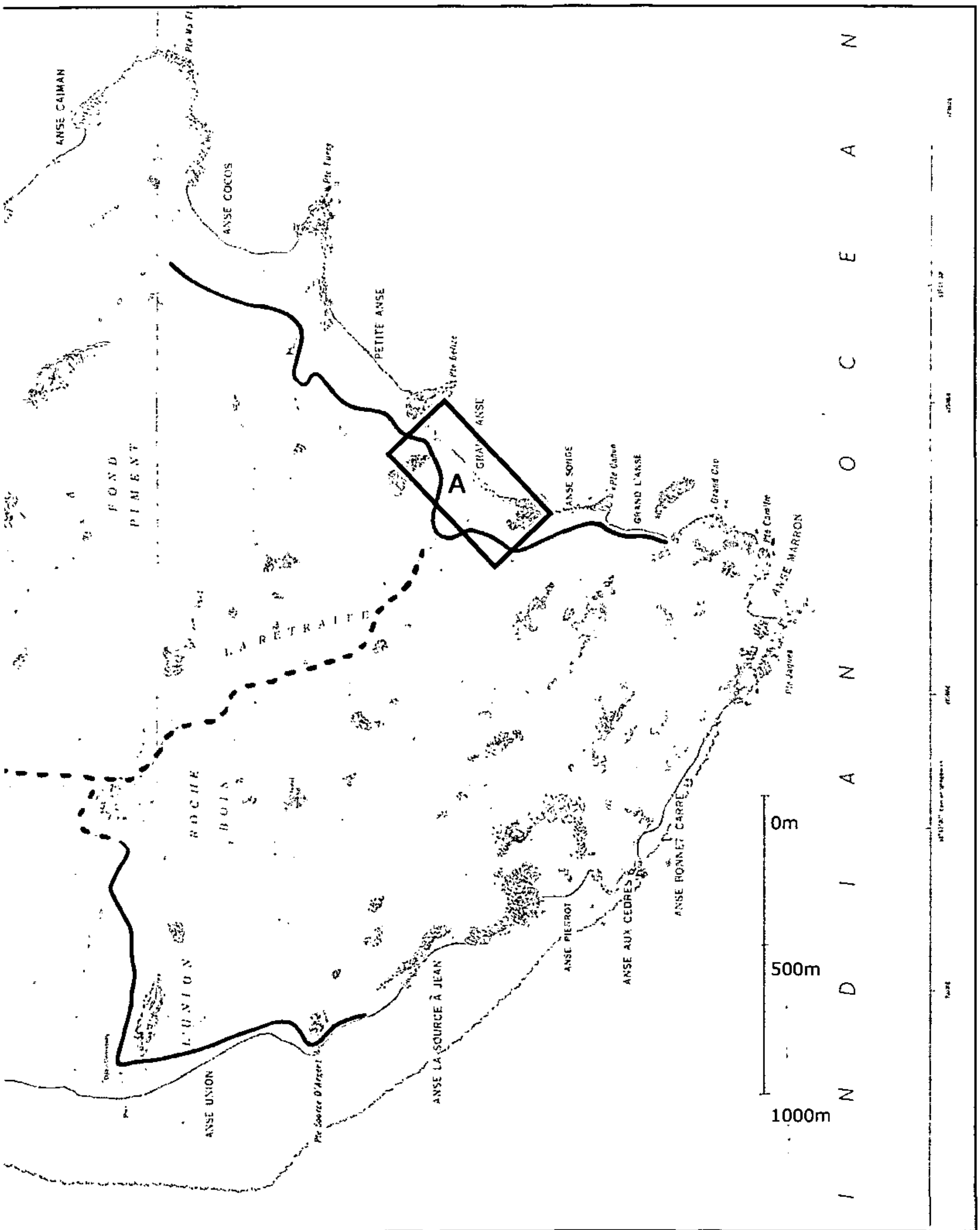


Figure 3.3: a) Map of La Digue displaying locations of bat detector surveys and a previously occupied roost. Hard lines represent methodological transects surveyed over two evenings with bat detectors, dashed represent general convenience surveys on foot (June to September 2004).



Point A refers to a previously occupied roost set in a boulder cave on the south-east of La Digue at Jardin Blanc, Grand Anse. It was recorded as hosting six individuals in August 1972, one in 1974 and three in 1976 (Racey & Nicol 1984). Subsequent visits to the region have failed to locate this roost again (Joubert, 1996), its exact location is therefore currently unknown. No bats calls were detected, or occupied roosts located as part of this survey, together indicating no populations of *C. seychellensis* currently survive on La Digue.

3.3.2. Mahé

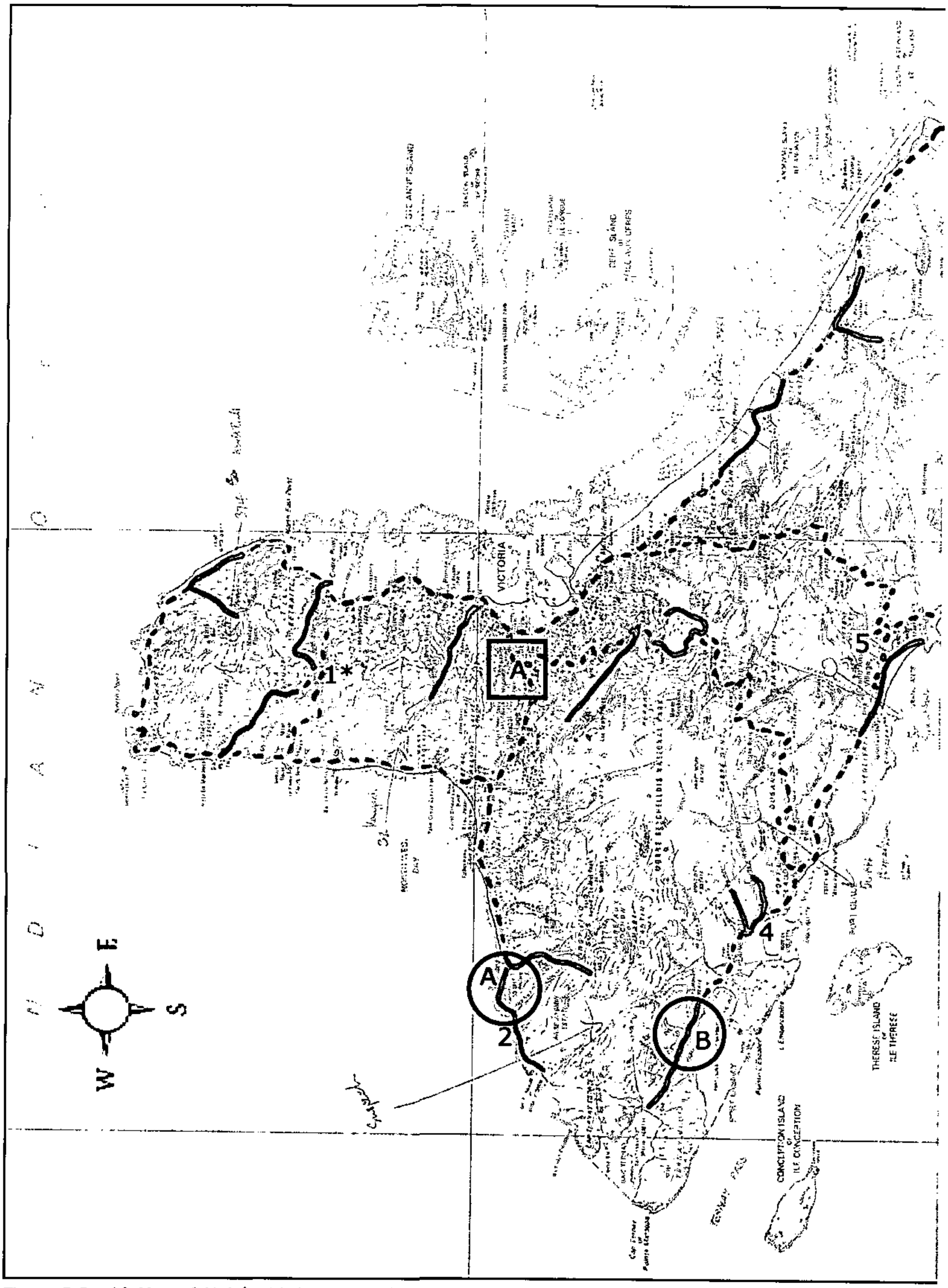
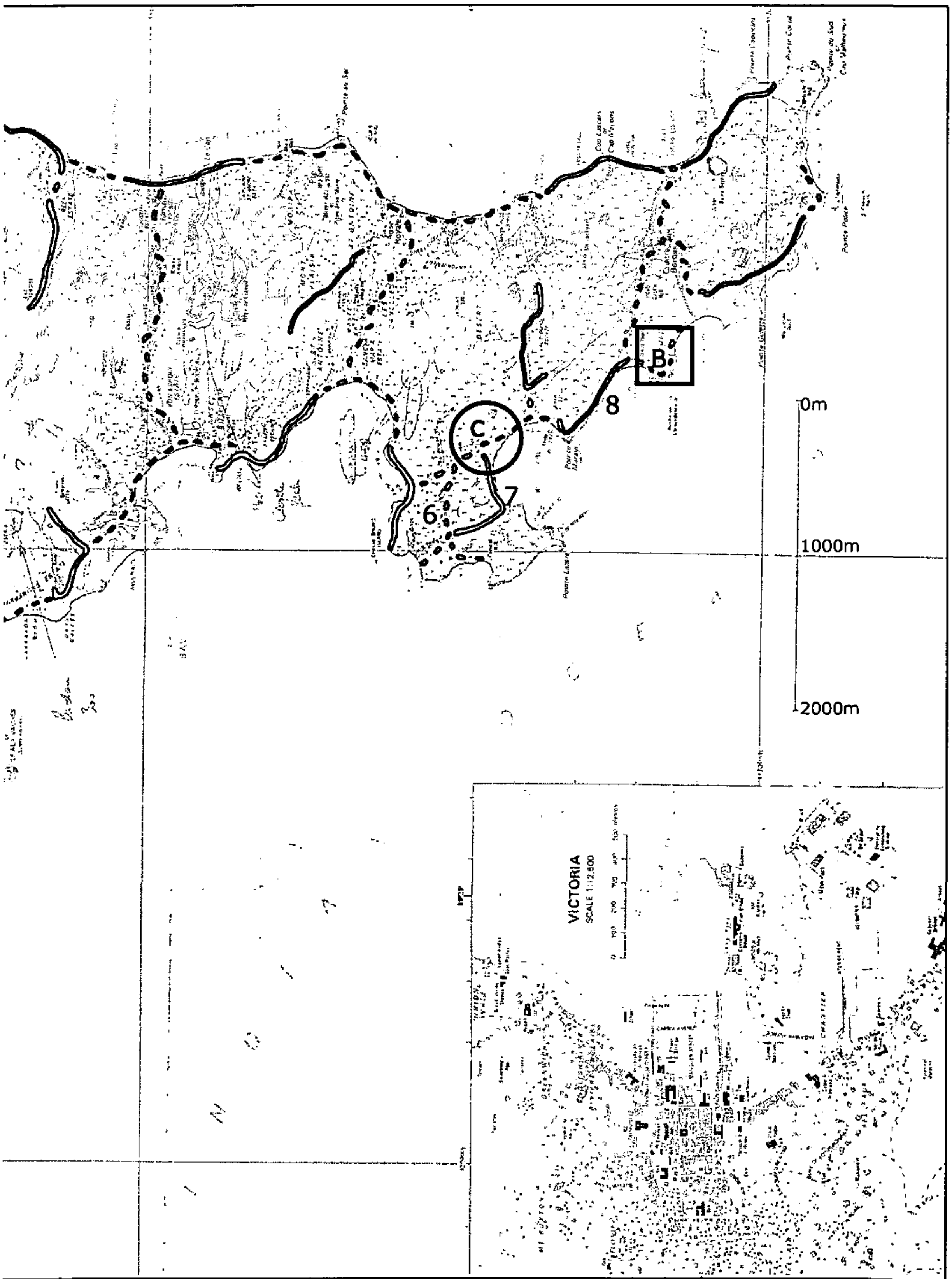


Figure 3.3: b) Map of Mahé with locations of bat surveys, roosts and current distribution of *C. seychellensis*. Hard lines: methodological transects surveyed two separate evenings with detectors, dashed: general car and convenience surveys (June - September 2004). Circles A, B and C: rough locations for the current roosts; A: the Bel Ombre roost, B: the Port Launay roost and C: the Baie Lazare roost (precise locations are held by the MENR and will not be disseminated to general public, see *Roost Searches and Characteristics*, pages 35-38 for details). Squares A and B provide locations for previously occupied roosts, neither could be located during this survey. A was a boulder cave situated (c.1950) at the old rear of the capitol port town of Victoria in the region



of Belonie, but has been since abandoned and possibly destroyed by the encroaching housing developments (N. Shah, pers. comm. 2004). B was situated in the south-west of Mahé at La Reduit. At the last visit (September 1995) evidence existed of a previously small population, but was suspected to have been unoccupied for some time (Joubert, 1996), its exact location is now unclear. Numbers 1-7 refer to locations at which the bats have been recorded. 1* is the La Gogue reservoir and was a previous recording made by Joubert (1996), but no bats could be located there during this survey. 5 is Grand Anse, approximately 0.5km along the road leading across the island, while all the others are on methodologically surveyed transects.

3.3.3. Praslin

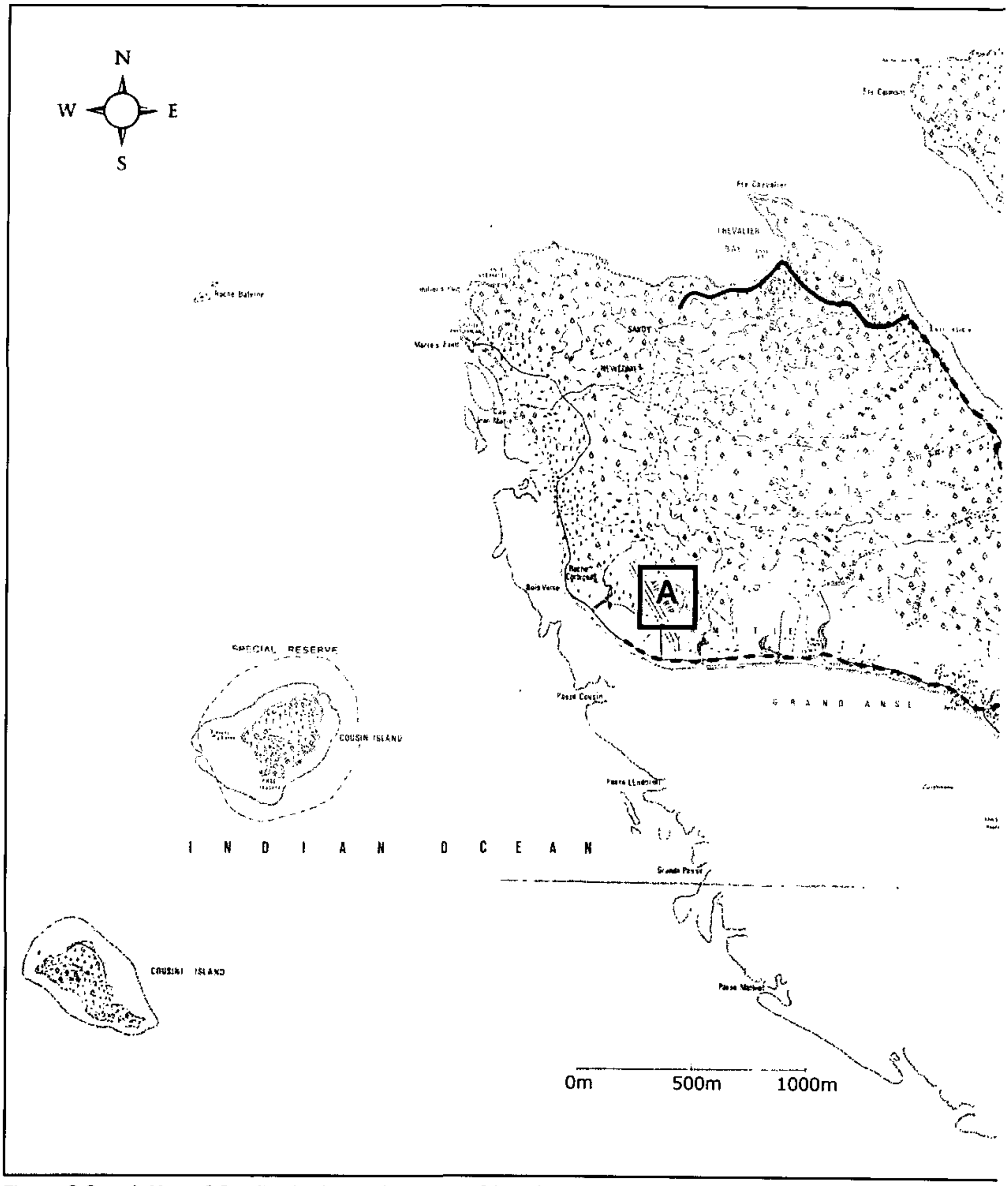
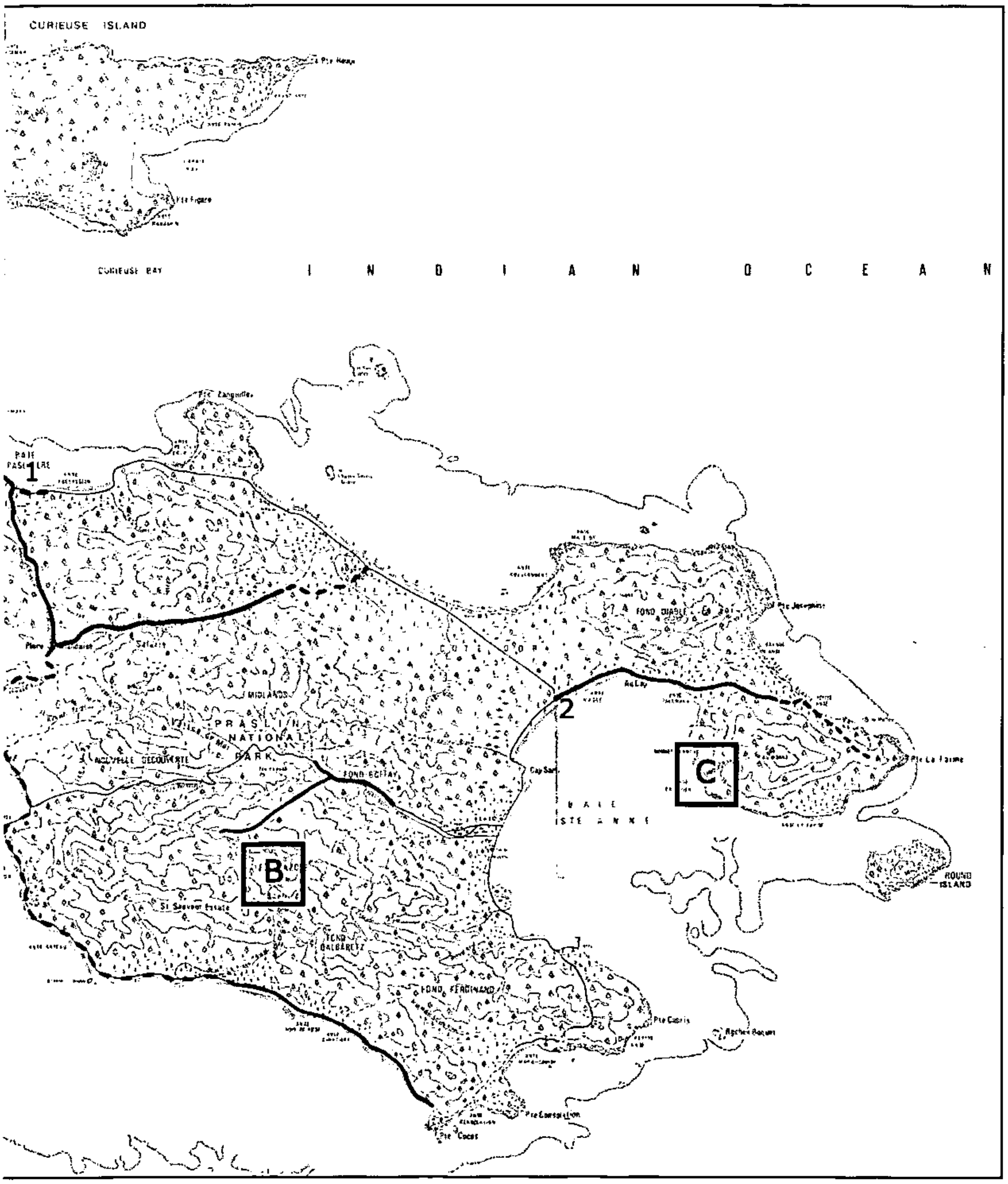


Figure 3.3: c) Map of Praslin displaying locations of bat detector surveys, previous known distribution of *C. seychellensis* and rough locations of previously occupied roosts. Hard lines represent methodological transects surveyed on two separate evenings with bat detectors, dashed represent convenience surveys on foot (June to September 2004). Squares A, B and C are the approximate locations of previously occupied roosts. A was a boulder cave located behind the airfield (Nicoll & Suttie 1982), but which has now been destroyed and replaced by a quarry (pers. obs.).



