MAINSTREAMING PREVENTION AND CONTROL MEASURES FOR INVASIVE ALIEN SPECIES INTO TRADE, TRANSPORT AND TRAVEL ACROSS THE PRODUCTION LANDSCAPE

REVIEW AND EVALUATION OF INVASIVE ALIEN SPECIES (IAS) CONTROL AND ERADICATION ACTIVITIES IN SEYCHELLES AND DEVELOPMENT OF A FIELD GUIDE ON IAS MANAGEMENT

REVIEW OF IAS CONTROL AND ERADICATION PROGRAMMES IN SEYCHELLES



Prepared by the Plant Conservation Action group

With contributions from the Island Conservation Society on control and eradication programmes carried out under the ICS-FFEM Restoration of Island Ecosystems programme - provided by Gerard Rocamora

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ANNEXES

ACRONYMS and ABBREVIATIONS

BAT	Bait Application Technique
BHC (gamma)	An organochlorine pesticide
BSU	Black-Spined sea Urchin
CABI	CAB International, and organisation researching agricultural and environmental issues
CEPA	Confederation of European Pest control Associations
CIRAD	Coopération Internationale en Recherche Agronomique pour le Développement
CORDIO	Coastal Oceans Research and Development in the Indian Ocean
COT	Crown Of Thorns starfish
DoE	Department of Environment
DPGS	Differential Global Positioning System
DRC1339	3-chloro-4 methyl benzenamine hydrochloride
EPPO	European Plant Protection Organisation
ETF	Environment Trust Fund (Seychelles)
ETH	Swiss Federal Institute of Technology, Zurich
FFEM	Fonds Français pour l'Environnement Mondial
GEF	Global Environment Facility
GIS	Global Information System
GISP	Global Invasive Species Programme
GOS	Government of Seychelles
IAS	Invasive Alien Species
IAEA	International Atomic Energy Agency
ICBP	International Council for Bird Preservation - now Bird Life International
ICS	Island Conservation Society
ICS-FFEM	Joint programme for rehabilitation of island ecosystems in Seychelles 2005-2009
IDC	Islands Development Company
INDUFOR	A Finnish company dealing with international forest management
IPM	Integrated Pest Management
ISSG	Invasive Species Specialist Group
IUCN	International Union for the Conservation of Nature
LD_{50}	The dose required to kill 50% of a pest population
MAT	Male Annihilation Technique
MENR	Ministry of Environment and Natural Resources
MENRT	Ministry of Environment, Natural Resources and Transport
NGO	Non-Governmental Organisation
NI	North Island
NZ	New Zealand
ORSTOM	The old name for IRD (Institut de Recherche pour le Développement)
PCA	Plant Conservation Action group
PIER	Pacific Islands Ecosystems at Risk database
PVC	PolyVinyl Chloride
RWB	Red-Whiskered Bulbul
SAA	Seychelles Agricultural Agency
SCMRT-MPA	Seychelles Centre for Marine Research and Technology - Marine Parks Authority
SIF	Seychelles Islands Foundation
SNPA	Seychelles National Parks Authority
SR	Seychelles Rupee
SWE	Seychelles White-Eye
UAE	United Arab Emirates
UNDP	United Nations Development Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
WWF	World Wildlife Fund / World Wide Fund for Nature

EXECUTIVE SUMMARY

In Seychelles in the past, many attempts have been made to control and/or eradicate a range of Invasive Alien Species (IAS) that have entered the country. Originally these were species that were creating problems for economically important activities such as agriculture, including coconut production. Occasionally the species that were a problem were actually native species rather than IAS, but due to human-induced changes in their habitat, the effects of the spread of the species were similar to the spread of an IAS, e.g. the native Melittomma beetle in coconut plantations.

More recently, management efforts have expanded to include IAS threatening native biodiversity, e.g. rats and cats on small islands, invasive plants in upland forests. In some cases, management programmes have included restoration to a more natural state and the reintroduction of threatened endemic species such as rare birds and plants.

As a result, for the purposes of this review, a broad view of what constitutes an invasive species has been taken: from native species that have ‘run amok’ in an economically important situation, to alien species that are negatively impacting agricultural crops, to alien species that are spreading naturally in natural or semi-natural habitats.

The overall objective of this report has been to compile and review all available documentation on past and current field management activities for IAS in Seychelles, including an evaluation of their effectiveness and efficiency. The aim has been to make data available to managers, to identify some best practices for the management of IAS in Seychelles, and to contribute to further awareness and education about IAS.

However, the production of the report was not easy because many control and eradication programmes in Seychelles have been poorly recorded, with no quantitative data or systematic follow up. Reports often proved difficult to locate and/or access. Recent reports have been more useful as they include more detail but in general there has been little quantitative information available, particularly financial details that would enable evaluation of efficacy. So it has proven difficult to fully evaluate IAS management programmes in Seychelles.

In this report, species have been grouped (e.g. mammals, creepers) and for each species described there is information about the biology and ecology of the species, its origins and presence in Seychelles, control programmes that were carried out and their results. Where possible, an assessment of the success of the programme and the methodologies is given. References are provided. Although invasive plants and animals, and agricultural pests are treated separately in the document, the reality is not always so clear cut because many agricultural pests also affect organisms in natural ecosystems.

There are basically four ways of dealing with invasive (usually alien) species that are already established:

- Eradication (total elimination of the whole population - the most final method, but often the most costly).
- Containment (restrict the spread of the species into other areas - only of value when the IAS population is very small or restricted to a limited area).
- Control (long-term reduction of the numbers and density of the species to an acceptable level - through mechanical, chemical, biological methods or an integration of more than one method).
- Mitigation (acceptance of the presence of the IAS + protection of affected native species).