B was a boulder cave roost situated somewhere in the region of Fond Azore on the border of Praslin National Park (V. Laboudalon, pers. comm.), C somewhere at Anse Badamier (Nicoll & Suttie 1982). The exact locations of each is now unclear and they are suspected to be abandoned. Numbers 1 and 2 represent locations where bats were recorded in car bat detector surveys by the MENR approximately three years prior to the date of this survey (c.2001) (J. Francois, pers. comm.). No bats were recorded, or roosts located during this survey, indicating that there are currently no populations of *C. seychellensis* surviving on Praslin.

3.3.4. Silhouette

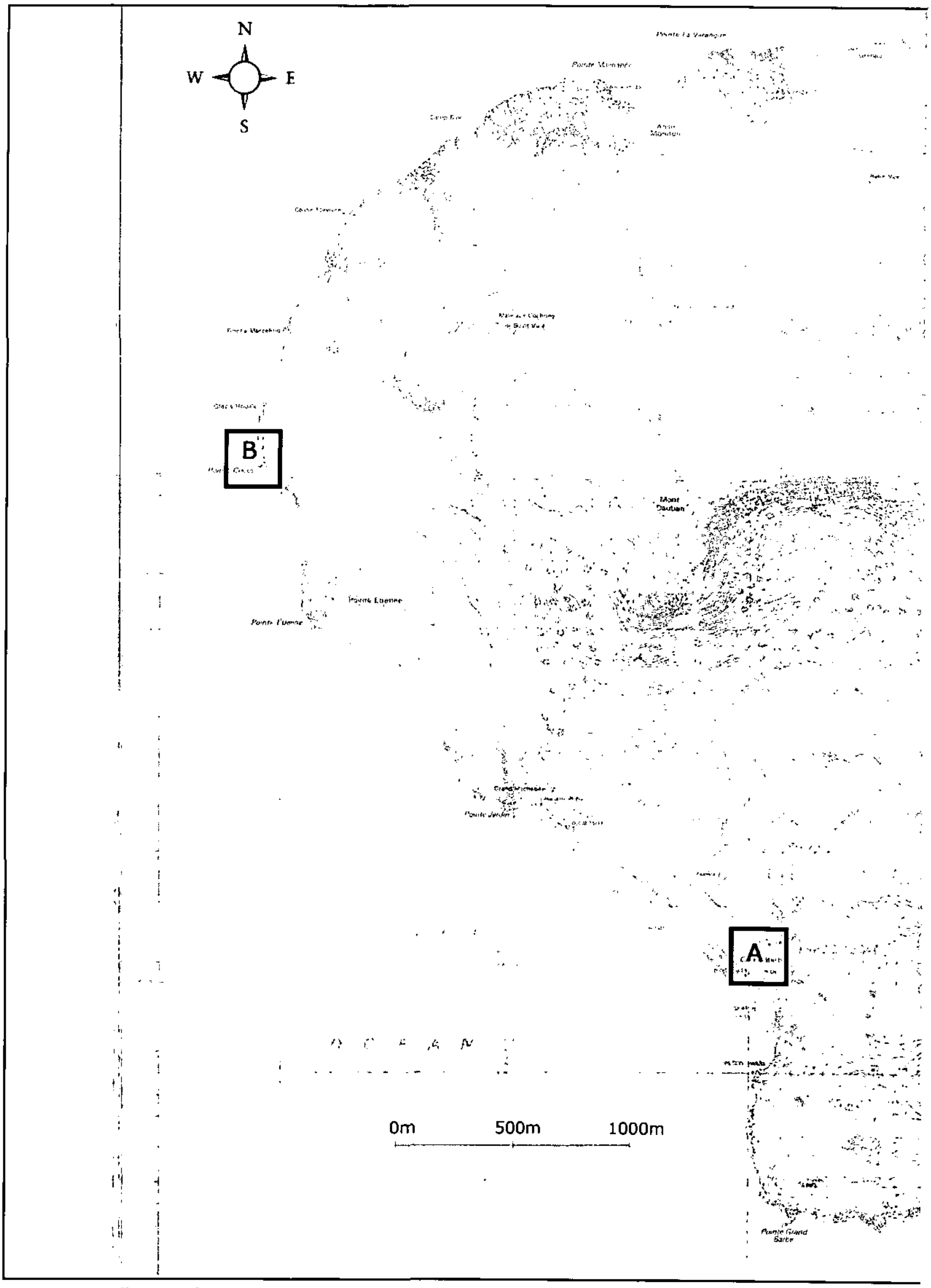
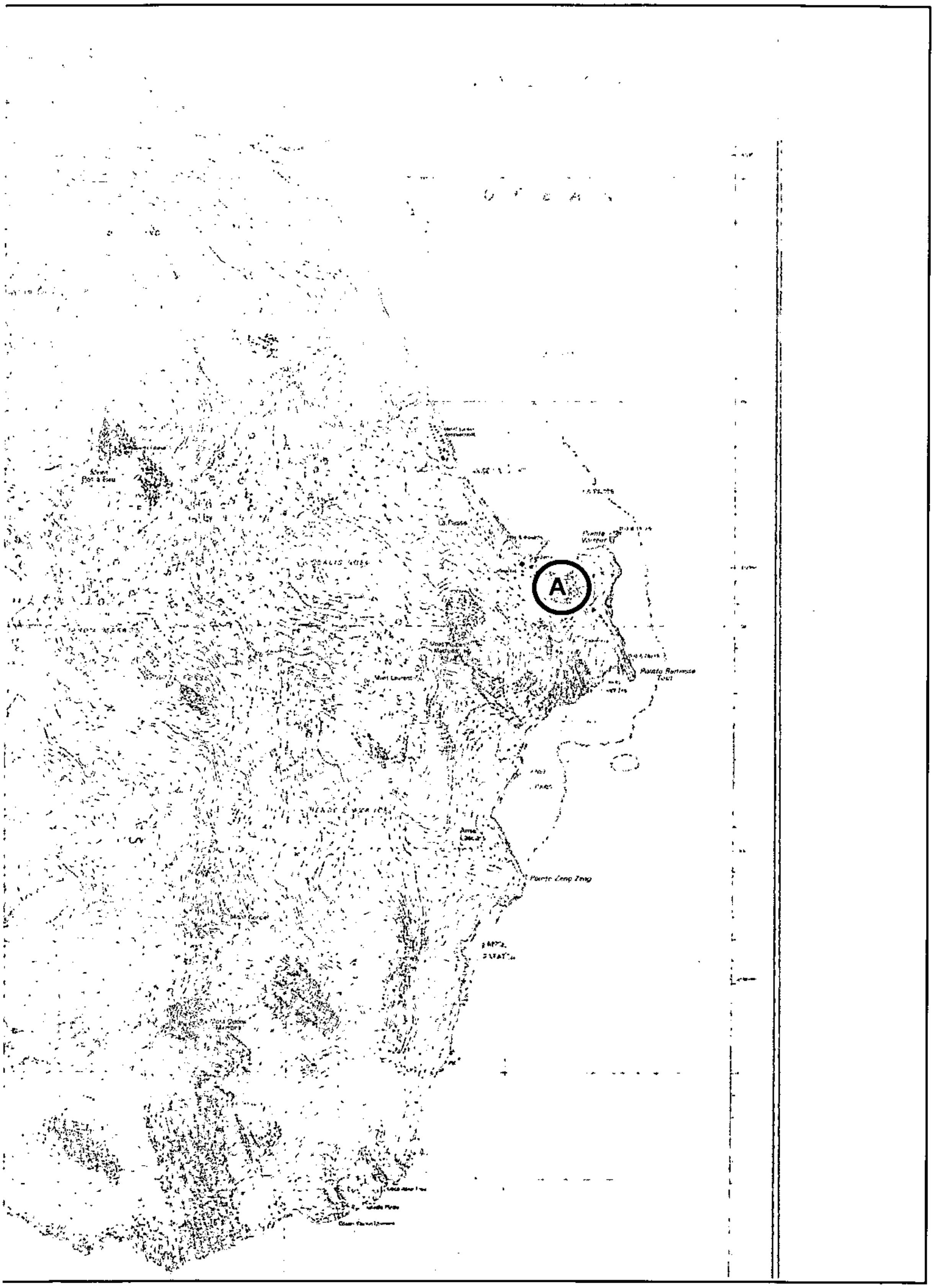


Figure 3.3: d) Map of Silhouette displaying the approximate locations of two previously occupied, and one currently occupied roost. Squares A and B represent the rough locations of the two previously occupied roosts, but found unoccupied at the time of last the visit. A is located on the south-west coast of Silhouette at Grande Barbe. Guano deposits indicate it was host to a large population of *C. seychellensis* with bats claimed to be present recent to the last visit (c.1995). B is north-west at Pointe Cocos, but is documented as having showed no signs of recent occupation (Joubert, 1996).



Circle A refers to the currently occupied roost based at La Passe on the east coast of Silhouette, the most densely populated region on the island. The roost is made up of two large and distinctly separate caverns 20m apart that are linked by a tunnel. It is currently home to the largest population of *C. seychellensis* in all of the Seychelles with c.32 bats in 2003, an increase from 20 recorded in 1996 (Gelach 2004).

3.4. Habitat sampling & bat presence along transects

3.4.1. Methods

3.4.1.1. Establishing transects

To begin to understand the foraging ecology and habitat preferences of this species and to assist in building up a map of its distribution, sampling transects were established across each of the islands under study.

Due to the dangerous topography of the granitic islands, transects were selected on the basis of ease of sampling during the darkness of the evening hours (i.e. on roads and trails) including some where bat presence had been recorded previously. They were spaced approximately evenly and to cover most of the coastal areas of the islands, again where past records have shown most of bat occurrence to be. However some upland transects were also used in order to rule out bat presence at higher altitudes (Fig. 3.3b). All transects were 2km in length and marked out with biodegradable flagging tape and permanent marker pen at every 20m point, each transect being numbered from 0 to 100.

Transects were sampled for both habitat characteristics and bat presence. The order of sampling was neither random nor systematic, but merely based on convenience given the time and transportation difficulties involved with traversing the islands.

3.4.1.2. Habitat sampling

Five by five metre quadrats were established at every 40m-point along each transect, starting at 0 and ending at point 100. These quadrats were alternated on each side of the transects and habitat data was then recorded from each. The habitat data collected were; canopy cover from each corner (using the observers own judgement) to the nearest 10%, canopy height from the transects to the nearest meter and the heights of 5 trees from within the quadrat. Ground cover and height of ground vegetation was also recorded from within each quadrat, each on a scale from 1 to 3. For cover, one represented a bare quadrat, or one with minimal cover; two represented some to much cover and three being fully or nearly fully covered. For height, one represented the majority of vegetation at less than 1m; two represented vegetation at 1-2m and three, 2m or above. Dominant species within each quadrat were also identified with the help of local botanists and all of the data entered into Excel spreadsheets for later analysis.

3.4.1.3. Bat presence and distribution

Each of the 2km transects were sampled twice for the presence of bats. Transects were walked with Batbox III ultrasound detectors by a minimum of two observers on two separate evenings. The first evening transects were walked in an arbitrary direction, the second evening, in the opposing direction. Sampling commenced at approximately 18:30 (dusk and commencement of most active bat period) with details of the ambient weather conditions noted, again on a scale of 1-3. Ambient weather conditions were cloud cover, wind strength and level of rainfall. Observers aimed to walk transects in approximately 1 hour, listening for bat activity with detectors set at 37.5kHz. The presence of bats along transects were recorded as bat passes and entered onto a datasheet. A bat pass refers to one continuously audible train of echolocation clicks as a bat flies into and then out of range. The time and the point along transect (aided by previous placing of flagging tape) and if possible the height and direction were also recorded for use in later bat roost locating and analyses.

General car and foot bat detector surveys were also carried out across the islands in the hours around dusk and dawn. Data obtained was not for the purposes of analysis, but to aid in establishing the distribution of the bats and locate further roosting or foraging sites. Major car surveys on were conducted on Mahé over two evenings. These consisted researchers driving slowly (~30km/h) along all the major coastal and inland roads of the island. Bat detectors tuned to 37.5 KHz were directed out of the car windows and observers listened for commuting and/or foraging bats. Any observations were then recorded for later scrutiny. Minor car and foot surveys were conducted during general travel to and from methodological transects and while navigating the islands.

3.4.2. Data analysis

3.4.2.1. Model selection

Habitat preferences and foraging behaviour were analysed through GLM models designed following the Information-Theoretic Approach, as described by Burnham and Anderson (2004). This system is designed to overcome errors and biases that result from other model selection protocols e.g. stepwise removal, stepwise addition etc. The protocol followed is outlined as follows: Independent variables were selected based on availability of data and predicted importance, from these, all possible combinations of the variables were listed, including those combinations that included only one variable, only two variables etc, up to one possible model that included all variables. The number of combinations possible follows the rule $2^n - 1$, where n is the total number of variables and one model - the null model (with no variables) is removed; thus with eight variables, there are 255 possible combinations. These combinations are then all run as models, fitted against the dependent variable. The models are listed according to ΔAIC (change in Akaike's Information Criterion), where AIC is an estimate of the relative distance between the fitted model and the unknown true mechanism that generated the observed data. Lower AIC values reflect a closer distance between the model and the true mechanisms, and therefore a stronger model for explaining the dependent variable. The 'best model' will thus be listed first, have the lowest AIC, and have a ΔAIC of zero (this being the difference between the model AIC, and the best model AIC).

This best model can be taken as the model to be used in interpreting the data; however, there may be several models with very different independent variables but very similar AIC values. There is thus a risk that by looking only at the best model, we may miss variables that are almost equally important. To overcome this problem we can look at the weight of each model e.g. the relative likelihood of that model representing the best model. These 'Akaike weights' (w_i) depend on the ΔAIC of all the models run, and can be used to determine a window of the best models. In this study, we defined this 'Occam's window' as including all models with a w_i of less than 4. The relative importance of variables occurring in the models in Occam's window is calculated by adding the w_i values of each model that the variable occurs in. These w+i values will therefore be greater for variables that are present in more of the top models and lower for those that only occur in one or two of the models in Occam's window.

The results from the best model GLM and the relative importance of variables in Occam's window can be compared. If the variables present in the best model, or the variables that have higher F values in the best model, also have the highest w+i values in Occam's window, then the best model does reflect the closest fit in explaining the data. If there is some disagreement between the two methods, then it is possible that variables not in the best model may also be worth considering when interpreting the data.

All of the analyses were carried out in the SAS System v. 8.02. Some of the dependent and independent variables fitted a Poisson distribution, and this was accounted for in the GLM. To control for multivariate analyses, the p_{crit} value was taken as p=0.05/n, where n was the number of independent variables in the model. An equivalent for the R^2 value was calculated from: R^2 equivalent = 1- (model deviance/null model deviance)

3.4.2.2. Habitat preferences

Habitat preference of the bats was studied by combining transect bat occurrence data, with the habitat data collected along each transect. Bat occurrence (where bat passes were recorded) was tested against habitat variables in a General Linear Model applied using the Information-Theoretic Approach as outlined in Burnham and Anderson (2002). This method allows the comparison of all possible models, and thereby the unbiased removal of unimportant variables to find the best possible model. To allow for the use of multiple variables, the p_{crit} was taken as 0.05/no. of independent variables.
Ten variables were available for entry into the GLMs: Canopy height (m), Tree density (no. per quadrat), Canopy Cover (%), Tree height (m), ground vegetation height (m), and presence/absence of four tree species, Cinnamon (*Cinnamonum zeylanicum*) (non-native) and Agati (*Adenanthera* spp.) (three non-native species), and Mangroves (*Mangliye* spp.) and Takamaka (*Callophyllum inophyllum*) (both native). Date of carrying out the transects was included in all models by default to account for its' large influence on the data, but was not of biological interest as the order in which we carried out transects was very biased by previous records of bat occurrence. Another variable, a score of presence or absence of any non-native species could not be entered into the model selection due to limits on the number of variables that could be considered in one model, but was added to the best model to see whether it increased the models' power (by comparing the R^2 equivalent values for the two models).

3.4.2.3. Foraging micro-habitat preferences

The micro-habitat preferences of the bats were tested by comparing foraging buzz activity with the habitat structure at that point (these were as collected during specific foraging observations and taken from bat occupied areas on transects). These data were tested in GLMs using the Information-Theoretic Approach as described above, but with number of feeding buzzes per bat pass as the dependent variable. Thus in this GLM, the initial independent habitat variables were: Canopy height, Canopy cover, Tree height, Tree density, Ground vegetation height, and the occurrence of three tree species, Agati and Cinnamon (introduced), and Takamaka (native). Mangrove trees were not common enough in this data set to be considered. Three other variables were included in models by default to account for their strong effect on the data: Recorder (the people carrying out the data collection), Minutes after local sunset (taken as 18:00), and Duration of the bat pass (in secs). As described above, these variables were then entered into the model selection protocol.