Control has been the main method used for dealing with IAS in the Seychelles, with varying degrees of success, but eradication programmes have been increasingly successful for certain IAS.

Good practice for IAS management requires that certain basic strategies are followed:

- Early reaction to a new IAS invasion.
- Preliminary studies to determine IAS population size and distribution in the area of infestation.
- A full feasibility study for a potential containment, eradication or control programme, including preliminary testing of techniques; assessment of risks to non-target species; cost-benefit analysis; identification of project partners, capacity needs and sources of funding; awareness programme requirements; and assessment of the need for follow up protocols to prevent reinvasion.
- Systematic methodologies and monitoring throughout the programme.
- Once containment / eradication / control of the IAS is assessed as feasible, then all procedures should be followed as outlined above.
- If, during the initial feasibility study, the IAS appears impossible to eradicate or control, then mitigation should be considered as an alternative strategy.

The programmes which have been most successful in Seychelles have mostly had a strategy in place similar to that outlined above. They have included not only quantitative assessment of populations, testing of techniques on both target and non-target species and full monitoring during and after the programme, but also achieved systematic application of the technique(s). Examples include recent rat eradication programmes on several small islands. Another factor which has been very important for success is ensuring that funding is sufficient for both the management programme and any required follow up. Sometimes less sophisticated programmes have also been successful, at least for keeping certain IAS under control, perhaps because they are simple and effective (e.g. House Sparrow, Indian House Crow). Occasionally success has been more through good fortune than through application of correct strategies! For example the early biological control of scale insects, and the eradication of cats on certain small islands.

However, in the past in Seychelles, suitable strategies for IAS management have not always been followed, for a variety of reasons, and control and eradication programmes failed to achieve the desired results. The reasons are many. For example, reaction to a newly arrived IAS may have been delayed so that management became less likely to succeed (e.g. Spiralling Whitefly, *Clidemia hirta /* 'Fo watouk'). Some programmes were *ad hoc* reactions to what was suddenly perceived as a crisis and therefore failed through lack of proper planning, e.g. many earlier agricultural pest programmes. Early chemical and biological control programmes were simply experiments without prior studies, without controls and with no studies of the effects on non-target species. Sometimes there was no apparent harm done, but very little is known about the possible side effects of such programmes. At times there were seriously harmful effects on non-target species, e.g. in the well-known case of the introduction of the Barn Owl, which soon discovered that the white Fairy Tern was easier prey than the Black Rat.

In other cases failure was due to lack of sufficient funds, lack (or loss) of capacity, logistical problems, or lack of follow up monitoring and/or protocols to prevent re-invasion of the pest species. Financing and well-trained personnel for strategic IAS control programmes have been a continuous problem in this small country, and remain so, although a trend towards government / NGO / private sector partnerships for management programmes seems to be helping to counteract this, e.g. programmes carried out under the recent ICS-FFEM 'Rehabilitation of Island Ecosystems' project. There also remain a few legal and other impediments, such as the continued presence of known invasive species on the outdated protected species list (e.g. Bwa Zonn / *Alstonia*), but hopefully these will be alleviated before long.

Recommendations of the report include ensuring that all future IAS management programmes in Seychelles follow a suitable management strategy as outlined above; devising a system for prioritising invasive species management, whether this is done at a national level or at an organisational / management level; reconsidering the possibility of biological control for certain agricultural species (e.g. Spiralling Whitefly); using Integrated Pest Management (IPM) where possible; encouraging public / private cooperation for IAS management; raising awareness about IAS in general so that people are sensitised to the risks and dangers once IAS become established in the country; and also remembering that climate change may bring further unknown risks with respect to IAS.

A follow-up activity for this consultancy, according to the Terms of Reference, is the production of a Field Guide to best practices for IAS management in Seychelles. Results from a questionnaire prepared as part of this report and discussions during a follow-up workshop helped to identify the type of information essential for the guide and what format it could best take. However, it became increasingly obvious during these discussions that such a field guide to best practices requires considerable further research because best practices cannot currently be given for many of the IAS in Seychelles due to lack of information on the efficacy of techniques and methodologies. Additionally, management practices used elsewhere would require testing and adapting to the specific conditions and situations within Seychelles before being included in a field guide, whether in printed or database format. It is therefore proposed by PCA that a smaller, more general, guide to overall best practices for IAS management would be more appropriate at this time.

Finally, within the GEF project, funds are available to develop a national database on IAS which should include the most effective control practices for the Seychelles. By creating a database, the results of this review will not be static and new information can be uploaded when it becomes available.

INTRODUCTION

Background

In Seychelles in the past, many attempts have been made to control and/or eradicate a range of Invasive Alien Species (IAS) that have entered the country. Originally these were species that were creating problems for economically important activities such as agriculture, including coconut production. Sometimes the species that were a problem were actually native species rather than IAS, but due to human-induced changes in their habitat, the effects of the spread of the species were similar to the spread of an IAS, e.g. the native Melittomma beetle in coconut plantations.

More recently efforts have expanded to include IAS threatening native biodiversity. Some programmes have centred on the eradication of species such as rats and cats from small islands, or the removal of invasive plants in order to restore the ecosystem to a more natural state. In several cases this has allowed for the reintroduction of threatened endemic species such as rare birds and plants.

As a result, for the purposes of this review, which is dealing with management of invasive species, a broad view of what constitutes an invasive species has been taken, from native species that have 'run amok' in an economically important situation, to alien species that are negatively impacting agricultural crops, to alien species that are spreading naturally in natural or semi-natural habitats, thereby producing significant changes in species composition, structure or ecosystem processes (the latter adapted from Cronk & Fuller 1995).

The overall objective of this report has been to compile and review all available documentation on past and current field management activities for IAS in Seychelles, including an evaluation of their effectiveness and efficiency. The aim is to make data available to managers, to identify some best practices for the management of IAS in Seychelles, and to contribute to further awareness and education about IAS.

IAS Management Strategies

There are basically four ways of dealing with invasive (usually alien) species that are already established:

- Eradication (total elimination of the whole population)
- Containment (restrict the spread of the species into other areas)
- Control (long-term reduction of the numbers and density of the species to an acceptable level)
- Mitigation (acceptance of the presence of the species + protection of affected native species)

Eradication is the most final, but often the most costly, so if unsuccessful, a major investment of resources may be wasted. It should only be carried out with proper planning: a feasibility study which includes IAS population estimates, analysis and testing of alternative methods, cost/benefit analysis, possible impacts on native species (which can be both negative and positive), follow-up monitoring, and protocols in place to prevent re-introduction. The methods used depend not only on the species but also on the level of invasion and are often situation-specific. In Seychelles, most such programmes have related to invasive mammals, particularly cats and rats on small islands.

Containment can only be used when the IAS population is already restricted to one or very few areas, which often means the species is a relatively new arrival. If appropriate measures are taken, the spread of such species can be limited. In Seychelles, examples are the invasive weed *Clidemia* (Fo watouk) which for some years was restricted to Silhouette, and Coconut Whitefly which first appeared on Mahé, although in both cases containment was not entirely successful.

Control can be through mechanical (physical), chemical and/or biological means, sometimes also combined with habitat management:

- Mechanical control can include manual removal and cutting (which is labour intensive), machine removal or clearance, and the use of traps and shooting.
- Chemical control normally requires the use of poisonous substances (e.g. pesticides, herbicides). These are often expensive, require trained personnel and special equipment for safe use, and in addition pests may develop genetic resistance to them. Non-poisonous chemicals include pheromones (chemical attractants) which lead the pest to killing traps.
- Biological control is the use of another organism to control the pest (e.g. a predator, parasite or disease of the pest). Alternatively it may involve the release of human-altered members of the pest species (e.g. sterile males) which mate with normal members of the population, leading to lowered numbers of offspring.
- Integrated pest management (IPM) takes a more holistic approach and uses a combination of different IAS control methods. This approach is now advocated as being more successful.

Control has been the main method used for dealing with IAS in the Seychelles, with varying degrees of success. In the early years of control of agricultural pests, various chemicals were used which are no longer considered safe to humans or to the environment (e.g. persistent organochlorine pesticides). Biological control was sometimes applied without the necessary preliminary precautionary studies, occasionally resulting in negative environmental effects (e.g. control of rats by means of introduced Barn owls which subsequently found native Fairy terns easier prey). However, in many cases, appropriate control methods led to reduced populations of IAS. Nevertheless, funding and long-term commitment were frequently required, so even apparently successful programmes may have been abandoned due to the expense and necessity for dedicated labour.

Mitigation does not affect the IAS itself; rather it concentrates on native species which are affected by the presence of the alien species. For example, the negative impact of Black rats on the eggs and chicks of the Black parrot on Praslin can be mitigated by building semi-artificial rat-proof nest sites. Sometimes however, mitigation can be a very expensive measure, as conservation of threatened endangered species can be complex and require translocation to other areas. This option has been successfully used for a number of endangered birds in Seychelles. Details of such mitigation programmes are not the subject of this report. However, where mitigation measures for native species have been used during an IAS control programme, information is recorded here.

Further information about IAS management strategies will be included in a guide to IAS management practices, which is planned as a second output for this consultancy.

<u>Producing the report</u>

To carry out this assignment, it was necessary to collect and collate all available documentation on past and current IAS field control and eradication programmes in Seychelles, and to attempt to evaluate these.

Unfortunately many control and eradication programmes in Seychelles have been poorly recorded, with very limited information being given in reports. Past government records and reports tend to be rather general, lacking details of the measures taken and/or the full results of field trials. Some records are difficult to locate and reports from private islands are sometimes completely lacking or unavailable for perusal, so there are some gaps in the information provided in this report. By far the best records are within published papers, frequently but not exclusively prepared or led by international consultants and collaborators who came to Seychelles specifically to assist with an IAS when it became a significant problem in the country, or who have been working for a particular organisation, government or NGO. Recent reports have been more useful because they include more details but one wonders whether in the future, these too could be lost.

In many IAS control programmes (particularly but not exclusively earlier ones) it is obvious that there was no quantitative or systematic follow up, so it is difficult to assess the effectiveness of the programme. If the IAS population was reduced, people were satisfied and no other follow up was considered necessary. It is therefore assumed that if there is no further record of the IAS being a significant problem, then the programme was at least partially successful, but this is hardly a satisfactory situation as there is no knowledge as to the size of remaining populations. Likewise with biological control, there may not be any indication of whether the control organism still survives and in what numbers, or whether it possibly had a negative effect on any other species that it was not intended to control, e.g. native species.

However, there are also situations where an eradication programme has been carried out on a small island of less than 80ha, and where although no quantitative follow-up took place, the absence of any signs of the eradicated animal in the next year has been sufficient to assume success of the programme simply because on a small island the presence of a large IAS would be very obvious within a few months. Notably of course this has been so for larger organisms such as cats, rats and Indian myna.