3.4.2.4. Habitat availability on unoccupied islands

As the surveys failed to detect any bats on two previously occupied islands (Praslin and La Digue), analyses were carried out comparing the habitats available on these islands with habitat that was utilised by bats on Mahé (e.g. those transects on Mahé where bats were detected). This was intended to demonstrate whether suitable habitat was available on the unoccupied islands, by comparing them with proven suitable habitat from Mahé. Habitat variables that were shown to be important for the bats were entered into Principal Component Analyses, and the resulting Principal Components then tested in 1-way ANOVAs for differences between islands. Again, to correct for multiple testing, the p_{crit} was taken as 0.05/no. of Principal Components.

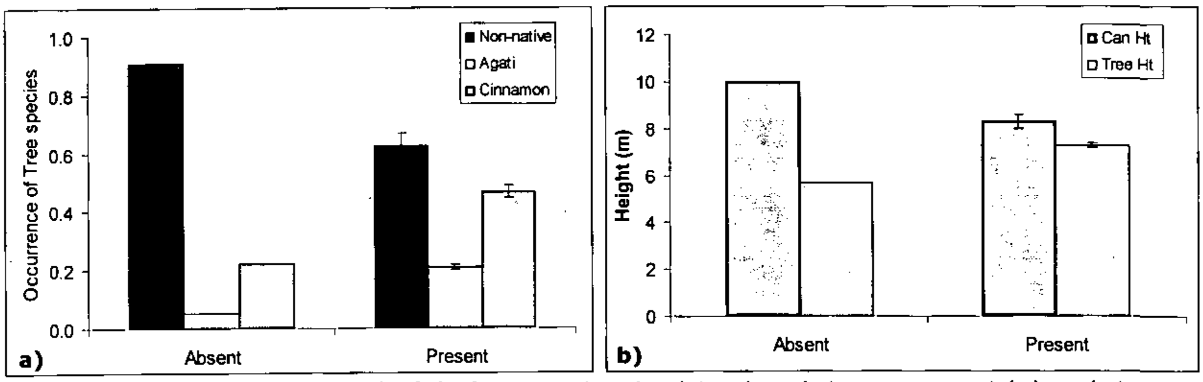
3.4.3. Results

3.4.3.1. Habitat preferences

The best model contained six of the ten initial variables, five of which had a highly significant effect on the occurrence of bats. Both Agati and Cinnamon presence had a strong positive effect on bat occurrence (Fig. 3.4a), as did tree height (Fig. 3.4b). Canopy height (Fig. 3.4b) and tree density ($F_{1,1713}=18.93$, $p<0.0001$) were both negatively related to bat occurrence, as, to a lesser extent, was ground vegetation height ($F_{1,1713}=13.31$, $p=0.0003$). The R^2 equivalent value for this best model was 0.322. This increased to 0.629 when presence/absence of Non-native plants replaced ground vegetation height as the sixth variable, significance and direction of relationships of the other variables did not change. Contrasting with the results for two non-native tree species, the presence of any non-native plant had a strongly negative effect on the occurrence of bats (Fig. 3.4a).

3.4.3.2. Interpretation of the GLM

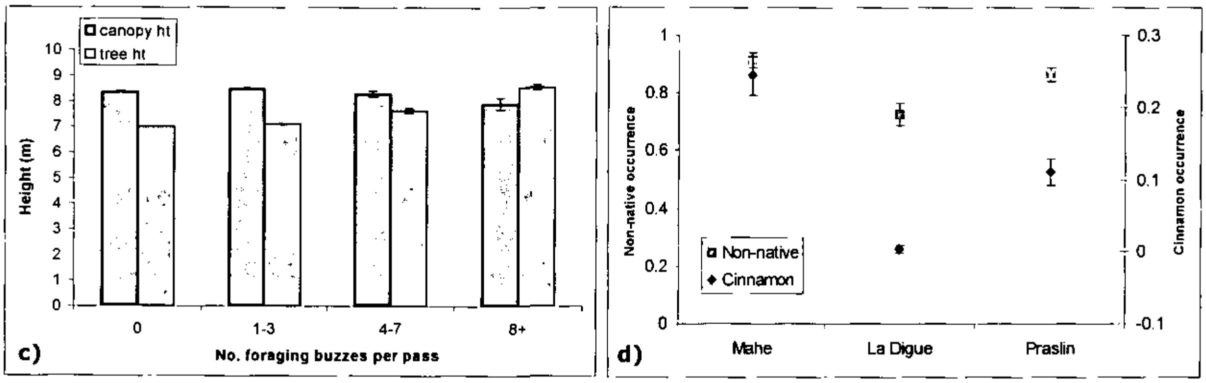
The apparent contradiction in the selection for taller trees but lower canopies as shown in the GLM model can be clarified by looking at the mean values for both variables. It actually appears that bats were selecting for areas where the canopy height (overshadowing the quadrats) and the tree height (of trees within the quadrat) are roughly equal (Fig. 3.4b). This, combined with the selection for lower tree densities, and for two large tree species, Cinnamon and Agati, suggests that the bats were selecting for mature forest with little secondary growth or understorey. This may also explain why the final GLM showed a strong selection for the introduced trees Cinnamon and Agati, but an equally strong avoidance of Non-native plants (Fig. 3.4a), as Cinnamon and Agati are both moderately large trees, and Agati in particular was associated with stands of mature trees. Many other introduced plant species are either associated with urban landscapes, or are shrubby, and thus the bats may simply be selecting for mature trees and against secondary or open areas.



Figures 3.4: a) Mean occurrence (± SE) of tree species at points where bats were present (where bat passes were recorded) and absent. Bats were selecting against the overall class of Non-native plants ($F_{1,1011}=7.84$, $p=0.005$), but were selecting for points with Agati and Cinnamon trees (respectively: $F_{1,1011}=71.03$, $p<0.0001$; $F_{1,1011}=49.15$, $p<0.0001$); b) Mean heights (± SE) of canopy and all trees in areas where bats were present (points where bat passes were recorded) and absent. Bats were found to select for lower canopy heights ($F_{1,1011}=26.02$, $p<0.0001$), and for higher tree heights ($F_{1,1011}=38.25$, $p<0.0001$).

3.4.3.3. Foraging micro-habitat preferences

Eight variables were present in the best model, this included the three that were present by default: Recorder, mins after sunset, and duration of bat pass, along with canopy cover and height, tree density and height, and Agati occurrence. The variable Recorder was removed as it was insignificant, and being a Class variable, decreased the power of the GLM. In the resulting model, canopy cover had no significant effect on foraging ($F_{1,347}=2.75$, $p=0.98$), however the bats appeared to show greater foraging activity in areas with lower canopy, lower tree density, greater mean tree height, and fewer Agati trees. The pattern of selecting higher mean tree height and lower canopy (Fig. 3.4c), along with a preference for lower tree densities ($F_{1,347}=10.53$, $p=0.001$), match the results from the habitat preference GLM, and suggest that mature tree stands are areas of greater foraging activity. The avoidance of Agati trees ($F_{1,347}=9.70$, $p=0.002$) contrasts strongly with the results from the habitat selection and warrants later consideration. The R^2 equivalent value for this model was 0.533.



Figures 3.4: c) Mean heights (± SE) of canopy and of all trees in areas where different foraging activity levels were recorded. Canopy height was negatively related to foraging activity ($F_{1,347}=12.63$, $p=0.0004$), but mean tree height showed a positive relationship with foraging levels ($F_{1,347}=6.22$, $p=0.01$). d) Mean occurrence (± SE) of Non-native plant species, and of Cinnamon trees on three islands: areas of Mahé where bats were present, and all surveyed areas of La Digue and Praslin. These were represented in Principal Component 2, which differed significantly between all three islands ($F_{2,377}=46.22$, $p<0.0001$).

3.4.3.4. Habitat availability on unoccupied islands

A Principal Components Analysis was carried out including those habitat variables that had been shown in previous GLMs to strongly affect bat occurrence on Mahé, e.g. both those that were preferred by the bats, and those that the bats appeared to avoid. Six variables were entered: Canopy height, tree height, tree density, and Agati, Cinnamon and Non-native tree occurrence. These gave four principal components that explained 80% of the variance in the six variables. Each component was then tested in a One-way ANOVA against Island. PCs 1, 3 and 4 did not differ significantly between islands (respectively: $F_{2,377}=3.5$ $p=0.03$; $F_{2,377}=0.25$, $p=0.77$; $F_{2,377}=1.06$, $p=0.35$; $p_{crit}=0.01$). PC 2, however, did differ between all three islands, and had the highest Eigenvectors for Cinnamon and Non-native tree occurrence (meaning that the component represented these two variables most strongly). Thus although in general the three islands did not differ in the habitat variables that affect bat occurrence, Cinnamon and Non-native tree occurrence did appear to differ, with both occurring at much lower densities on Praslin and La Digue than on Mahé (Fig. 3.4d).

3.4.4. Discussion

Results from transects carried out on Mahé suggest that when Sheath-tailed bats are present within woodland they are selecting for areas with mature trees and the related forest structure of little understorey and low tree density. This includes areas with isolated tall tree stands in relatively open areas, e.g. along roadsides and around housing. The very high prevalence of Agati and Cinnamon in wooded areas on Mahé meant that these appeared to be selected for when looking simply at occurrence of bats. However, the foraging activity of the bats implied an avoidance of Agati, and no relationship with Cinnamon. This, combined with an overall avoidance of non-native plants suggests that these species may not form ideal foraging areas. It is possible that this relates to the invertebrate load associated with native and non-native tree species, something which will be discussed later.

Comparisons of bat-occupied areas on Mahé, with available habitat on Praslin and La Digue suggest that there is plenty of available habitat for the bats on these two unoccupied islands. This leads us to the conclusion that the moderately recent loss of the populations on these two islands was not due to loss of habitat. Later we will examine other possible explanations for the apparent loss of these populations.

3.5. Roost searches & characteristics

3.5.1. Background

Locating roosts was one of the primary goals of this expedition. The locating of roosting colonies makes it easier to accurately assess the population status of this species and utilise the proposed remote roost monitoring to gain more information on roosting ecology. However, the granitic islands of the Seychelles archipelago are littered with granite boulders (Fig. 3.5a). As such the possibility for boulder caves acting as roosting sites for this species are immense. The locations of suspected roosts were searched on a convenience and systematic basis throughout the time in the field.

Figures 3.5: a) Photo displaying the granitic topography of Mahé, Seychelles. Granite boulders litter the island providing potentially limitless number of roosting sites and making casual roost searches unviable.

With the high number of possible roosting sites and low number of occupied roosts, understanding the roosting requirements of this bat is very important if conservation actions are to be successful. Key parameters relating to the physical characteristics of current roosting sites were recorded and comparisons of these parameters between roosts from different locations may provide an insight into which characteristics are most important for roost site selection.

3.5.2. Methods

General searches were carried out in areas of known bat presence, where past documentation and local information hinted at the possibility of roosts, in areas of previously abandoned roosts and anywhere the team felt worthwhile. These searches simply consisted of team members walking in such areas and looking in all caves and crevices.

Systematic searches were carried out in areas of high bat activity where roosts were assumed to be present. With synchronised watches, observers were spaced over large areas with bat detectors to listen for the bat passes. The earlier to known emergence times (~18:30), or return times (~6:00) contacts were made, the nearer to roost an observer was assumed to be. Further observers were then moved in to this area and the same process conducted again on subsequent mornings and evenings, until a clearer picture of the precise location could be built. An exact roost location was then searched for in daylight, with minimal disturbance of resting bats being a priority.

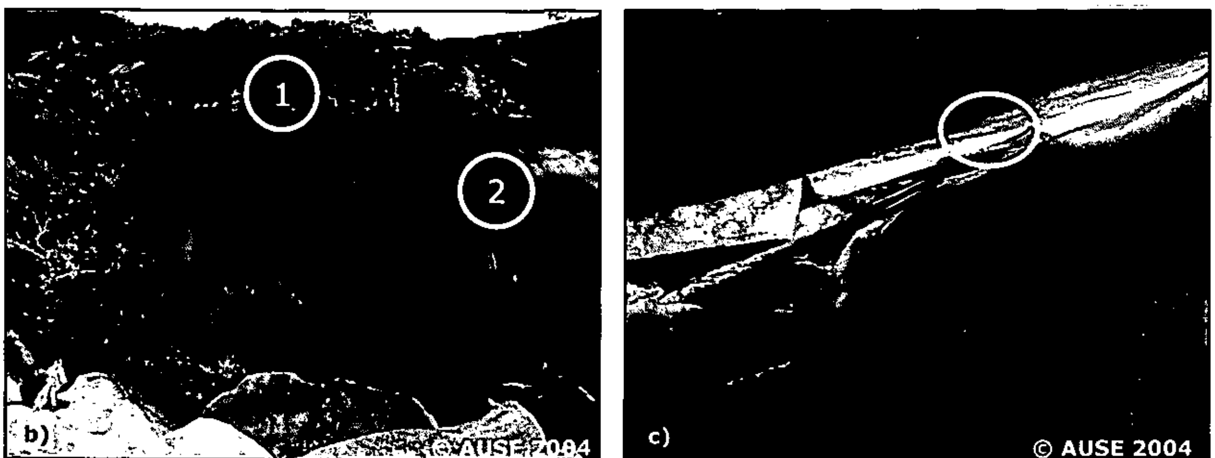
3.5.3. Results

Three boulder cave roosts were located on the west coast of the main island of Mahé with assistance from the Ministry of Environment and Nature Seychelles. Despite past records of roosts on La Digue and Praslin (Nicoll & Suttie 1982, Racey & Nicoll 1984), no active roosts were located on either island during the present survey. One roost was found in each of the three areas: Port Launay/Cap Ternay, Anse Major and Baie Lazare (Fig. 3.3b). The following account describes each roost in turn including external and internal roost appearance, surrounding vegetation and current and possible future threats.

Given the nature of these roosts as few in number and critically important for the survival of the species, precise locations are not to be disseminated to the general public. Records are being maintained by the MENR for use in future monitoring studies.

3.5.3.1. Anse Major

Located off the Anse Major trail in Bel Ombre, this roost was in a large tidal boulder cave behind a steep glacis (see Fig's 3.3b, pages 24 & 25; and 3.5b, below). The main roost cavern ceiling sloped at an acute angel and was open, admitting daylight (Fig. 3.5c). However, to the left and right hand side of this cavern, two smaller, darker compartments were present. Bats were seen roosting and in flight, both the main cavern (3-7 bats) and the darker side compartments.



Figures 3.5: b) Roost along the Anse Major Trail Mahe, Seychelles. Bats were observed exiting at point 1 and feed in a circular pattern. Occasionally bats returned back to the roost at point 2. Feeding would decrease and bats would fly left in the direction of a known feeding area. c) Inside Anse Major roost, Mahe Seychelles. The roost was very light, bats were observed to be roosting in both the lightest parts and darker areas of the cave.

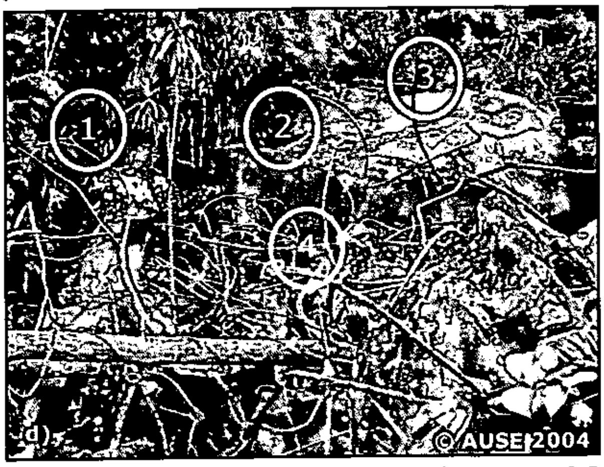
Two main exit points were identified: a south facing, narrow, horizontal opening at the top of the glacis (Fig. 3.5b, 1) (~19m asl) and a north facing, smaller opening at the bottom of the glacis (Fig. 3.5b, 2) (0m asl). Bat activity was more common from the former exit. No vegetation obstructed the exits, allowing a clear flight path out the roost. A third exit was also identified to the side of the roost which was obstructed by native and non-native vegetation; only one bat was observed using this.

The glacis at Anse Major was void of vegetation but dense vegetation surrounded it, ranging up to 8 m in height, comprising both native (*Euphorbia pyrofolia, Canthium rouge, C. blanc, Draceana reflexa* and *pandanas* spp.) and non-native vegetation (cocoplum (*Chrysobalanus icaco*), cinnamon (*Cinnamomum zeylanicum*), Lantana (*Lantana camara*) and *Tabebuia* sp).

Signs of human disturbance in the form of litter were identified outside the roost site, most likely due to local fishermen who claimed it to be a good fishing spot (P. Contance, pers. comm.). No signs of disturbance were found inside the roost. The coastal location, and lack of vegetation cover, meant *C. seychellensis* was very exposed to weather effects on roost emergence.

3.5.3.2. Port Launay/Cap Ternay

Located on the edge of Morne Seychellois Park (at the bottom of the Mare aux Cochon hill) in the area of Port Launay, this roost was within a complex boulder field, approximately 30-50m inland from the coast (see Fig. 3.3b, pages 24 &25). Inside the roost, little light penetrated and the cave extended deep into numerous compartments of which many had acute sloping ceilings. The exact roosting location of bats in this cave was unclear due to the complexity of this roost.



Figures 3.5: d) Port Launay roost, Mahé. Points 1,2,3 & 4 represent areas where bats were observed entering and exiting. Electricity pylons were erected very close to the roost resulting in clearly visible habitat disturbance. Bats were observed in this area both feeding and commuting. e) View inside the Port Launay/Cap Ternay roost near exit point 3. This tunnel was one of the main commuting routs linking the suspected roosting site to the rest of the cave and the outside. Bats were suspected to be roosting deeper within the cave, in caverns beyond the person in the photo. To the left of the person is another tunnel linking this region to a larger cavern where exit points 1 & 2 are located.

Four exits were identified from the roost, two of which had high levels of bat activity: one facing south (Fig. 3.5d, 1) and the other facing south east (Fig. 3.5d, 3). Sparse vegetation was noted at these exits but was not apparently obstructive, allowing a clear flight path out of the roost.

Vegetation surrounding this roost was diverse and variable in height (1-15m) and density. Both non-native (agati and bread-fruit tree (*Artocarpus altilis*)) and native (*Dracaena reflexa, Kapiler* spp., *Canthium rouge, Lantannyen milpat, Terminalia catappa, Phyllanthus pervilleanus*) plant species were evident in the immediate roost vicinity (Fig. 3.6d) Cinnamon was also widespread and continues to be regularly felled to control its spread in this area (T. Vel, pers. comm).

There are clear signs of periodical disturbance at this roost. In 2000, an electricity pylon line was erected directly outside this roost and vegetation was, and continues to be, regularly felled to protect the pylon (Fig. 3.5d). It is unknown if this disturbance is harmful to *C. seychellensis* or not. However, no signs of disturbance were found inside the roost. The conservation status of this roost is unclear as it is situated on the edge of the protected Morne Seychellois Park.