A number of recent eradication and control programmes have been conducted as part of the ICS-FFEM 'Rehabilitation of Island Ecsosytems' four-year project. For these programmes, the information in this report is contributed by the Island Conservation Society (see box on page **8**).

Financial details are almost invariably absent or extremely limited in reports, so it has been difficult to assess the effectiveness and efficiency of control programmes. In the report by Mwebaze et al (2009), which forms a separate activity of this GOS-UNDP-GEF IAS Project, the authors indicate that almost $US 7 million per year is spent on the control of just 6 major species or species groups of IAS in Seychelles, and the total economic impact of these same species is some $US 31 million per year. In other words, once an invasive species is in the country, control programmes do not come cheap! Where costs are available for a control programme, they are included in this report.

In order to determine which species are currently considered by stakeholders to be a problem, and to check for the availability of further IAS control programme information, a questionnaire was devised, the feedback from which has been useful in writing the report. But overall it has been very difficult to fully evaluate the control programmes which have been carried out in Seychelles because of the reasons outlined above. Therefore in the report, where possible for individual species or species groups, suggestions are made as to lessons learnt, along with limited conclusions about best management practices. General conclusions and recommendations are given in the final section of the report.

The structure of the report

In this report we have included only species that have been controlled to some significant extent in Seychelles. This also includes species which are not in the IAS Baseline report (Nevill 2009), having been assessed as native species or otherwise considered not to be IAS, e.g. Bracken fern, Rhinoceros beetle. As mentioned above, in the past such species may have been considered as pests because of their negative impact on an economic activity. In some cases the control programmes for such species provide useful information, records of methods and lessons that could be of value in the future.

Some species which are in Nevill's 2009 IAS Baseline report are not included here simply because there have been no recorded attempts to control them in the field. This does not preclude such species from being included in a field guide of best IAS management practices which will be produced as a subsequent output of the overall GEF-IAS project.

Species have been grouped (e.g. mammals, creepers) and for each species described there is information about the biology and ecology of the species, its origins and presence in Seychelles, control programmes that were carried out and their results. Where possible, an assessment of the success of the programme and the methods used is given. References are provided at the end of the information for each species, genus or group, as appropriate. Since the IAS Baseline report (Nevill 2009) already includes information about IAS, e.g. threats of each species to native flora and fauna, and more details about their distribution within Seychelles, such details are not included in this report.

At the end of the report are some broad conclusions, and recommendations for the future.

Annexes include the results and an analysis of the Questionnaire responses from stakeholders.

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The ICS - FFEM Programme 'Rehabilitation of Island Ecosystems' 2005-2009

This project has made a significant contribution in the fight against invasives in recent years by conducting a dozen eradication or control operations of alien animals, habitat restoration in various islands, and the conservation introduction of several rare and threatened animals. Lead by the Island Conservation Society (ICS), it was conducted in partnership with a variety of private owners, NGOs and governmental partners, with a 30% co-funding provided by Fonds Français pour l'Environnement Mondial (FFEM).

Achievements include the eradication of rats on 5 islands out of the 9 successful island eradication attempts conducted in Seychelles, totalling c.450ha and an increase of almost 50% in the rat free area of the granitic islands. In each island, abatement measures to minimise risks of reinvasions have been designed and implemented. Rats have been eradicated from North Island, Conception Island, Anonyme Island and Ile aux Rats in the granitics; Grande Ile, Grand Polyte and Petit Polyte (Cosmolédo atoll) in the outer islands; and they are permanently controlled in the two main breeding areas of the endangered Seychelles White-eye on Mahé (President of UAE properties). Barn Owls have also been eradicated from North Island, efficient control programmes for Barn Owls and Mynas are operational on Aride and North respectively, and the control of cats was started on Grande Ile. A total of c.45ha of habitat were partially or fully rehabilitated, including almost 40ha done by North Island under the guidance of the Plant Conservation Action group, plus some smaller areas on Conception, Anonyme and Grand Polyte. The islands restored now host transferred populations of threatened endemics (Seychelles White-eye, Black mud terrapin, Leaf insect), seabird species are starting to recolonise them, and additional (re)introductions are envisaged.

The sections of the report referring to achievements conducted under the FFEM project have been contributed by ICS, except for the Myna text which was written by PCA with inputs from ICS and North Island.

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Personnel of the Conservation and Forestry Sections in the Division of Environment were very helpful in locating documents and records, particularly Ronley (aka Rodney) Fanchette, Majela Athanase, Sheila Ah Thong and Basil Esther. Will Dogley from the Seychelles Agricultural Agency provided both documents and a considerable amount of additional information about agricultural pests. Dr David Rowat of the Marine Conservation Society of Seychelles gave valuable information on marine organisms. Rainer von Brandis was particularly helpful in providing information about the goat eradication on Aldabra Atoll. Several individuals working within other organisations and overseas were able to support the information in this report by providing personal and/or verbal accounts of control programmes or specific answers to questions where clarification was required. To these people, who are acknowledged in the text, a special thanks.

We would also like to thank those organisations and individuals who answered the questionnaire which was circulated by PCA as part of the search for information on IAS control programmes (see Annex 1 and 2). Stakeholder views about the IAS which are of concern in the Seychelles context were important in validating our assessment of IAS for inclusion in this report and for formulating the objectives of the subsequent IAS workshop.

Participants at the half-day workshop held on 29th September 2009 also played a role in providing feedback on drafts of this report and in generating very useful discussions about the potential for developing a field guide to best IAS management practices in Seychelles. This discussion helped us to formulate the concept of an alternative smaller IAS management guide as an interim output. Names of participants can be found in Annex 3.

Our thanks go also to the UNDP Project Coordination Unit, especially Jan Rijpma and Brad Auer, for their support and advice. The international consultant Dr Charlotte Causton gave very helpful comments and suggestions for the report and required that we consider more seriously how Seychelles can improve IAS management programmes to bring them up to international standards. Her considerable efforts on our behalf to provide relevant information on IAS control programmes in other parts of the world, will prove valuable in the production of a field guide to best IAS management practices and also towards a possible system for prioritising management actions on IAS. Our sincere thanks.

1. INVASIVE MAMMALS

Seychelles has only two types of native mammal - fruit bats and insectivorous bats. Rats (*Rattus rattus*, the Black Rat) were probably the earliest invaders, arriving on ships during earlier centuries. A number of mammals were introduced after human settlement of the islands, including domestic and agricultural animals such as cats, dogs, goats, cattle, horses, rabbits, etc., a few of which became feral, particularly on smaller islands and outer islands that were more or less abandoned following previous economic exploitation. A few outer islands also have feral pigs. Aldabra Atoll is the only island where goats became truly feral.

One unusual introduction was a mammal from the Western Indian Ocean, the Tenrec/Tang (*Tenrec ecaudatus*), which originates from Madagascar and was introduced as an additional protein food source via Réunion in about 1880. Most introduced mammals in Seychelles are not considered as alien invasives (the main exception being the Rat) unless they become a problem for land owners. Most mammal control and eradication programmes have therefore been on small islands where rats and cats were affecting important seabird nesting colonies or endangered endemic bird populations or, more recently, where ecosystem rehabilitation programmes are being carried out.

Feral cat (*Felis catus*) / Sat maron

Biology and ecology

- Domesticated in Egypt about 4,000 years ago. Translocated by humans to almost all parts of the world as pets and rat-catchers.
- Feral cats tend to be small animals, up to 5 kg, but more commonly 1.5-3.0 kg, while domestic cats are usually larger. Colour is variable in domesticated varieties, but feral cats typically revert to black, tabby or tortoiseshell with varying amounts of white.
- Predatory by nature, they can easily become feral and hunt for themselves, feeding on birds, reptiles, small mammals and invertebrates. They are especially destructive on islands where native wildlife evolved in relative isolation from predators.
- Mean home ranges have been estimated at 2.5 km^2 (ranging from 0.75 to 9.85 km^2). Prey availability may determine size of home range. Cat activity is bimodal, with peaks near dawn and dusk.
- Cats are intensive breeders. A female cat reaches reproductive maturity 7-12 months of age and can come into oestrous as many as five times a year. Gestation lasts 63 to 65 days, and the average litter is four to six kittens. Weaning takes 35-40 days. They can reproduce in any month of the year where food and habitat is sufficient. An adult female may produce up to three litters per year.

Presence in Seychelles

- Introduced early in the history of human settlement of the islands (1770 onwards), spreading to almost all islands. Often introduced to islands to help control rats.
- Never apparently present on Cousin Island and Bird Island (Parr et al. 2000).
- Following eradication attempts on several islands of importance to seabird breeding colonies and/or endangered endemic birds in the 20th century, several other islands are now cat-free (Aride, Cousine, Curieuse, Denis, Fregate, North, and probably Picard, Polymnie and Malabar on Aldabra Atoll).

Control programmes

- Aride Island: a small granitic island 71ha, 8 km north of Praslin, managed as a nature reserve since 1975; now managed by a local NGO, Island Conservation Society. Landing is by means of the island's boats only.
  - 1930s (***Physical method***): The cats introduced in 1918 were eradicated using dogs and boys to catch the cats (number of cats not recorded) according to Watson et al. (1992). At the time Aride was privately owned, with coconuts, agriculture and sea bird cropping as the main economic activities.
  - Post-1930s: No cats have ever been recorded or seen since that time.

- Fregate Island: a privately owned granitic island of 210 ha, 55km east of Mahé, accessible by boat or small aeroplane, with high class tourism and also agriculture as activities.
  Physical and chemical methods
  - 1960: 86 cats were trapped or poisoned (poison not named) on Fregate because they were threatening the population of rare Seychelles Magpie Robin (Seychelles Government 1960).

- 1970s: several cats were caught (method not recorded): 5 in 1979-80 and 17 in five months prior to February 1981 (Watson et al. 1992)
- 1981-82: a team of two, with advice from a consultant from the NZ Wildlife Service plus the support of one person from the Seychelles Conservation Division, carried out systematic trapping over the whole island, setting traps along the path network to give near regular distribution (no distance recorded).
- Baited traps were used, with a mixture of baits tried and with alternate on-off trap timing, and changing positions of traps to avoid trap-shyness. Traps were visited at dawn and dusk, and closed during the day if in magpie-robin territories and areas where there were domestic animals.
- In addition, poison baits (poison not recorded) were injected into small cubes of fresh fish and laid at c.20m intervals along the middle of paths at dusk; uneaten baits were collected early the next morning.
- A total of 53 cats were known to be poisoned or trapped during the intense eradication period and 3 subsequently. Follow-up trapping during 1982 confirmed cat eradication. (All information from Watson et al. 1992)
- Post-1982: There have been no sightings or signs of cats since that time.