3.5.3.3. Baie Lazare

Located in the area of Baie Lazare, approximately 100m above sea level and <800m from the coast, this roost was in a boulder field at the top of a river valley (see Fig. 3.3b, pages 24 & 25). The external appearance of the roost is a glacis with one main roost cavern within. Within the main cavern, the ceiling slopes at approximately 45° and the ground, also at an acute angle, is composed of loose soil (Fig. 3.5f). It is unknown how far this cave extends. Bats were observed flying within, and roosting on the ceiling, in the darker areas of this cavern.

Only one main roost exit was identified from which bat activity was noted: a south facing triangular exit approximately 160cm from ground level, at its highest point. Through this exit bats were seen flying through a gap between two boulders forming a passage; an endemic palm was partly covering this route, but the bats were able to manoeuvre in small spaces at great speeds.

Figure 3.5: f) Entrance to the roost at Baie Lazare.

Vegetation surrounding this roost was from 1-20m high (from ground level) and a high number of native and endemic species were noted in the immediate roost vicinity. Many of these species were not identified at the other two roost sites. Cinnamon was also noted as being widespread in this area.

This roost is surrounded by a tourist resort and therefore is immediately threatened by future expansion of this resort; this could encroach into the forest valley in which the roost is found. The local resort owner revealed plans for future development in this small area but did not pinpoint exactly where it would be happening (Anon. pers. comm.).

3.5.4. Future roost searches

Two further possible roost locations were identified in the Port Glaud area and far south-west of Mahé during the present study. Therefore, further studies are required in order to determine the possibility of additional roosts not only on Mahé, but Praslin and La Digue.

3.5.5. Roosts in Silhouette

It was not possible in the present study to visit the La Passe, Silhouette roost sites of *C. seychellensis*. However, recent studies carried out by Burgess & Lee (2004) and Gerlach (2004) indicated approximately 32 *C. seychellensis* individuals were distributed between two north-west facing, sheltered boulder cave roosts in La Passe.

3.5.6. Conclusion

Ongoing tourist developments on the small main island of Mahé means *C. seychellensis* boulder cave roost sites are increasingly being threatened by disturbance. Therefore, it is essential to monitor and protect known roost sites, and continue searching for additional roost sites, in order to protect and prevent the extinction of *C. seychellensis*.

3.6. Activity Patterns

3.6.1. Methods and Analysis

A total of seven all-night recording nights were obtained from areas adjacent to each of the three known roosts on Mahé. Three nights of data were obtained adjacent to the Port Launay and Anse Major roosts respectively, and one night of data was obtained adjacent to the Baie Lazare roost. Whenever a bat pass was heard, the start time (in hours and minutes) was noted, together with the number of bats present, the number of feeding buzzes heard within the pass, and the exact bat pass duration (in seconds).

With regard to the analysis, sunset times were obtained for each survey night (via www.timeanddate.com). The amount of bat time (in seconds) and number of feeding buzzes was then determined for each hour after sunset. If two or three bats were noted for a particular length of time, the amount of bat time was doubled (or trebled) for the duration of that time.

3.6.2. Results

Bats from all three roosts studied showed the most activity during the first hour after sunset, both in terms of the number of bat-active seconds, and the number of feeding buzzes. By the fourth hour after sunset, bat activity at all three roosts had reached a low level, which was usually then maintained throughout the night (the exception being bats at the Baie Lazare roost which had a pre-dawn activity peak). However, bats were active throughout the night at all roosts.

When the data from all the roosts is analysed together, there is a statistically significant difference in both the number of seconds of bat activity (Kruskall-Wallis ANOVA, $H=13.18$, $DF=11$, $P=0.281$) and the number of feeding buzzes (Kruskall-Wallis ANOVA, $H=14.43$, $DF=11$, $P=0.210$) between the separate hours after sunset. Most feeding buzzes occur in the fist hour after sunset (Fig. 3.6d(a)), however, bat activity does not decline until the fourth hour after sunset (Fig. 3.6d(b)). The most efficient foraging period is therefore the first hour after sunset (Fig. 3.6d(c)).

There is a statistically significant positive correlation between the number of feeding buzzes per hour, and the number of seconds of bat activity per hour (Spearman's rank correlation coefficient, $r=0.843$, $P=<0.000$) (Figure 3.6d(d)).

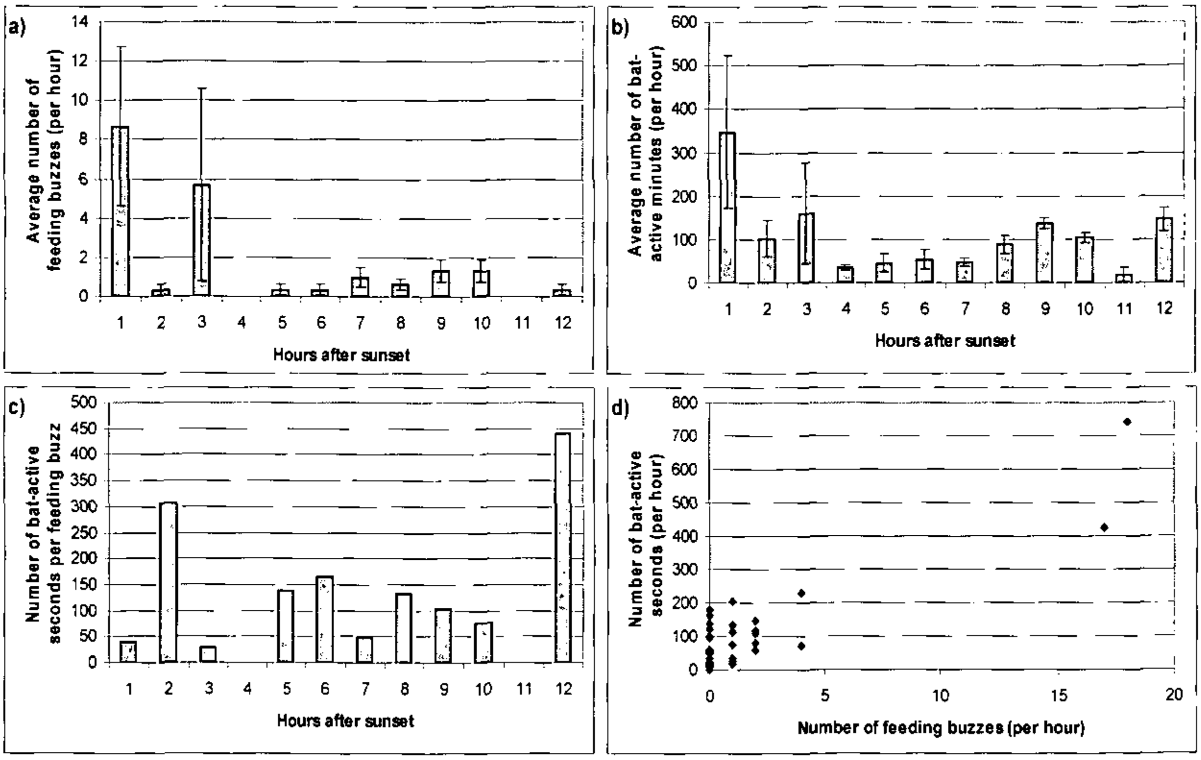


Figure 3.6: a) Graphs depicting foraging data from the Anse Major roost (+/- standard deviation where applicable) (n=3).

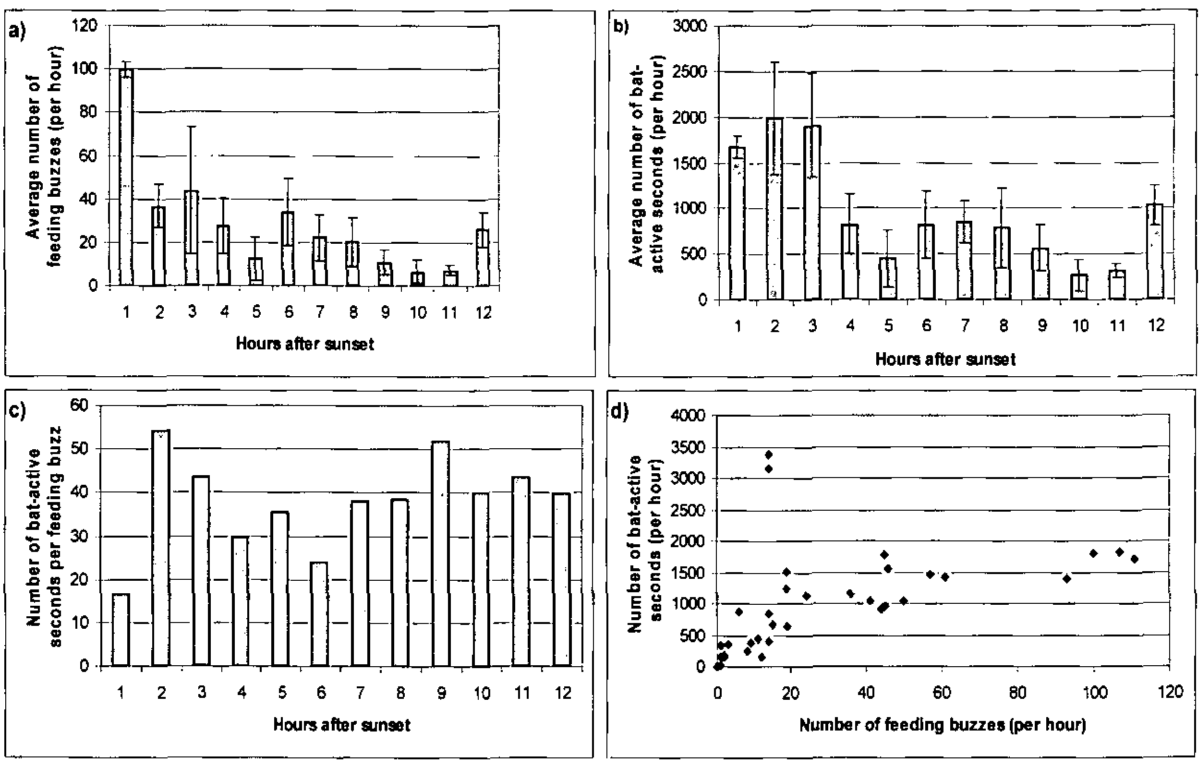


Figure 3.6: b) Graphs depicting foraging data from the Port Launay roost (+/- standard deviation where applicable) (n=3)

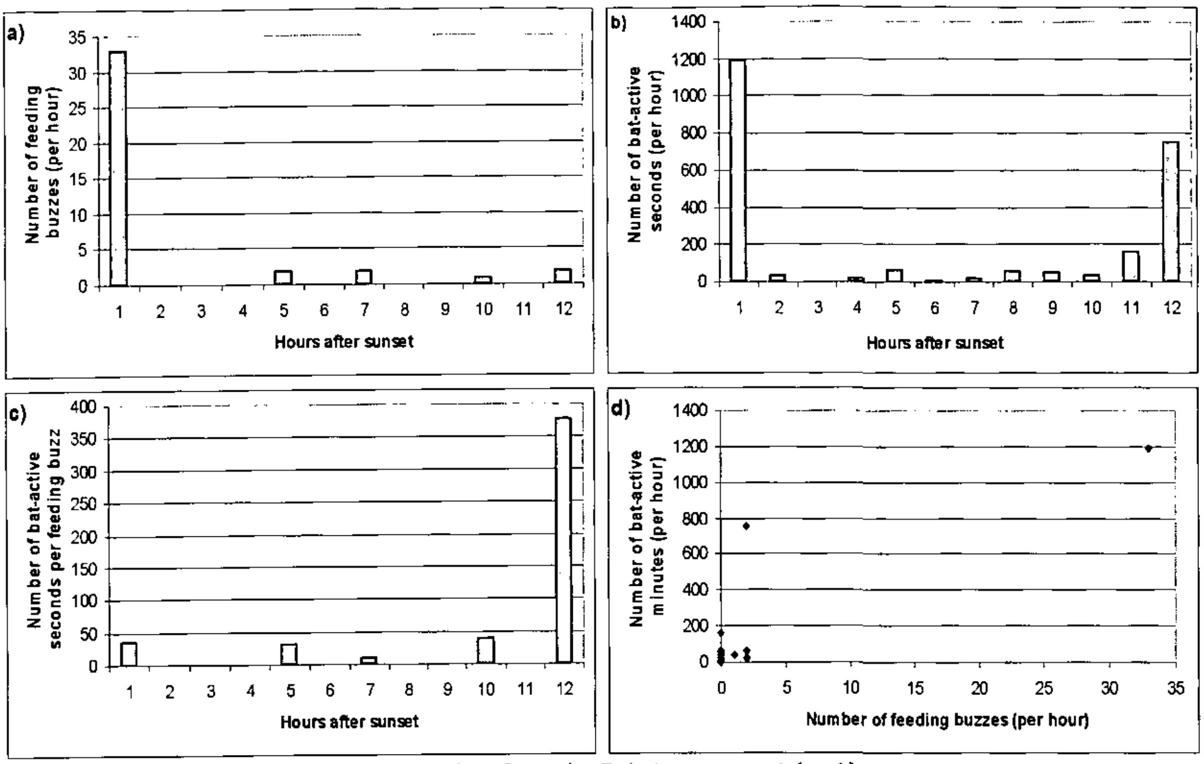


Figure 3.6: c) Graphs depicting foraging data from the Baie Lazare roost (n=1).

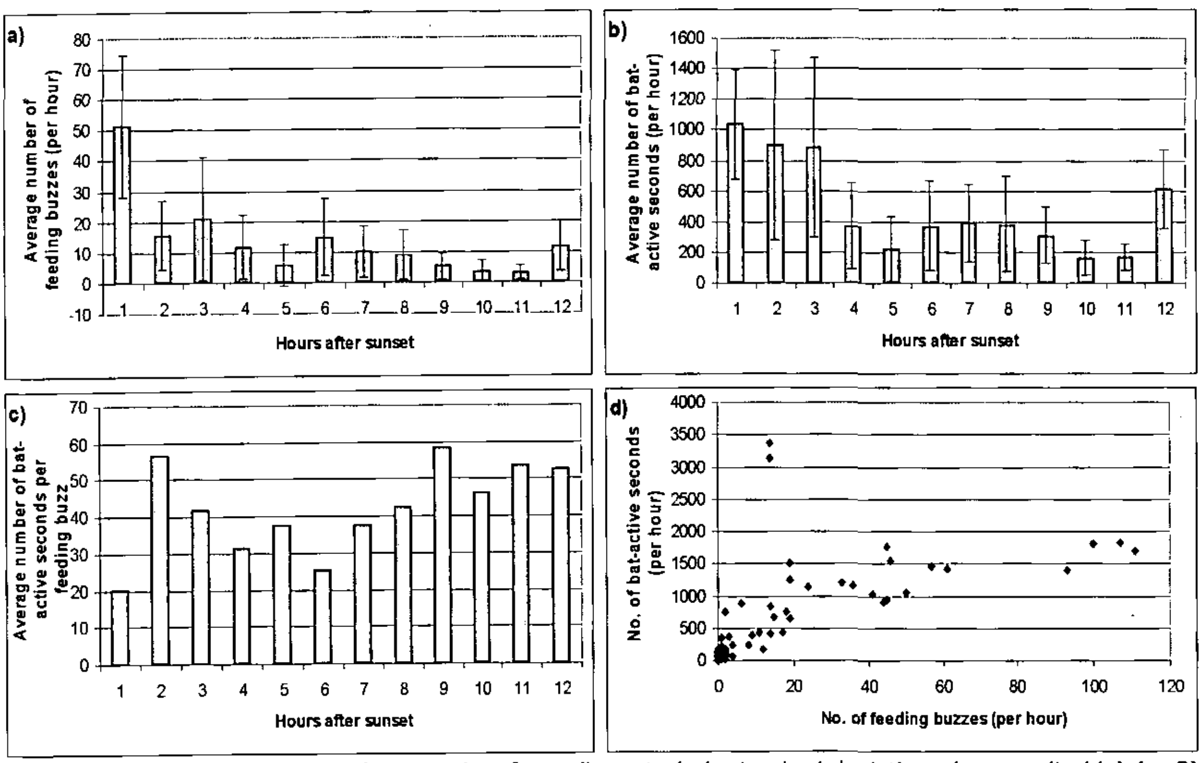


Figure 3.6: d) Graphs depicting foraging data from all roosts (+/- standard deviation where applicable) (n=3).

3.7. Factors Affecting Roost Activity

3.7.1. Methods

Analyses on activity and behaviour at roosts were carried out on all-night observations from three roosts on Mahé. In total 7 all-night observations were carried out, 3 at Anse Major, 3 at Port Launay, and 1 at Baie Lazare. Bat passes and social calls were used as two measures of activity. To investigate what was influencing activity at the roosts these two variables were analysed in GLMs following the same protocol as above. Eight factors were entered into the model selection, three by default were in all models: *time* (as mins after sunset), roost *site*, and *night*; six more were available for selection: *rain cloud* and *wind* (each on a 0-2 scale), an *observer* code (representing the group of observers present) and *roost occupancy* (whether the activity took place within or outside of the roost - 0/1). The factors *site* and *night* were crossed to examine any effect of different nights within the same roost. When studying social call activity, occurrence of a simultaneous bat pass (*BP*) was added as another factor, and was included in all models by default. General activity patterns throughout the night were also studied qualitatively, by transforming observational data into average per minute rates within each hour.

3.7.2. Results

Model selection for influences on bat pass activity at the roost highlighted three factors as highly significant, which were roost *site*, occurrence of *rain*, and *roost occupancy* (see Table 3.7a). The R^2 equivalent for this model was 21.95%. Although they were not a significant factor, *cloud* cover and *observers* were also present in the best model, along with the defaults *time* and *night*. Model selection for influences on social call activity led to a best model which included the defaults *site, time, bat pass* and *night*, along with *night*site* and *roost occupancy.* The R^2 equivalent for this model was 62.83%, representing a very powerful model, with *time* being the only variable that did not show a strong significant influence. The only factor in the best model, which did not have a significant effect on social call activity, was time (see Table 3.7b).

Tables 3.7: a) GLM results of effects on rates of bat pass activity outside the three roosts, $p_{crit}=0.05/7=0.007$. Direction of the relationship is given for the three significant factors, in the Class factor, *Site*, only the Anse Major roost (A) had a significant negative effect on bat pass activity. **b)** GLM results for effects on rate of bat social calls, $p_{crit}=0.05/7=0.007$. Direction of the relationship is given for the four significant factors, in the Class factor of *Site*, the only site that had a significant effect on activity was the Anse Major roost (A).