▪ Cousine Island: a privately owned small granitic island of 25ha, 5km from the southern coast of Praslin, accessible by boat (landing is only by the island's boat) and helicopter. Managed as a nature reserve with very small scale high class tourism.
  - Cats were only introduced to Cousine between 1971 and 1972.
  - 1983-1985 (***Physical methods***): The eradication programme started April 1983 and continued until June 1985. All work was conducted by one government employee who made 4 x c.1 week visits to the island, plus details were recorded for another period of 12 days. Total days worked on Cousine = c.43.
  - Traps set were all 'Walk-T-Traps', mostly placed on low lying land (spacing of traps and type of bait not recorded). The daily average number of traps set for each of the four weekly visits ranged between 16 and 28. All traps were 'unset' at the end of each of the week-long visits.
  - A total of 73 cats (33 male + 40 female) were caught and destroyed. 32 were caught in the first 12 day period; 14 and 18 in the next two weekly periods. 23 cats were described as juvenile, 50 as adult. They were all in good condition with a maximum weight of 4.1kg. The remains of Audubon Shearwater were found in the stomachs of all cats, except 4 which were empty and 7 had other bird species in them. (All information from Laboudallon 1987).
  - Post 1985: No cats or signs of cats have ever been sighted since that time.

▪ Curieuse Island: a granitic island of 286 ha, 1km from the northern coast of Praslin, accessible by boat only; part of a marine national park and managed by the Seychelles National Parks Authority.
  - 1998: A cat and rat eradication feasibility study was carried out by a NZ expert and government environment department employees (Merton 2001).
  - 2000 (***Chemical and physical methods***): Eradication programme started in July, one week after rat eradication poisoning had taken place (see p.17) so that a primary food source would be absent and the cats would be more susceptible to baiting. It should be noted that at least 3 cats were found dead 14 days after the first rat bait application and before the first 1080 poison was laid for cats, and 4 others disappeared. They are believed to have died as a result of Brodifacoum poisoning, probably from eating rain-softened rat bait.
  - Seventy bait stations around habitations and in selected natural sites were pre-baited with special pelleted chicken meal cat bait, but due to non-acceptance this was modified to canned tuna in oil. After one week, non-poison bait was replaced with toxic bait containing 0.1% 1080 (sodium monofluoroacetate). Baits were changed daily over a 2-3 week period. There was no mortality of non-target vertebrate species (and giant tortoises on the island were penned prior to rat poisoning).
  - One week after toxic baiting started, 90 leg-hold traps (Lanes Ace and Victor 1.5) were set at approx. 100m intervals along established tracks and baited with non-toxic canned tuna.
  - Local personnel were trained to continue the poisoning and trapping through 2001 until cats were eradicated. No formal trapping system was considered necessary as any sign of cats would have been easily spotted. The last cat trapped was caught in February 2001.
  - Organisations involved: Ministry of Environment and Transport, Marine Parks Authority, New Zealand Dept of Conservation. Finance was from a Dutch Trust Fund grant. (All information from Merton 2001)
  - Post-2000: No cats or signs of cats have been seen on the island since that time.

- Denis Island: a privately owned, flat coral island of 143 ha, 95km north of Mahé, accessible by boat and small plane. High class tourism but also managed partly as a nature reserve by local NGO Green Island Foundation.
  - 1998: A cat and rat eradication feasibility study was carried out by a NZ expert and government environment department employees (Merton 2001).
  - 2000 (***Chemical and physical methods***): Eradication programme started in June, one week after rat eradication, as for Curieuse, and as part of the same two-island cat eradication programme and 3-island rat eradication programme. Exactly the same methodology was used but the number of bait stations was 52, 1 cat was lost after the rat eradication, apparently from Brodifacoum poisoning, as on Curieuse. The last 2 cats were trapped between July and September 2001.
  - Organisations involved: Ministry of Environment and Transport, Denis Island management, New Zealand Dept of Conservation. Finance was from the island owners. (All information from Merton 2001)
  - Post-2000: No cats or signs of cats have been seen on the island since that time.

- North Island: a privately owned granitic island of 201ha, 27km northwest of Mahé and 6km north of Silhouette. Previously a coconut plantation, now with a high class tourism establishment and environmental restoration programme.
  - 2003 (***Chemical and physical methods***): 30 feral cats were estimated present on North Island prior to the eradication operation.
  - Eradication commenced directly after the first attempt to eradicate rats from the island (see p.19), based on the assumption that cats deprived of a major food source would be more likely to take bait or be caught in traps.
  - 50 Sentry cat bait stations were established along a purpose-cut track system linked to existing roads, providing coverage over the whole island. Particular attention was paid to known traditional cat feeding areas around staff housing and dump sites.
  - 7 days after the second aerial bait application for rats, the cat bait stations were stocked with non-toxic bait (a mixture of cooked rice, tinned tuna and vegetable oil).
  - After 6 days of non-poison baiting, toxic gel containing 0.1% 1080 was added to the rice and fish baits for a period of five nights. Old bait was collected and burned each day, along with any equipment used in the handling of the poison, and the ashes buried.
  - After the 5-day period of toxic baiting, 72 "Victor" No. 2 (and some No. 3) leg-hold traps were set at 150-180m intervals along the track system and access roads. Traps were baited with tinned tuna in oil and checked and re-baited daily.
  - 16 dead cats were found during the seven day period that 1080 toxic baits were set out. 5 more cats were caught by the traps, giving a total of 21 cats collected during the programme.
  - A second trapping session was undertaken about one month later using the same sites and bait mix. No cats were caught. Periodic maintenance trapping was expected to be undertaken for a period of at least 8-12 months by North Island staff.
  - Organisations involved: North Island management, team of 3 New Zealanders (1 Expert, 1 assistant, 1 helicopter pilot), Nature Seychelles (a local NGO). (All information from Climo 2004)
  - Post-2003: No cats or signs of cats seen since the eradication.