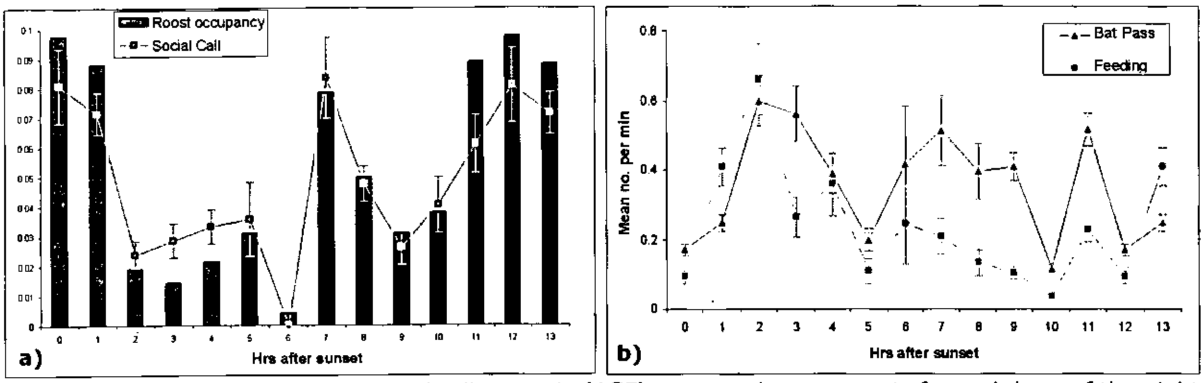
a)

Source	No. DF	Den DF	F value	p value	Direction
Site	2	1472	8.65	0.0002	A -
Time	1	1472	0.27	0.6037	
Night	1	1472	1.15	0.2829	
Rain	1	1472	20.92	<.0001	-
Roost	1	1472	84.32	<.0001	-
Cloud	1	1472	3.5	0.0617	
Observer	1	1472	4.75	0.0294	

b)

Source	No. DF	Den DF	F value	p value	Direction
Site	1	1473	75.68	<.0001	A +
Time	1	1473	2.41	0.121	
Bat Pass	1	1473	172.95	<.0001	-
Night	1	1473	46.07	<.0001	+
Night*Site	1	1473	43.35	<.0001	A -
Roost Occupancy	1	1473	982.9	<.0001	+

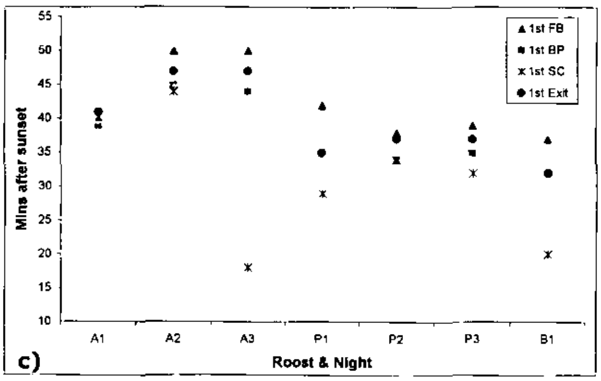
The results in Tables 3.7a and b show the direction of the significant relationships, thus bat flight activity was negatively affected by rain, and was also, and logically, less likely within the roost. In contrast social behaviour was not affected by weather, but was instead much more common while bats were within the roost (see Fig. 3.7a). This tendency fits in with general knowledge of bat behaviour, and also explains the negative relationship between bat flight, and social activity. Interestingly, levels of social activity at the Anse Major roost differed significantly between nights independent of weather. This, and the observation that both flight and social activity differed between roosts (site was a significant factor in both GLMs), suggest that further work in this area would reveal other influences on bat behaviour at the roost. For example, numbers of bats present, breeding stages, and numbers of dominant males present could all have major influences on the activity within a roost. It is also possible that ambient air temperature, wind direction, and disturbance prior to or during emergence could also affect behaviour within and outside the roost.

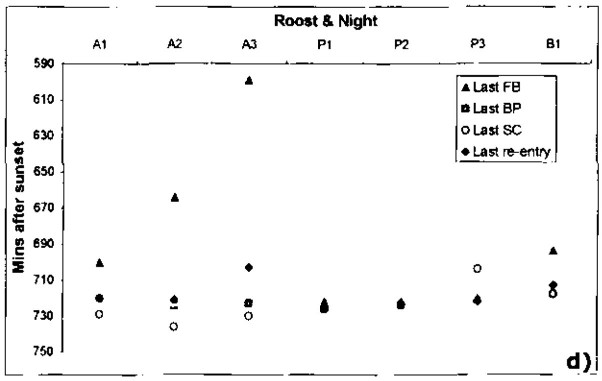


Figures 3.7: a) Mean numbers of social calls per min (±SE), averaged across roosts for each hour of the night, with mean occupancy of the roost, again averaged across roosts (0=outside roost, 1=within roost). b) Mean numbers of bat passes and foraging buzzes per minute (±SE), averaged across each hour of the night and across all roosts.

Roost activity during the night does show some trend towards three peaks, at dusk emergence, roughly at 1am, and just before dawn. Figure 1 shows the strongly related levels of social activity and occupancy of the roost throughout the night, with roost activity dropping off sharply 2 hours after sunset (8pm), peaking sharply 7 hours after sunset (1am), and showing a less marked decrease and then increase again between 1am and dawn. Complementing this observed pattern is the trend seen in bat pass activity and rate of feeding buzzes when looked at in the same way (Fig. 3.7b). These behaviours show a strong peak just as roost occupancy drops off at 8pm. Although patterns after this peak are not that clear, there is a general drop off in activity around the roost, followed by moderate levels of activity (but not foraging activity) following the 1am return to the roost. These results suggest that the main period for foraging in *C. seychellensis* is in the first half of the night, in the second half of the night, some bats appear to return and remain near the roost, whereas others may return and then depart again for another foraging trip before dawn. These data would obviously benefit from larger sample sizes, as seven nights is not enough to fully investigate affects on activity decisions made by the bats.

Another pattern of interest is the behavioural sequence at the roost at dawn and dusk. The time of the first and last social call, bat pass, feeding buzz and observed emergence/return to roost were summarised for each night of observation. There is an apparent tendency for the behavioural sequence to at dusk to be: social call – bat pass – emergence – foraging; and for this to be mirrored at dawn (see Figs. 3.7c & d). An interesting difference between dusk and dawn is the time span over which these first occurrences take place, e.g.: within one hour of sunset, but spanning more than two hours prior to dawn. Thus, matching suggestions from Figs. 3.7a and b, the return to the roost at dawn is not as synchronised as is the emergence from the roost at dusk.





Figures 3.7: **c)** Times of the first dusk occurrence of Feeding Buzzes (FB), Bat Passes (BP), Social Calls (SC) and observed exit of the roost (Exit) for the three roosts: Anse Major (A), Port Launay (P), and Baie Lazare (B), and for each night at that roost. **d)** Times of the last occurrence at dawn of Feeding Buzzes (FB), Bat Passes (BP), Social Calls (SC) and observed re-entry to the roost (Re-entry) for the three roosts: Anse Major (A), Port Launay (P), and Baie Lazare (B), and for each night at that roost.

Figure 3.7: *e)* A *C. seychellensis* in the Anse Major roost, Mahé, Seychelles, September 2004. This individual is visibly alert of the observer's presence, but was not greatly disturbed.

3.8. Behaviour at the Roosts

Evening observations at the three roosts were carried out to determine emergence times, and to gain an estimate number of bats emerging from each roost. The time of the first social call, bat pass, feeding buzz, and observed emergence were all recorded, along with numbers of bats seen, exits used, and weather conditions.

A maximum number of seven bats were seen exiting both the Anse Major and the Port Launay roosts, with only one bat observed at the Baie Lazare roost. Mean numbers of bats seen emerging from the Anse Major and Port Launay roosts were 4.5 bats (see Fig. 3.8a). Three exits were used at the Port Launay roost, with just one exit in use at the other two roosts.

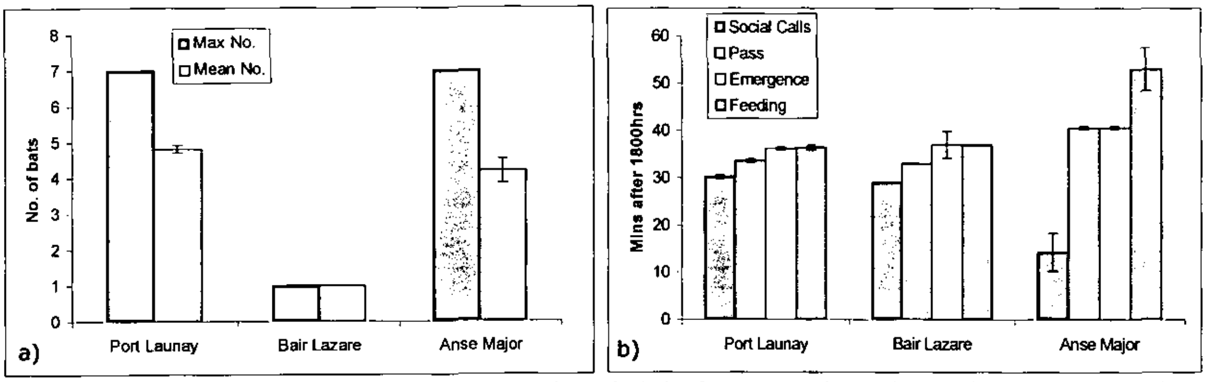


Figure 3.8: **a)** Maximum numbers and mean numbers (±SE) of emerging bats observed at each of the three roosts on Mahé. **b)** Times of the first occurrence of bat activity at the three Mahé roosts (means where possible ± SE). Data include 11 nights at Port Launay, 5 at Anse Major, and 2 at Baie Lazare.

Social calls were heard first at all three roosts (see Fig. 3.8b), followed by bat passes (e.g. flight activity within the roost). At Port Launay and Baie Lazare emergence was accompanied with immediate foraging activity, but at the Anse Major roost, the first foraging activity was heard a few minutes after emergence. As only one or two data points are available for the Baie Lazare roost, comparisons with this roost are not too reliable, however, 11 observations were carried out at Port Launay, and 5 at Anse Major allowing more certainty of these times. Thus the bats appear to become active within the roost between 1815 and 1830 hrs, and to emerge from the roost at around 1840hrs, with foraging commencing on emergence or shortly after.

3.9. Prey abundance studies

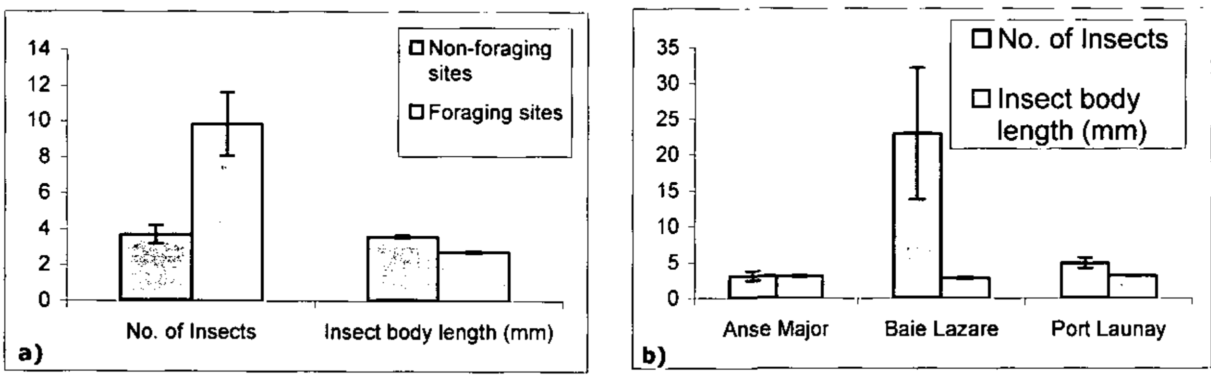
3.9.1. Methods

Foraging data were collected at two sites where bats were observed feeding. Behavioural observations were carried out at the three known roosts on Mahé. The observers were in place from dusk to dawn, noting bat activity, whether commuting, foraging or social behaviour. Simultaneously, overnight insect sampling was carried out using Malaise traps that were placed on a feeding site and on a non-feeding site in the area around the roost.

Invertebrate abundance was compared between foraging, and non-foraging areas, and between areas near each of the three roosts on Mahé. The analyses involved a multivariate GLM (data residuals fitting normality), with roost and foraging/non-foraging as fixed factors, and both number of insects, and mean length of insects as dependent variables. As two variables were considered, the p_{crit} value was taken as 0.025 to correct for Type 1 errors. Dunnett C *post-hoc* tests were carried out on Roost results, assuming unequal variance.

3.9.2. Results

Insect abundance differed significantly between foraging and non-foraging sites, with areas that were used by the bats for foraging being occupied by greater numbers of insects (see Fig. 3.9a). Insects were also more abundant around the Baie Lazare roost that around either Port Launay or Anse Major (see Fig. 3.9b), which did not differ from one another (from *post-hoc* tests). Mean length of insects, however, did not differ significantly between roost areas (p=0.58), or between foraging and non-foraging sites (p=0.03).



Figures 3.9: a) Numbers of insects and mean insect body length (mm) at bat foraging and non-foraging sites (mean ± SE). Significantly more insects occurred at foraging than non-foraging sites: $F_{1,7}=13.54$, p=0.008. Mean insect length did not differ significantly. b) Mean numbers of insects, and insect body lengths (± SE) found in the area of the three Mahé roosts. Insect body length did not differ significantly, but greater numbers of insects were found at Baie Lazare than at the other roosts: $F_{2,7}=14.64$, p=0.003.

Although data were limited, due to technical difficulties, the power of the GLM in explaining insect abundance and insect body length was sufficient to allow confidence in the results obtained (adjusted R^2 values of 0.78 and 0.42 respectively).

3.10. Diet analysis

3.10.1. Background

Assessing bat diet in association with prey availability can provide information to help to conserve these critically endangered bats. Approaches taken to diet analysis include analysis of the stomach content, faecal analysis, analysis of culled parts discarded by the bat, and direct observations. Analysis of faecal matter is non-destructive, and was the approach taken in this study. Problems associated with faecal analysis stem from the fact that most bats chew their prey into un-identifiable mess. It is often possible, however, to identify the consumed prey items to the level of order or even family. Disadvantages from this approach are the lack of data on differential digestion (and thus a bias towards insects with less digestible hard parts), and the uncertainty of the time of consumption arising when samples are collected from beneath the roost.

3.10.2. Methods

Bat faecal pellets were collected from beneath the roosts, as individual pellets, although collection sheets were put in place. Due to the small population sizes of the *C. seychellensis*, these collection sheets failed to accumulate sufficient material for the purpose of analysis. Samples were stored in 70% ethanol, and analysed using a 40X binocular microscope. Insect remains were identified to the level of order, in the absence of information on the insect fauna of the Seychelles.

3.10.3. Results

The faecal analysis revealed that *Coleura seychellensis* consumes prey mainly from the insect orders Coleoptera (beetles), Lepidoptera (e.g. moths) and Diptera (e.g. flies), and occasionally remains of insects from other orders were found. The composition of the diets of bats from different areas of the island of Mahé (the only place where guano was collected from the roost floors) showed variation in both composition of prey items and their relative abundance in the faecal pellets (Fig. 3.10). This variation may be due to differences in deposition time, and the results may be biased by the fact that bats may visit different foraging areas to prey on particular species, and move from one foraging site to an other one from night to night. The variation may also be representative of a true difference in the diets of bats from the different areas.

3.10.4. Discussion

Deposition rates of guano were low to an extent that prevented large amount of sample material to be collected. Individual pellets were collected from the cave floor at the three roosts, and the time of deposition for each pellet is not known. It is also not known whether pellets collected were laid by only one individual, or by several different bats. Faecal pellets of any one bat can often reflect successful feeding in a swarm of insects, and contain remains of only one type of insect prey. If pellets were collected from known bats, individual variation in diets could be studied to investigate whether the bats forage together or often fly to different areas to forage individually or in small groups. Group foraging could reflect good quality foraging areas that can support several feeding bats.

The findings of the diet analysis gave no indication that *Coleura seychellensis* uses a gleaning mode of feeding; however, this possibility cannot be excluded due to small sample sizes. The findings do suggest that the bat is an opportunistic predator that can vary its insect prey according to what is currently available. A non-selective feeding strategy may render the bats more adaptable to changing conditions in their foraging habitat, as changes in vegetation may affect the insect communities the bats exploit for food. The diet of the bats is likely to vary seasonally, as the weather conditions in the Seychelles vary so that during the Southeast monsoon from May to October strong winds prevail and the rainfall decreases to a lower level. During this period, insect abundance is likely to be at its lowest, and increase again during the rainier monsoon brought on by the Northwest trade winds.

Seasonal and spatial variation in the diet of *Coleura seychellensis* ought to be studied in greater detail, to assess the importance of each different prey type, coupled with information on habitat type supporting any particular type of prey. This information would be very useful in deciding on protection of foraging habitats of the bats.

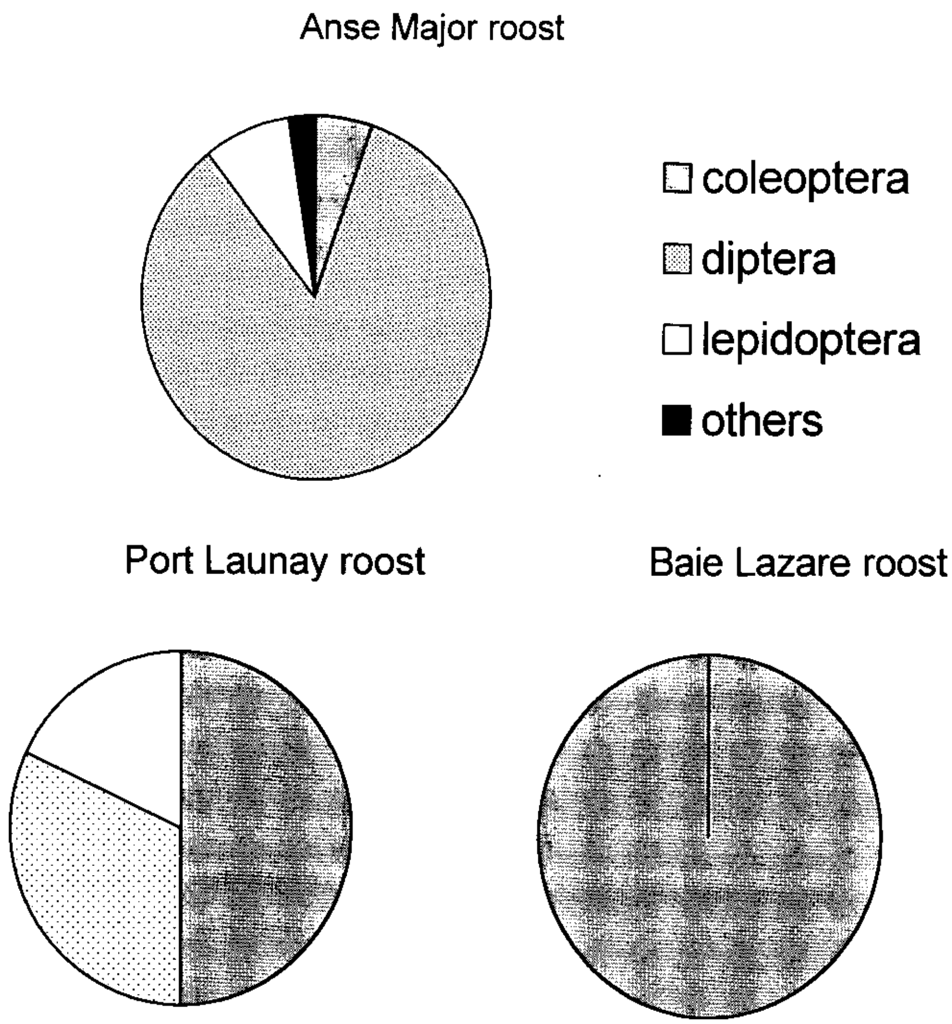


Figure 3.10: Relative abundance of remains of prey items found in the faecal samples collected from three roosts, at Anse Major, Baie Lazare and Port Launay. Coleoptera appear to be the most common prey item consumed, as the samples from Baie Lazare contained only Coleoptera remains. At the Northern end of the island, Diptera made a larger contribution to the diet of the bats, and a more diverse array of prey items was consumed.