- D'Arros: a privately owned low coral island of 150ha, part of the Amirantes group, some 220km from Mahé. Accessible by boat and small plane.
  - 2003: Cats were eradicated during a rat and cat eradication programme on the island. 21 cats were killed. (Engelhardt pers. comm. No details made available)
  - Organisations involved: D'Arros management, New Zealand expert, Nature Seychelles.
  - 2005: Eradication was confirmed successful during a follow-up survey by Nature Seychelles. (Engelhardt pers. comm. No details available)

- Cosmoledo (Grande Ile and Grand Polyte): Cosmoledo is a raised coral atoll of 8 main islands 1075km south west from Mahé. The two islands are on the east side and linked during low (spring) tides. Managed by Islands Development Company. Menai, the largest island (14km from Grande Ile and Grand Polyte), remains infested by cats. Eradication planned as part of the ICS-FFEM project Rehabilitation of Island Ecosystems,
  - 1968-2003: Continuous cat presence reported on Grande Ile; droppings found in 2002 on Grand Polyte by V. Laboudallon (pers. comm.).
  - 2005: Cats seen repeatedly on Grand Ile during the October mission, also old cat droppings on Grand Polyte. Cat eradication plan consisted of a pre-feeding and poisoning phase (with 1080 gel), to be followed by trapping, and if necessary shooting to dispatch remaining trap shy animals.

- 2007 (***Chemical and physical methods***): Rat eradication conducted in November on Grande Ile (c,143ha), Petit Polyte (1ha) and Grand Polyte (21ha) through 2 aerial droppings of Brodifacoum cereal pellets 20 ppm. Cats observed on Grand Ile only, numbers guesstimated at possibly 40-50 animals.
- 1 m wide tracks were cut around the island (including one on dune crest) to place feeding tables and traps. Cat eradication plan reviewed: poison (1080 gel) and 50 special cat traps with rubber protection imported, and 82 wooden feeding tables built to ensure that non-target species such as Robber-crabs were not affected by poison.
- 2008: A clear reduction in the number of cats observed during the survey rat trapping operation in November suggested a significant drop in abundance due to secondary poisoning and less food resources after the rat eradication. Remaining number estimated to be 20-30 individuals maximum (Roland Nolin & André Labiche pers. obs.). No signs of cats observed on Grand Polyte; it is unclear whether their extinction on the island happened prior to, or as a result of, the 2007 rat eradication.
- 2009: 25kg of canned cat food and feeding tables sent to Assumption and Cosmoledo by boat in February-March, but logistical difficulties and the capture of one boat by Somali pirates forced the pre-feeding and poisoning operation to be postponed.
- Information from Climo & Rocamora (2006), Rocamora (2007), Rocamora & Jean-Louis (2009).

Note on the cat population of Aldabra Atoll (World Heritage Site)

- Aldabra is a very large raised atoll c.1,100km southwest of Mahé, with a total land area of 153km^2, but total area (including mangrove, lagoon and channels) of 346km^2. Managed by Seychelles Islands Foundation.
- Cats were established on Aldabra as early as 1892 (Abbott 1893 cited in Wanless et al. 2002), but currently believed to only occur on Grande Terre (Wanless et al. 2002)
- The most intensive study of cats at Aldabra was done by Seabrook in 1985/86, mainly on the south and west coasts of Grande Terre. She trapped 16 cats and collected 52 scat (droppings) samples, finding green turtle hatchlings featured prominently in the cat diet, followed by rats and cockroaches as the next most abundant, but also geckos, skinks, crustaceans, other insects and birds and even fish and seagrass.
- The male-biased sex ratio of trapped and shot cats and the observations of cats in poor condition (von Brandis 2007; Bergeson via Mortimer pers. comm.) suggest that the cat population on Aldabra is stressed.
- Cats may well have had a very serious impact on the fauna in the past, especially the avian fauna. The disjunct distribution of cats and rails on Aldabra strongly suggests that cats were responsible for the local extinction of rails on those islands where cats occur (i.e. Grand Terre) or are known to have occurred in the past (i.e. Picard).
- Control programme (***Physical methods***): opportunistic trapping (live box traps) and shooting of cats has been carried out on Grande Terre over recent years. Regular Gin Traps are not appropriate for use on Aldabra because there are too many possible non-target species, e.g. robber crab *(Birgus latro)*. Other factors that make complete eradication difficult on Aldabra include its large area, the difficult terrain and the elusive behaviour of the cats. Nevertheless, cats on Picard appear to have died out naturally and, although there have been reports of cat sightings on Malabar, there is no evidence of viable cat populations there. Even systematic monitoring would be very difficult on these islands because of the above reasons and also multiple trail cutting would be too invasive in this World Heritage Site.
- Recommendations: Von Brandis (2007) recommends a pilot programme to test all feasible methods of eradication. A combination of the most effective methods could then be used to attempt eradication over a series of years. He suggests that potential methods of eliminating cats at Aldabra include: Baiting + shooting; tracking with dogs + shooting; call recordings + shooting; ‘fall-through’, leg-hold’ and ‘walk-in’ traps; mechanical poisoning (such as food solidification agents); and chemical poisoning.

Conclusions

- Cat eradication seems to have been successfully carried out by poison baiting and trapping on small islands.
- Most programmes appear to have followed some form of systematic method, but details are not available for all the programmes.
- There is little information on the effects of trapping on non-target species.
- On the smaller islands, the lack of monitoring to confirm eradication was probably less important because the islands are inhabited and remaining cats would have been quickly spotted.
- The methods used on small islands would not be appropriate for larger islands because too many non-target species or pet animals would be affected. Aldabra also presents a special case because of the difficult terrain, large area and non-target species that could be affected.