3.11. Call characteristics

3.11.1. Background

Bats are very vocal animals. They produce echolocation calls for navigation and prey detection when foraging in the dark. The pulse structure of these calls is constrained by the habitat use of the bat. Body size is also a very good predictor of the dominating frequencies of the calls, so that smaller bats use higher frequencies. Studying the bats' call characteristics can provide an easy access to information about their ecology, and for this purpose recordings of the echolocation calls of *C. seychellensis* were made.

3.11.2. Methods

Recordings were made using the Petersson D240x and Sony Minidisk. An attempt was made to obtain recordings of foraging bats, commuting bats, and bats inside the roost emitting social calls. For this purpose, recordings were made in areas where bats were frequently found foraging, as well as inside the roost caves where disturbance to the bats was minimized. For analysis, Petersson Batsound software was used.

Recordings were made of *Coleura seychellensis* echolocation calls both outside and inside cave roosts. Recordings were made of three types of calls: commuting, foraging and social. Only a few good quality recordings of each call type were available for analysis, although useful information was obtained from these recordings.

3.11.3. Results

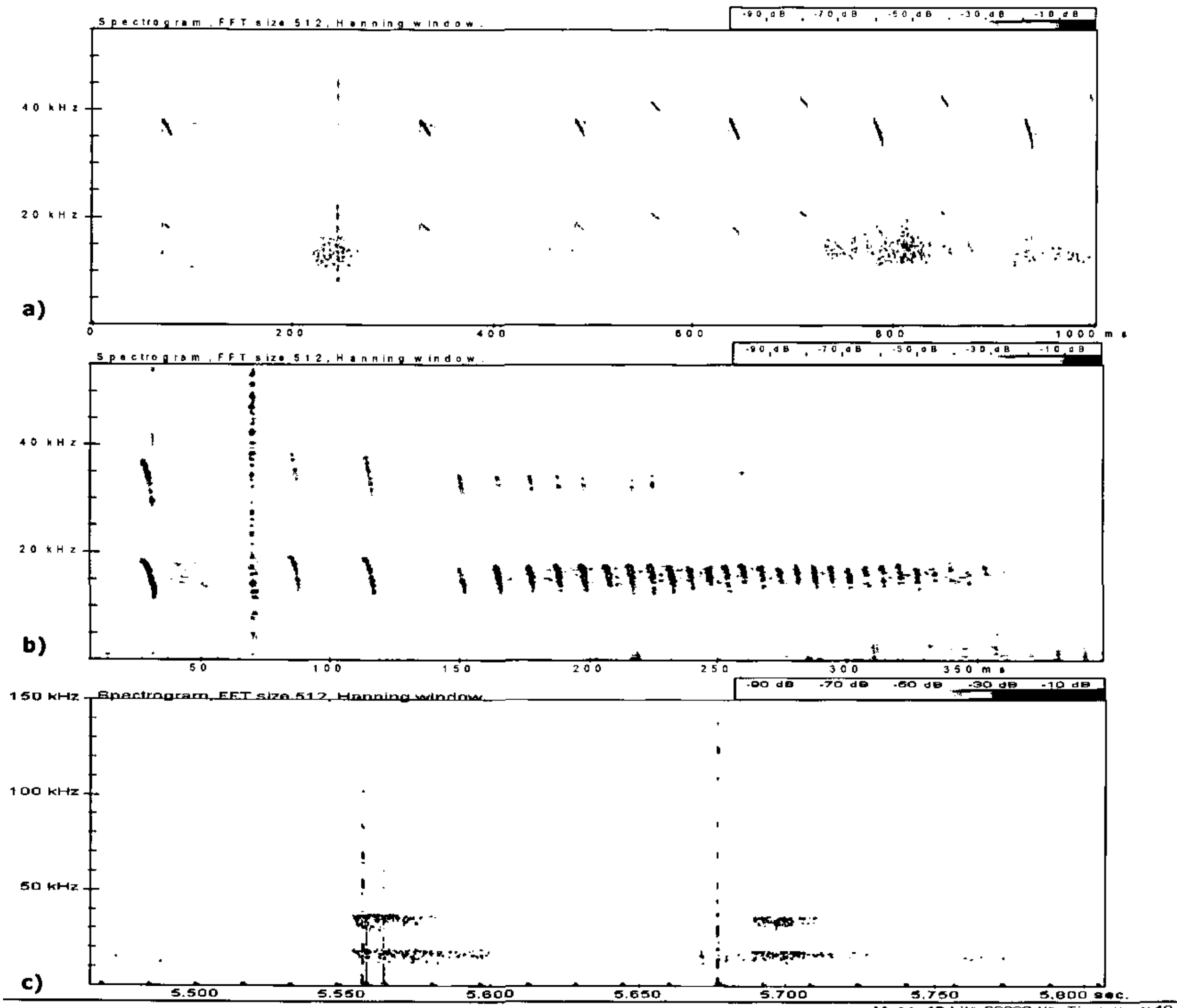
Bats emitted echolocation calls in frequencies in the range 46.6 kHz down to 12.0 kHz in some situations. Bats commuting in open habitat and in forest edge habitat emitted frequency modulated (FM) calls with the start frequencies ranging from 46.4 – 35.5 kHz and the end frequencies of 41.3 – 25.3 kHz in the second harmonic, and the fundamental frequencies in the first harmonic ranged from starting at 23.0 – 17.3 kHz and ending between 20.2 – 11.6 kHz, the lower frequencies recorded before prey localisation (Table 3.11, Fig. 3.11a) Most amplitude was on the second harmonic, the audible component of the calls being weaker. However, in the feeding buzz, a shift was observed, so that during the precise target localisation and attack, most amplitude was on the first harmonic, at frequencies audible to the human ear (Fig. 3.11b) Inside the boulder caves, the bats emitted echolocation calls at slightly lower frequencies and steeper modulation, still in the ultrasonic range of 37.0 – 28.0 kHz. The calls were of short duration, ranging from approximately 11.5 to 5.5 milliseconds, with a pulse interval of 66 – 164 ms (Fig. 3.11c).

Table 3.11: Average summary statistics for orientation calls (n=117)

Call duration (ms)	Frequency of maximum energy (ms)	Maximum frequency (kHz)	Minimum frequency (kHz)	Interpulse interval (ms)
4.28	38.7	40.55	35.38	83.32

3.11.4. Discussion

The call parameters (frequency, duration, steepness of frequency downward modulation, interpulse interval) varied, and some evidence exists that the bats are able to adjust their echolocation calls in response to different situations, for example in the presence of conspecifics, or in changing habitat conditions encountered when foraging on the wing. The call structures suggest that *Coleura seychellensis* is dependant on open space habitat, and can also exploit insects flying close to vegetation - however possibly not in the closed forest habitat. The low frequencies used in the feeding buzz (Fig. 3.11b) suggest a larger size of prey items available to the bats. As insects in the Seychelles are characteristically small, it could be argued the bats may be suffering from poor resource availability. A qualitative analysis of the prey items consumed could clarify the question of prey selection, and could be compared against a detailed insect survey carried out to investigate prey availability in important bat foraging habitat. The echolocation calls used by the bats suggest the importance of good quality forest edge habitat, where insect abundance is sufficiently high to render foraging for these fast flying aerial hawkers worthwhile.



Figures 3.11: a) Sonogram depicting a search phase call sequence. The calls were frequency modulated, and most amplitude was in the frequency range of ca. 45 kHz to 33 kHz, and subsequent calls had different start and end frequencies. b) Sonogram depicting a feeding buzz (preceding prey capture). The calls were frequency modulated, and most amplitude was in the frequency range of ca. 18 kHz to 12 kHz, and the interpulse interval and call duration were decreased towards the terminal phase of the sequence. c) Sonogram depicting social calls.
All sound recordings (time expanded 10 times) were made using a Pettersson DX240 bat detector and Sony minidisc recorder, and analysed using the Batsound computer program.

3.12. Pesticides as a factor in the decline of *C. seychellensis*

An extensive literature search covering the available records of insecticide use in the Seychelles was carried out in the Seychelles National Archives and the findings are detailed below.

With the recent knowledge in the past few decades regarding the harmful effects of pesticides and organochlorines to mammals, it has been suggested by Joubert (1996) that pesticides may have been a factor in the decline of the sheath-tailed bats in the Seychelles. Krunthanut (1986) showed that insectivorous bats had higher pesticide residues than fruit bats in Thailand including measures of aldrin, dieldrin and DDT among others.

Interviews with mature residents of the Seychelles support the idea that this endemic species noticeably began declining during the 1960's and 1970's. Reports were given by several people that during the 1960's the evening sky around Victoria (Seychelles' capital city) would be filled with bats (Anon. pers. com). It appears that there may have been a roost in Victoria but as the capital further developed any roosts present were destroyed by human disturbance. No bat calls were detected in this area during the recent expedition. In fact no bat calls were detected on the east coast during the three months investigation. However, further monitoring throughout the year is required to confirm the absence of bats along this coastline (most of the major development on Mahé has occurred along the east coast (pers. obs.) (see Fig. 3.3b, pages 24 & 25). Nevertheless, the abundance of roost locations among the granite rocks (Nicoll & Suttie, 1982) should allow for at least some relocation along the east. What other factors could have led to the decrease in numbers?

In the late 1960's the Seychelles' government realised the economic viability of tourism. Hotels and restaurants were established along coastlines. Efforts were made to ensure that the Seychelles had what tourists required for a suitable holiday destination. The problem of irritating biting insects was recognised as possibly impeding the creation of tourist resorts.

Mathias and Laurence (1970) conducted a study into the distribution and control options for sandflies (*Leptopconops spinosifrons)* in the Seychelles. In this study they recommended the use of insecticides and physical alteration to the land alongside possible tourist beaches in order to control sandflies. They state that this midge was a problem in the development of tourism in the West Indies and such a sufficient nuisance that it led to the closure of a hotel in Cambodia due to lack of control measures (Mathias & Laurence 1970). They also investigated the chemicals present on the island to facilitate pest control and suggested that "pyrethrum synergist and malathion should be accumulated" as the amount of insecticides in the Seychelles was not sufficient for appropriate control. The experimental procedure used malathion spray on beaches and suggested the use and trial of Trichlorphen (Dipterex), Fenitrothion (Agrothin) and Paraquat (Gramoxone).

Way (1973) states that malathion/diazinon was used on a weekly basis to control the sandfly and that DDT was also used for experimental purposes. The quantity of DDT used is not specified nor is it clear if DDT was used on other islands. Records about the use of different pesticides in the Seychelles have been lost due to agriculture office relocation (Anon. pers. comm).

Malathion was used in the Seychelles to control and kill off insect pest species, species which may have been a vital component of the diet of the sheath-tailed bat. However, indirectly this organophosphate chemical could also accumulate internally in the bat. Malathion is converted into a more toxic substance once ingested by animals and can affect the nerves connected to muscles in mammals (Cox 2003). Pond bat populations in the Netherlands have declined due to pesticide residues (Leeuwanagh & Voûte 1985, in Hutson *et al.* 2001). Streit *et al.* (1995) showed that selected organochlorines accumulated more intensely in bats compared with tits. This is due to the feeding rate of the juvenile bats from the mother compared with chicks. Therefore infant bats can bioaccumulate pesticides from their mothers through the placenta and mammary glands as in the case of the common pipistrelle (Nagel & Disser, 1990). Pesticides such as malathion also affect the sperm of rats and mice (Cox, 2003). Male bats retain much of their accumulated organochlorine pesticides as they cannot pass them out of their system as in females (Nagel & Disser, 1990). This may affect the breeding rate of *C. seychellensis* if in fact malathion did affect the bats directly or indirectly.

Mathias (1971) compiled a list of the pesticides used against other island pests including dieldrin and chlorfenvinphos against the banana weevil (*Cosmopolites sordidus*). Fumigation of coconut trees in Praslin with Paradichlorenzene (PDCB) also occurred although was not successful; subsequently organochlorines were used to control a pest species of the coconut (Mathias 1971). The banana and coconut crops are another source of income to the people of the Seychelles and would require suitable pest control.

Another chemical highly recommended to rid the island of pest species is aldrin. Haines and Haines (1979) suggested and tested aldrin to control the crazy ant (*Anoplolepis longipes*), an invasive insect which causes much damage to agricultural crops. It is also a pest in the domestic areas and could be a threat to livestock (Haines & Haines, 1979). They included aldrin in bait laid out for the crazy ant. The bait appeared to be more attractive to crazy ant than other species of insect (Haines & Haines, 1979). *C. seychellensis* is an aerial hawker and therefore the crazy ant would never be part of their diet. However, Robinson and Tuck (1997) quote Meyrick (1911) as saying that much of the insect larvae present in the Seychelles are ground dwellers and live off dead and decaying vegetable matter. This could very well mean that insects which the sheath-tailed bat feed upon may be contaminated with aldrin during the larval stage of life, which may lead to aldrin accumulating in *C. seychellensis*.

Dieldrin, aldrin (two very similar chemicals) and malathion have been used on Mahé and Praslin but it is not known in what quantity. It would also be beneficial to find out which chemicals, if any, were used on Silhouette as this island contains the largest known population, 32 at the last count (Gerlach 2004). The sheath-tailed bat has not been recorded on La Digue in the last 30 years, and it would also be interesting to know what chemicals and pesticides have been used there in favour of agriculture. Comparing chemical use and bat population would give us an insight into a possible cause of decline in the bat population. Internal investigation is required to discern if any pesticide residue is present in the population. However, as the bat is listed as critically endangered and the population is dangerously low, this course of action is deemed highly unwise, except in the exceptional circumstance that an already deceased bat should be discovered.

3.13. Education and Public Awareness

As part of Project Aim 4, the expedition worked hard to increase the public's awareness regarding the plight of this bat, inform nationally and internationally the work being conducted and foster a sense of national pride towards the species in the hope of aiding future conservation measures. Very few Seychellois actually knew this species existed. As a result of our publicity efforts its profile and awareness surrounding its current dire conservation situation have been greatly increased. Below are set out the ongoing methods by which we set about this task.

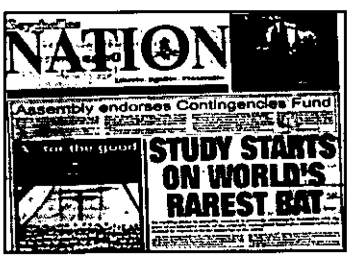
3.13.1. Prior to departure

Local newspaper, Aberdeen: Short article highlighting plans for a team of local students to go on an expedition to help conserve this critically endangered bat.

Regional newspaper, Aberdeenshire: Another article with a team photo.

Morning news roundup: Interview with Sinclair Laing highlighting the expedition, its motivations and proposed outcomes.

3.13.2. In the field



NATION

Assembly endorses Contingencies Fund

STUDY STARTS ON WORLD'S RAREST BAT

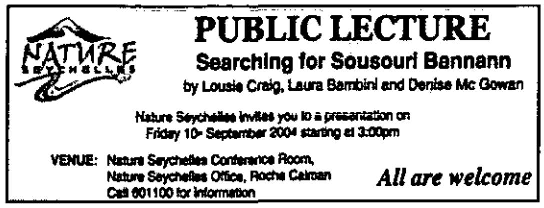
Seychellois National newspaper: Front-page article with team photo outlining the commencement of this new project. Included details of the team, the project, its motivations and proposed outputs. It also provided details of the project's local collaborators and work previously conducted.

National Workshop: The project team hosted an outdoor evening to inform WCS of the bat and its conservation plight. They were also provided with the opportunity to see and hear the bats first hand and given practical training in the use of bat detectors in the hope of passing on this knowledge to their groups.

Wildlife Clubs spot world's rarest bat

Seychellois National newspaper, Environment Section: Roundup of the project's work with the WCS.

A PowerPoint presentation for project collaborators and the general public, hosted at NS head office. Outlined the urgent conservation situation, the projects work, preliminary results, along with the proposed outputs. Attended by the Seychelles Broadcasting Corporation (SBC).



Environment Documentary: A short film covering the work of the project, the MENR and local NGO's is being produced for airing in the Seychelles in the near future. Current plans are to include portions of the public presentation and an interview with team members.

3.13.3. Post fieldwork

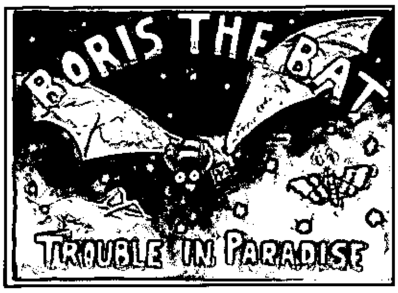
National Bat Conference, poster presentation and seminar: A poster was provided for display at the BCT's annual conference (2004) and a place has been allocated at the 2005 annual conference (2nd-4th September 2005, York University) for two team members to give a talk on the project and its results.

Aberdeen University Expedition Society, Expedition Evening Talks: A presentation in late November 2004 to university lecturers and students. An opportunity for those attending to find out more from the previous years expeditions.

35th Annual Symposium, seminar: Talk highlighting this project and its results to be presented by Prof. Paul Racey (19th-22nd October 2005).

10th Annual Symposium, seminar: Another project seminar, this time presented by team member Laura Bambini (21st-26th August 2005, NUI Galway).

The Society for Conservation Biology, poster presentation: Annual Conference (2005) in Brasilia to be attended for poster presentation providing a roundup of the project.

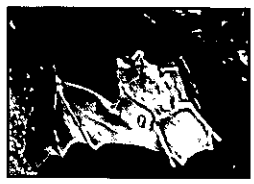


'Boris the Bat: Trouble in Paradise', children's book: Illustrated children's book has been drafted. Once produced it will be provided free of charge to the WCS for their members, and may go on sale in the shops in the hope of providing a little ongoing financial support for local environmental education and/or the long-term monitoring of *C. seychellensis*.

Oryx, scientific article: Another Seychelles endemic close to extinction. Is *Coleura seychellensis* still the rarest bat in the world? On the brink? Research article currently being submitted.

Conservation Biology, scientific articles: Habitat requirements of the critically endangered Seychelles sheath-tailed bat (*Coleura seychellensis*) and the implications for its' conservation. and Research Note: Behaviour at roosts of the critically endangered Seychelles sheath-tailed bat (*Coleura seychellensis*). Articles being scribed for submission.

'Bats on the Brink': Final Report. Dissemination of this document providing full details of the expedition and its findings.



Press release: Post submission of this final report a press release giving details of the end of the project, its findings and its successes.

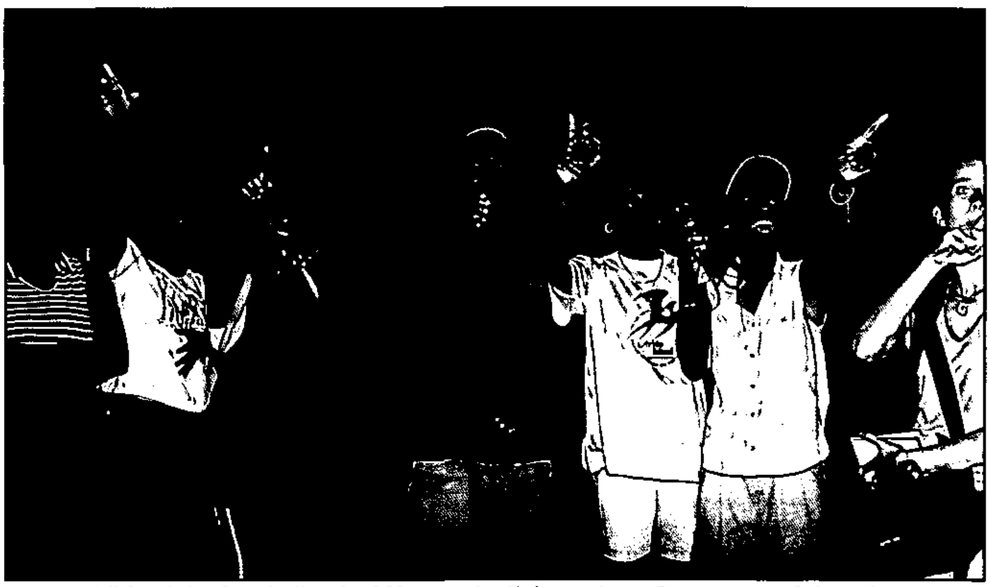


Figure 3.14: Wildlife Clubs Seychelles (WCS) experiential evening. One aspect of the education and public awareness campaign was hosting an educational and experiential evening for the WCS. As can be seen in the photo, it was thoroughly successful and enjoyable for all involved and knowledge gained is now being passed down to the club's children.

3.14. Conclusion

3.14.1. Breadth of the study

This study benefited immensely from the availability of a large team of workers, which allowed an unprecedented breadth and depth of study to be carried out on *Coleura seychellensis* in a relatively sort space of time. Because of the numbers of observers involved, it was necessary to design relatively simple methods in all parts of the study, which had the two-fold advantage of reducing observer errors in data collection, and in making the methods much more easily taught and maintained. As one of the main aims of this study was to help put into place a continuous monitoring programme, this latter factor was vital to the success of long-term work.

As mentioned above, this study involved an array of methods designed to maximise the breadth of knowledge gained on *C. seychellensis*. Initially the study focussed on transect-based surveys designed to locate foraging areas of the bats, to assess the distribution of the species, and to gain information on habitat requirements (linked with habitat surveys carried out at the same time). Foraging sites located as part of the transect surveys could then be used as focal points for intensive collection of data on foraging behaviour of the bats. These areas also formed the initial base for starting roost location searches, which involved carrying out increasingly small-scale emergence watches which led to the precise location of two previously unknown roosts being discovered on Mahé.

This study was able to add considerably to the known distribution of the bat on Mahé, whilst also confirming that local populations on Praslin and La Digue appear to now be extinct. The initial plan was to visit Silhouette, and to gather habitat and foraging behaviour from this apparently stable and well-monitored population. Such data would have permitted a valuable comparison with data from populations on Mahé, with methods, observers and time periods being constant between the two. However, organisational complications made a visit to Silhouette impossible, and we were forced to drop this part of the study.

3.14.2. Call characteristics

Recordings made during foraging observations, and during visits to roosts allowed a detailed analysis of the call structure of the species to be carried out. Parameters of echolocation calls suggest that *C. seychellensis* is adapted for foraging in relatively open spaces either within or outside of forest covers. Interestingly, analysis of feeding buzzes of the bats showed a shift to lower frequencies, suggesting that the bats were targeting relatively large prey items. In fact they may have been targeting larger prey items than their calls have developed for, a possibility, which may tie in with other data collected on insect availability and pesticide use.

3.14.3. Habitat requirements

Surveys and foraging studies permitted useful insight into the habitat requirements and how these may affect bat distribution. Both analyses of data collected from transect surveys and data collected during foraging observations suggested that when *C. seychellensis* forages within forests, it selects areas with taller trees and little understorey (possibly representing more mature structures) and may preferentially forage away from non-native plant species. This preference for habitats with open areas (forest edges, forest gaps and open sub-canopies) fits in with the call characteristics suggesting an open area aerial hawker. If the bats avoid non-native species for foraging, this raises the possibility that non-native tree species may represent sub-optimal prey resources, with perhaps different insect communities or smaller insect loads. This is an area that requires further and more specific study.

3.14.4. General behavioural observations

As part of the surveys carried out, several behavioural phenomena were observed, which may, as part of longer term studies provide more information on the ecology of the species. One such observation was that bats were often observed foraging in pairs, especially in the area around the Port Launay roost. Bats were also observed foraging and commuting along roads, usually flying at around 2-7 meters height, below the roadside canopy. In the vicinity of Port Launay and Baie Lazare, bats were seen to forage in a clearing in the forest, and above boulder fields, and at Anse Major, they were seen foraging at the canopy level of trees on the side of a glacis.

An attempt was made to estimate the distances travelled by bats from a known roost, with the effort was limited to visual observations, and recorded times of bat passes heard on the bat detectors. *C. seychellensis* is a fast flyer and it seems plausible for it to commute over relatively long distances. In addition, Mahé is relatively small, and it is plausible that all the bats seen in the course of the study had commuted from the three known roosts. However, it is not unlikely that foraging areas will change as prevailing wind direction changes with the season, and causes insect availability to change. With foraging areas shifting, bats may switch roosts to be more ideally located, and this being the case, it is likely that several roosts remain to be located on Mahé.

3.14.5. Population estimates and roost location

From observations at roosts, emergence counts were possible, with a maximum total of 16 bats being observed at the three roosts. The Baie Lazare roost appeared to be occupied by just one bat, and although emergence counts do not provide an accurate population count, these numbers indicate roost sizes alarmingly smaller than that present on Silhouette.

3.14.6. Roost activity patterns

Observations carried out at the three known roosts revealed interesting preliminary data on behaviour of *C. seychellensis* at the roost, specifically, highlighting the importance of roosts as centres of social activity and as foraging areas just after emergence. Both observations at roosts, and data collected from automatic recording stations at roosts demonstrate that there is near continuous activity at roosts throughout the night. There was a distinct peak of roost occupancy near midnight, as bats returned from early night foraging trips. Emergence times fitted in with arrival times at foraging sites, indicating an early evening peak of foraging activity.

3.14.7. Insect abundance

Despite methodological problems and repeated equipment failure, the study collected preliminary data on the availability of insect prey in areas that were and were not used for foraging. In general, insect numbers were surprisingly low, although comparative data (with other islands, or previous studies) were not available. The most marked finding was that insect numbers, although still low, were much higher in areas that were used for foraging, indicating unsurprisingly that bats were indeed selecting for optimal foraging habitats.

3.14.8. Causes for the population decline

This study has added considerable information to the current understanding of the ecology of *C. seychellensis*. The information on habitat requirements has contributed considerably to proving that population extinctions on Praslin and La Digue were *not* due to loss of suitable habitat. Conversely the strong relationships found between habitat structure and bat distribution and foraging suggest that habitat structure will have sufficient influence to affect the distribution of the remaining populations.

Local information suggests that roost disturbance or destruction may have occurred in several places, including on Praslin. Although such human activity is likely to cause severe stress to the bat population, it does not, in isolation explain the local extinctions that have occurred, as many roosts will have escaped any frequent human attention. However, the finding that roosts and roost vicinities are so vital as locations for both social and foraging behaviour emphasises the importance of effective roost protection, and in addition, the correct management of habitats surrounding the roosts.

Perhaps the most alarming finding of the study was the combined evidence for very low insect abundances, and the literature on historic and current pesticide use on all the main islands. These two parts of the study lead to the conclusion that pesticide use for both agriculture and the tourism industry may have played a fundamental role in changing insect availability throughout the historic range of the bats. It is highly likely that this has contributed massively to the decline and extinction of populations of *C. seychellensis*.

Other factors that have been proposed prior to this study, such as barn owl predation and closure of roost entrances through vegetation growth, did not appear to be significant issues during the course of this study. Although predation is a factor that has not been studied in any detail, and as such, remains an unknown element.

3.14.9. Education and Public Awareness

Due to much effort exerted by the project's team and collaborators, a very successful campaign of education and publicity relating to C. seychellensis and this research expedition was carried out. Utilising a large range of media (TV, radio and tabloids, seminars and scientific and general publications), on a local, regional, national and international level, allowed bat and conservation education and dissemination of results to a wide range of audiences. As a result, the plight of this bat and the work and recommendations of this project has been raised on an international level.

3.14.10. Future work

The main drive was to develop a Species Action Plan from which involved organisations could co-ordinate the future conservation of this species. The Action Plan enclosed in this report (section 4) outlines several proposed conservation and management projects.

Aside from the immediate and vital implementation of the Action Plan, this study has also raised other questions and projects which are planned for the near future. The team are currently in discussions with other ecologists from this field regarding how best the remaining funds could be allocated to maximum conservation effect for this endangered species. It is expected that at some point in the near future, one of more of the original '*Bats on the Brink'* team members will return to the Seychelles to take part in a small follow-up to this project. One of the team members (Sinclair Laing) is already preparing a return to commence a new project and plans are to pool resources relating to accommodation, transport and perhaps manpower in order to spread the remaining funds further.

3.14.10.1. Utilizing New Technologies

A new technology has recently been developed to survey bats involving the playing back of bat social call components through an ultrasonic loudspeaker (Hill & Greenaway, 2005). Such playback calls can attract bats from a wide area. As we were successful in recording social calls of the Seychelles sheath-tailed bat, we hope to trial this method in the near future. Should this technology work, it will prove a powerful survey tool.

Use of a thermal imaging night vision camera would allow detailed behavioural observations to be made within the roost. However, as this is an expensive piece of equipment, there are currently no plans to make use of such technology.

3.14.10.2. Direct Action - Physical Roost Protection

Physical barriers such as walls and grilles have successfully protected cave bat roosts from human disturbance in Britain, notably those of greater and lesser horseshoe bats (*Rhinolophus ferrumequinum* and *R. hipposideros*). Dr Roger Ransome (an expert on the use of such grilles) has agreed to help us explore the possibility of using similar techniques to protect the roosts of the Seychelles sheath-tailed bat.

3.14.11. Summary

This project represents a major addition to the drive to conserve this critically endangered species. New information on habitat requirements and the two-fold value of roosts, highlight those areas that require the most urgent protection. Evidence of the influence of pesticide use on reducing prey availability remains preliminary. However we feel that this area is absolutely vital to both understanding the decline of the species, and in mitigating the current status and allowing the recovery of the species.

The methods developed for this study, and the training of local biologists has laid the groundwork for effective continued monitoring and study of the bat populations. By maintaining reliable methodologies we can ensure that continuous data collection can be compared across all populations and across different survey periods.

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4. Species Action Plan

4.1. Suggested Conservation Strategies for the Seychelles Sheath-tailed Bat (*Coleura seychellensis*)

This Action Plan has been developed on the basis of fieldwork and research carried out by the Aberdeen University Expedition 2004, Nature Seychelles and the Ministry of Environment and Natural Resources Seychelles. The aim of the Action Plan proposes a broad array of management and education goals that will allow protection of the extant populations of *Coleura seychellensis*, and work towards the re-establishment of the species across its former range and the increase of populations. The goals are separated into short and long-term Action Points, respectively aimed at 1-2 year time scales, and continuous or 10+ year projects. The Action Points fall into four categories:

Education, which encompasses programmes aimed at raising public awareness and public responsibility, public dissemination of knowledge and progress, and the active encouragement of youth conservation awareness.

Protection, which includes those measures which are intended to conserve the current *C. seychellensis* population, and which take steps to prevent any detrimental activity.

Mitigation, which involves both ecological and political programmes aimed at encouraging the expansion and growth of the extant *C. seychellensis* populations. These are designed based on our current best knowledge of the species, and will of necessity adapt as our understanding of the species ecology increases.

Research, further research projects are suggested which would further our ability to successfully adapt conservation measures to the requirements of *C. seychellensis*. Other research possibilities of a less applied nature are not considered here, although their value is also high.

4.2. The Action Plan

4.2.1. Education

Short-term Action Points

1. Through public media, to increase awareness of the identity and conservation status of *C. seychellensis* throughout the Seychelles. This has been commenced with considerable success through newspaper, radio and television coverage. A children's book currently under construction will, along with work with school and youth groups, instigate the education of younger members of society, and aims to increase both awareness, and a sense of responsibility towards the native wildlife.

2. Again, using public media, to commence a programme of education aimed at raising awareness of the multiple affects of both public and private pesticide use. As well as emphasising the negative impact of these chemicals on *C. seychellensis* (through a reduction of prey abundance and a possible impact on male fertility) and other native fauna, the drive should also allow people to understand the potential risks to public health and to the wider environment (e.g. coral reef damage from pollutant run-off) via overexposure and contamination of water.

3. To encourage and educate towards the use of more native tree species in garden and ornamental settings.

4.2.2. Protection

Short-term Action Points

4. The immediate need for the protection of the present *C. seychellensis* populations is for the establishment of some form of reserve status around known foraging areas and areas of mature forest. This does not have to take the form of National Parks, but may involve the categorisation of such areas as Species Protection Areas (SPA: as is used in the European Union). This would involve the assurance that certain activities could not take place in those areas, such as wood burning, and felling of trees over 5m tall; and that other activities such as housing development be carried out in accordance with ecologically sensitive guidelines. These could be that no non-native plants are introduced to gardens, that native trees cannot be cut down, or that stands of trees must be planted along roadsides to soften the habitat damage. Use of pesticide chemicals should be banned or strictly controlled throughout an SPA.

5. As has proved useful in the UK, the introduction of legal protection of the bat would allow criminal charges to be brought against anyone proven to *intentionally* or recklessly disturb or harm any *C. seychellensis*, whether in the roost or foraging.

Continuous Action Point

6. The high level protection of all known roost sites is currently requiring revision, as roosts were newly discovered in 2004. Maintaining the confidentiality of roost locations is obviously essential out side of involved conservation bodies. Treatment of all roosts should be open to review by all conservation bodies, both to ensure that disturbance is always kept to a minimum, but also to allow a control of monitoring methods and a synchronisation of data.

4.2.3. Mitigation

Short-term Action Point

7. Immediate constructive results for the Seychelles fauna as a whole, as well as *C. seychellensis* in particular, could be gained by tightening and enforcing the legal control of pesticide use and deforestation. Programmes to encourage the use by businesses (particularly non-agricultural businesses) of alternative methods of pest control should be developed and potentially made compulsory.

Continuous Action Points

8. As research has demonstrated that vegetation structure, as well as the presence of native species, is important to the successful foraging of *C. seychellensis*, a long term programme of forest management should be commenced. This programme should aim to promote the establishment/retention of mature forest canopies with little or no understorey and promote the replacement of non-native tree species with native ones, to the benefit of this bat species.

9. To increase forest cover in areas where urban presence is already high, roadside verges and garden edges could be planted with native trees in the same way, gradually removing any cinnamon, as these trees mature. Research has shown that the species is capable of using residential areas, thus this programme could, with little impact on residents, considerably increase the bats' available foraging habitats.

4.2.4. Research

Short-term Action Point

10. Much further immediate effort is required aimed at locating and recording the locations of all of the remaining roosting sites and foraging areas of *C. seychellensis.*

11. An immediate requirement is the study of nocturnal insect abundance associated with different medium/large tree species. We need to clarify the relative prey richness associated with each tree species to ensure that reforestation programmes are designed to benefit the invertebrate community. This enrichment will obviously be of benefit to a wider array of species, beyond the immediate need to aid *C. seychellensis.*

Continuous Action Points

12. Following on from the shorter term project in Point 10, there is a need to monitor changes in insect abundance over time. This will allow conservationists to follow the effects of reduced use of pesticides, increased forest cover and increased native tree presence. This study will be vital in predicting and validating the success of the long term conservation of *C. seychellensis.*

13. To follow the success of all the above Action Points, it is essential that a long term and well controlled monitoring programme is put into place to study both the roosts of the species and the bats' foraging areas. This programme should encompass the possibility that roosts and foraging areas may change with season, or that new sites may be established as the population increases. This can be achieved in part with the continued use of car bat detector surveys, whereby researchers drive slowly (~30mph) along coastal roads for two hours after dusk and before dawn with a bat detector(s) tuned to 37.5 KHz directed out of a window(s). It is recommended that this be conducted on a monthly basis, endeavouring to cover the entire coastal road system during each survey period. There is also a need to monitor the breeding activity of this bat to provide vital further information into the reproductive health of the population and to monitor changes in bat abundance over time. This can be achieved through a minimum recommendation of a twice yearly roost count, both before and after breeding (thought to occur in November). However, this should be done in such a way as to cause minimal disturbance to roosting bats, e.g. from a safe vantage point, or via the development of improved remote survey methods.

N.B. It is important that all these programmes are collaborative in order to achieve the greatest success, and that with regards to research, all parties maintain standard methods and share findings (according to their Memorandums of Understanding). This is aimed at uniformity of data collected resulting in data that are as reliable and as accurate as is possible and that all the information that is obtained is available to all to the benefit of future assessments.

Appendices

Appendix A

Standard methods recommended for the long-term monitoring of the Seychelles Sheath-tailed bat, Coleura seychellensis

General guidelines

Take a note of the weather at the start of each observation; devise a scale (e.g. rain 1= no rain, rain 2= drizzle, rain 3= rain) and keep this as standard. During observations, note down any change in weather (if it doesn't change, don't need to note down anything).

Transects

Survey by car, driving slowly (30 km/h), bat detector out on both sides of vehicle, tuned to 37.5 kHz frequency

- note down exact location and time of bat contact
- note whether bat is foraging or commuting; if searching for roost, direction of bat flight is also important when piecing together time-maps
- when making these observations, the car can be stopped and bats watched for a couple of minutes from the road

Survey by foot, allocating 1 km or longer transects to cover areas where a bat contact was had; preferably the following night from contact, and at the same time.

- walk slowly, at 30 min/km
- don't stop when contact occurs
- note down all visual observations, in particular number of bats, flight direction and/or patterns, how high the bat is flying, whether it follows the road etc.
- note activity: feeding/foraging

Foraging

On a known foraging site, select appropriate time and duration for observation, for example 2 hours between 18:30-20:30 or 04:00-06:00, and keep this time as standard.

- note down time (when a call starts), start the stop-watch, count and note down number of feeding buzzes
- when the call stops, stop the stopwatch and note down the duration in seconds
- each call duration should be noted down with maximum accuracy; thus valuable data on feeding rates in different areas can be acquired
- when >1 observers, it is good to have one person making visual observations on behaviour i.e. flight pattern, direction and height

Emergence and population size estimation

Position observers in a suitable place close to roost exit taking care not to obstruct the bats' flight path. Where several exits are known, place an observer next to each exit whenever possible.

- be in position by 18:25; note down any social calls, time and other bat activity heard from within the roost
- note down exact time of emergence, bat number and direction of flight
- bats often go in and out of roost a few times before leaving for the nights' foraging, therefore stay in place until activity ceases or becomes less frequent (at least until 19:15)
- if counting bats inside the roost is deemed necessary, this should be conducted in absolute silence and at around 18:00 when bats are already active within the roost. If bats become distressed, this exercise should be halted immediately.

Roost searches

From information gathered from transect data, plot the distribution and earliest time of bat contacts on a map (evening: 18.30-18.45, morning: 05.50-06.10). Position as many people as possible, each with a bat detector, in the vicinity of the suspected roost area using the earliest point of bat contact as a guideline. Ensure the following observations are noted:

- Weather
- Time of first contact
- Direction and height
- Number of individuals

Using this information, reposition people around the first point of contact for the next morning's or evening's roost search. Continue with this method until nearing the time that bats emerge or return to the roost. To aid the roost search, a map of the area could be drawn up, noting the earliest times of contact and direction of flight. This may give a better idea as to where the roost is positioned. Indications of a roost locality include a high number of individuals, high rate of activity, and social calls. Daytime searches can also be conducted to locate potential roost sites i.e. in boulder fields.

Appendix B

Sample field data collection sheet for bat detector transects.

This sample data collection sheet is only to be used as an example. The details contained within are fictitious and aim to provide a guide to future users of such methods of data collection. Refer to other sections within this report (e.g. Appendix A, *Standard Methods*) for further details on sampling and data collection relating to *C. seychellensis*.

General

Organisation: *Aberdeen University* Project: *Bats on the Brink*

Names of observers: *Sinclair Laing, Louise Craig & Lorraine Marshall-Ball*

Date (dd/mm/yyyy): *1 3* / *0 6* / *2 0 0 4*

Time start (hh:mm): *1 8* : *3 0* Time finish (hh:mm): *1 9* : *3 0*

Location (island, region & road/trail): *Mahé, Bel Ombre, Anse Major trail*

Transect code: *AM1* Transect length: *2km (2000m)*

GPS Co-ord's start: *04º 34' 9S / 055º 22' 51E* Finish: *04º 34' 9S / 055º 22' 51E*
(Only if GPS is available)

Climate (circle the appropriate number):

Rain: (1) 2 3 Cloud: 1 2 (3) Wind: 1 (2) 3 Direction: N E S (W) Moon: 1 2 (3)

Habitat (details of the locale, e.g. glacis, road, forest trail and major plant structures and species that occur):

Mostly a glacis trail, starts along road with few houses and predominantly small ornamental garden plants and fruit trees. Moving into forest trail with Cinnamon and Agati dominating and little understorey. Average tree height approx 7m.
Moves into a mostly open glacis trail with few large trees. Mostly native palms (~2-4m tall), Euphobia, Vanilla, few Cinnamon trees.

Bat activity (details of bat activity along the transect, e.g. points bats heard and type of activity. If possible include details of bat numbers, heights and direction of flight):

In forest area of trail, ~600m from start and near last house on trail. 2 bats seen flying under canopy along trail, 4m above ground. Also heard foraging.

Glacis area, ~1km from start. 1 bat heard commuting.

Notes (details of anything interesting or unusual encountered, i.e. regarding climate, habitat or bat activity):

Glacis location open to the elements and much windier.

Insect abundance visibly higher in forest trail than on glacis.

Appendix C

Video Monitoring Equipment

Components of the system

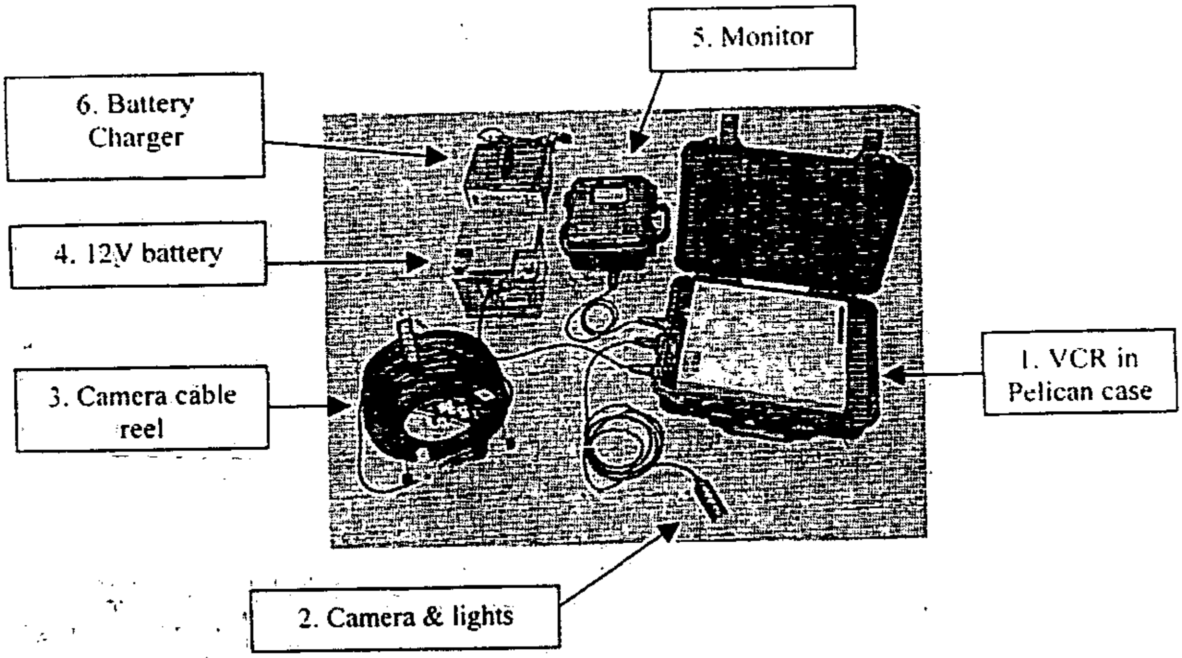

Figure AC1: Components of the video monitoring systems supplied by NS and MENR for use with remote monitoring of *C. seychellensis* roosts. Due to the limitations of the system for this purpose and the irregularity with which it is possible to obtain adequate supplies within the Seychelles, this system proved to be of little practical use for this project. However, the development of a similar, but appropriate system would be of great benefit in future monitoring projects.

---

1. Videocassette Recorder (VCR) in Pelican Case: Panasonic VHS time-lapse in 1500 size Pelican case.
2. Camera: Bullet type camera, infrared LED's in a waterproof enclosure, plus cable.
3. Cable reel: 100m 2-core coaxial cable with waterproof Amphenol connectors.
4. 12V Dryfit^{TM}, 36Ah battery with cable and connector.
5. Video Monitor: BW door monitor (with optional 2 internal batteries) and video cable and connector.
6. Battery charger: Electro products 12V, 10 amp battery charger.

Supplier

Predator Monitoring Systems
Model SRU-30
Electronics Laboratory
Science & Research Unit
Science Technology & Information Services
Department of Conservation
PO Box 10-420, Wellington, New Zealand
E: mdouglas@doc.govt.nz
E: scockburn@doc.govt.nz

Appendix D

A Computer Downloadable System to Monitor Bat Activity.

N C Downs and P A Racey
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Abstract

We describe a system for automatically recording the activity of echolocating bats which produces computer downloadable data. When several of these systems are deployed simultaneously, comparable estimates of bat activity can be obtained and habitat preferences established.

Introduction

The relatively recent development of reliable bat detectors has facilitated the automatic recording of bat activity (Hayes & Hounihan, 1994; Sedgeley and O'Donnell, 1994). Bat detectors, voice activated tape recorders and speaking clocks, similar to those used by Sedgeley and O'Donnell (1994), have been used in Aberdeen with some success, allowing the recording of both the number of bat passes and feeding buzzes. However, the tape often ran out at sites with sustained bat activity, the output of the bat detector during light wind triggered the tape recorder, and the time required to transcribe the tapes was a major drawback. This prompted the development of a new system which coupled a bat detector to a computer downloadable logger through an ac/dc convertor as follows;

The System

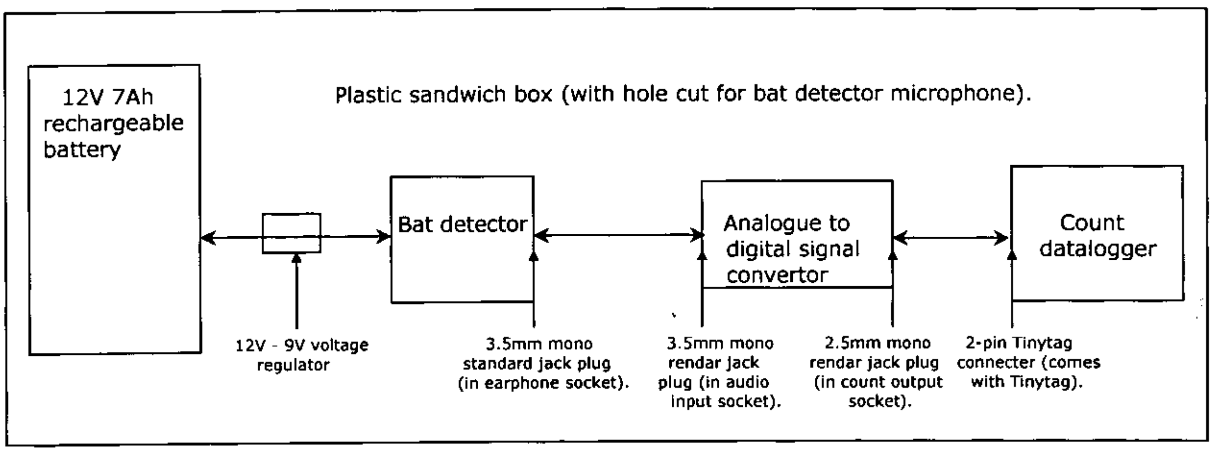


Figure AD1: Components of the computer downloadable systems supplied by Aberdeen University for the monitoring of bat activity levels and patterns. This system was deemed to be of little use outside roost in the Seychelles due to interference from external stimuli (such as crickets). It was also limited by the availability and reliability of essential system components (such as batteries).

Battery (Approx cost £21)

A 12V 7Ah rechargeable battery was used to power the bat detector. It can provide constant power for approximately 14 nights, and is therefore preferable to the small 9V batteries for which the Batbox 111 is designed. These 9V batteries have an effective lifespan of only about 10 hours, and the power they provide decreases throughout this time. However, in order to facilitate the use of a rechargeable battery a 12V-9V voltage regulator must be provided. This was constructed in the electronics workshop at Aberdeen University, based on the circuit diagram shown in appendix 1.

Batbox III Bat Detector (Approx cost £124)

This detector is a relatively cheap and effective model that possesses both tunable bandwidth and volume controls.

Skye Analogue-digital Signal Convertor (Approx cost £97)

This device converts the analogue signals from the bat detector into digital signals which can be recorded by the datalogger. Every half second a positive or negative signal is sent to the datalogger, indicating the presence or absence of ultrasound respectively. This device also has a threshold dial, which can be used to filter out background ultrasound such as that produced by a light wind.

Gemini Tingtag Count Datalogger (Approx cost £130)

This datalogger can only be programmed by Orion Tiny Logger Manager (OTLM) computer software, and can record at a wide range of time intervals from every second to every 10 days. The loggers have a capacity of 7900 readings. In our fieldstudies dataloggers are set to record every minute. This means that every minute the datalogger sums up how many positive half-second signals it has received from the signal convertor.

Connections

Non-standard jack plugs are required for some connections (Fig. AD1).

Operation

This system allows us to record at sites where there is a lot of bat activity. It also provides data that is immediately available (Fig. AD2), and is less sensitive to extraneous ultrasound than the previous arrangement. When several such systems are deployed on the same night comparable estimates of bat activity can be obtained with great efficiency, allowing bat habitat preference to be determined.

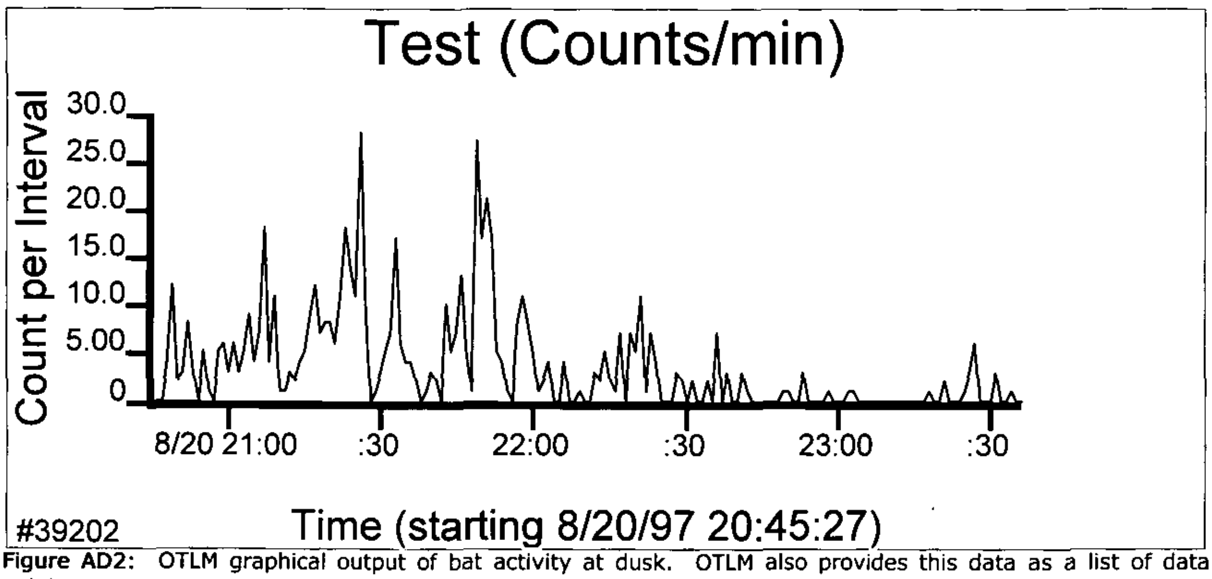
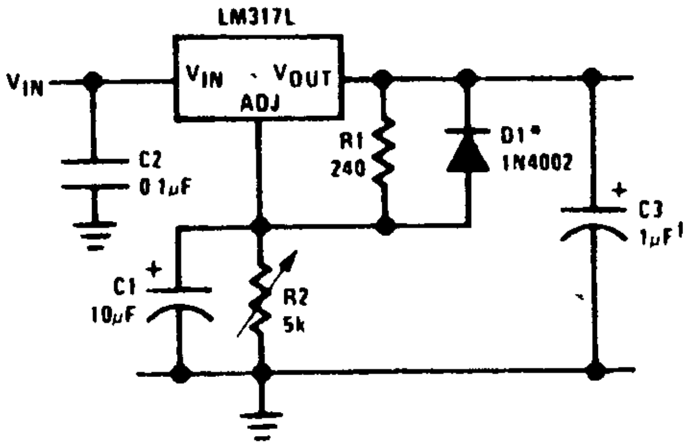


Figure AD2: OTLM graphical output of bat activity at dusk. OTLM also provides this data as a list of data points.

There is some variability in the operation of the bat detectors and signal converters. In order to minimise this, the volume control on the bat detector, and the threshold dial on the signal converter were adjusted to the lowest possible settings that detected the sounds of fingers being rubbed together directly in front of the bat detector microphone.

Supplimentals

Supplemental a) Adjustable voltage regulator with improved ripple rejection (12V - 9V convertor) (National Semiconductor Corporation part LM 317).



Supplemental b) Equipment suppliers

Battery **Bat count unit (analogue to digital signal convertor)**
597 - 835 12V 7Ah SBR 1260

RS Components Skye instruments limited
P.O. Box 99 Unit 32
Corby Ddole Industrial Estate
Northants Llandrindod Wells
NN17 9RS Powys
Tel: (01536) 201201 LD1 6DF
Fax: (01536) 201501 Tel:(01597) 824811
Fax: (01597) 824812
E-mail: skyemail@skyeinstruments.com

Tinytag count logger and OTLM software
313 - 266 IP68 count

For orders under £500 :- For orders £500 or over:-
Alana Ecology Ltd Gemini data loggers (UK) Ltd
Rock Cottage Scientific House
Sarn Terminus Road
Newtown Chichester
Powys West Sussex
SY16 4HH PO19 2UJ
Tel/fax: 01686 670643 Tel: 01243 783210
E-mail: alana@dial.pipex.com Fax: 01243 531948

Batbox III
Stag electronics
4 Esprit Court
New Road
Shoreham-by-sea
West Sussex
BN43 6RB
Tel (07000) 228269

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Sedgeley, J. & O'Donnell, C. (1994) *An automatic monitoring system for recording bat activity*. Department of Conservation, Wellington, New Zealand.

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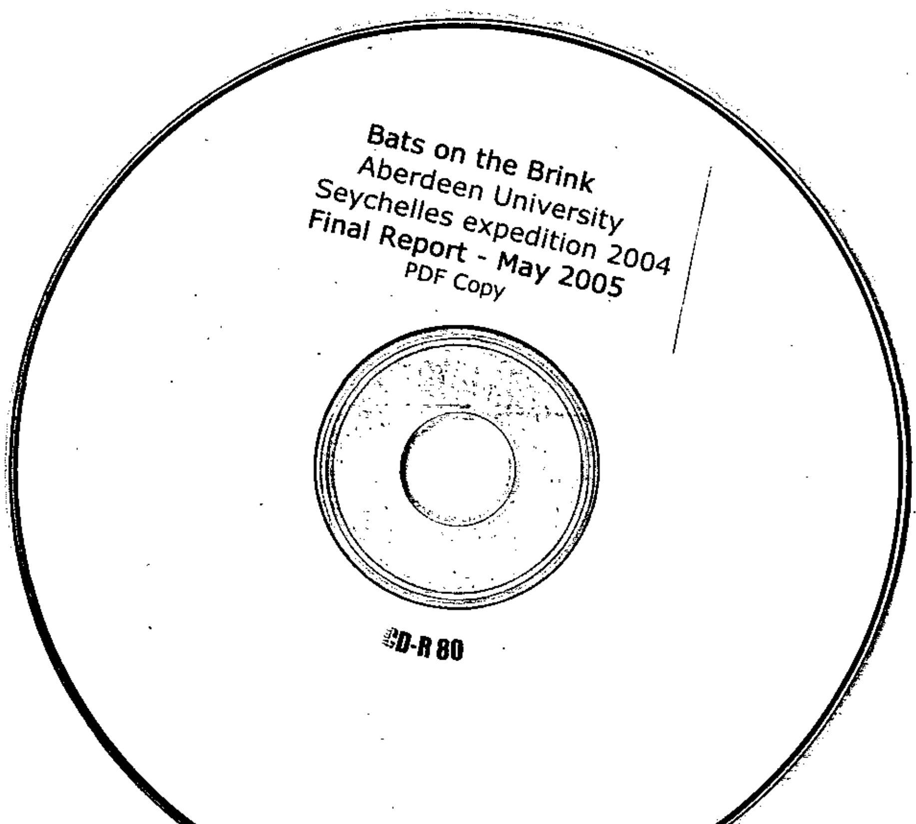
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