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Black Rat (*Rattus rattus*) / Lera

Biology and ecology
- Medium size rodent now found on all continents, with a long tail; variable in colour from brown to grey to blackish, with often paler underparts.
- Omnivorous opportunistic feeder.
- Very agile and able to climb trees, run along ropes and wires, etc. Primarily nocturnal.
- Very flexible in its choice of habitat, not being restricted to areas of human habitation if there is ample food in woodland and shrubby habitats.
- Breeds throughout the year, often several litters per year, although more likely to have large numbers of offspring in the wet season.
- Able to carry certain diseases, of which the worst in Seychelles is Leptospirosis which can be fatal.

Presence in Seychelles
- First recorded in 1773 but almost certainly present before that time on at least Mahé. Transferred to other islands by boat.
- Present on almost all islands. In the past, the climbing habit of this rat allowed for considerable damage to coconut plantations, as well as other agricultural produce at a time when agriculture was the mainstay of the Seychelles economy. As rats also act as carriers of leptospirosis, which can be deadly to humans, they are often feared. Therefore the government has frequently run control programmes on the main granitic islands, and most outer island managers carry out their own limited control programmes.

- The small islands that escaped rat introduction have had great value as biodiversity-rich habitats, e.g. Aride, Cousin, Cousine. More recently, rat eradication programmes have created further rat-free islands, allowing threatened animal species to be re-introduced, e.g. North Island, Denis Island. However, in all cases it is necessary to ensure that stringent protocols are followed in order that rats are not reintroduced.

Control programmes

- Granitic islands (20th century): The Agriculture Department (and later the Ministry responsible for Environment) kept annual records of the number of rats killed up until the late 1980s. At the start, a bounty of 2 cents was offered for each dried rat tail handed in. In 1947, the bounty was raised to 5 cents, resulting in more than 350,000 rat tails handed in between 1947 and 1949. The bounty was increased to 10 cents in 1963, in which year 152,776 rat tails were handed in (compared with an annual average of 46,000 for the previous four years). Even though the coconut industry went into decline as tourism increased during the 1970s, rats were still very numerous and in the 1980s the bounty increased to 1 Rupee, after which people became more wary of handling rats due to the fear of the rat-transmitted disease, leptospirosis, which can be lethal to humans. (Most information from Seychelles Government agriculture reports)
- ***Physical methods***: In the early days traps were mainly of the local type known as "lasonmwar" made from bamboo, wood and string, later replaced by wire mesh live traps, snap traps and various types of rat glue (W. Andre pers. comm.).
- ***Chemical methods***: Poisoning campaigns were organised when rat populations appeared to be increasing, using poisons such as zinc phosphide in the early years, followed by anticoagulants e.g. warfarin in the 1950s, later combining the poison with a bait of sugar and ground maize in waterproof wax blocks, which avoided previous wastage due to rapid disintegration. These poison blocks were sold to the public (Seychelles Government agriculture reports). Occasional campaigns continue, although nowadays often organised by the Ministry of Health and using both chemical and physical methods.
- ***Biological control***: In 1949, three Cape Barn Owls (*Tyto alba*) were introduced from East Africa, as a trial for rat control, and released on Platte Island, where they were reported to feed exclusively on rats. In 1951 and 1952, 15 and 12 more owls were brought from East Africa and released on Mahé, where they were observed to feed on rats and cockroaches. By 1956 the owl was breeding and pellets revealed 80% rats and 20% White/Fairy terns. By 1958 owls were found on Praslin, Silhouette, North and Aride. In 1960 owls were reported to be feeding mainly on rats and to a lesser extent on Fairy tern, Tenrec, Mice, Frog and Cockroach. (Seychelles Government agriculture reports)
- Due to an increased awareness of the need for conservation of biodiversity in the late 1960s, a reversal in policy in 1969 resulted in a R5 bounty being offered per dead owl, with some 40 owls brought in during the first two years (Seychelles government agricultural reports). Numbers after that time were not well recorded.

- Haut Barbarons & La Misère (ex-Tracking Station): private properties, home to about half of the Mahé breeding population of the endangered Seychelles White-eye (SWE), known to be very sensitive to nest predation from rats and large birds. Rat control done as part of the ICS-FFEM project Rehabilitation of Island Ecosystems,
    - 1997-2005: Monitoring of SWE populations conducted by Conservation section (DoE), and ICS after 2002.
    - 2006: Track lines were cut into the vegetation to create two permanent 50m grids of bait stations to control rats over a total of c.20ha: 14 ha at Haut Barbarons (59 stations) and c.6 ha (32 stations) at La Misère (ex-Tracking Station). Habitat is mainly broad-leaf woodland, plus some buildings.
    - 2006-2009 (***Chemical and physical methods***): Refilling of bait stations done twice a month, and 2 cage trapping sessions done twice a year (around September and May) to control efficiency of the protocol and to eliminate surviving and re-invading rats. Protocol ongoing.
    - The reduction in the level of infestation since the programme started, measured from the number of rats caught per 100 (corrected) traps night, has been very high at both sites.
    - Despite the success of the protocol in controlling the rodent populations and an initial increase in the number of SWE territories and individuals at both sites, the SWE population later decreased at Haut Barbarons.
    - *Rattus norvegicus* is also present at both sites but represents only a small minority in the number of rats trapped.
    - Organisations involved: Island Conservation Society and Management of the President of United Arab Emirates Affairs (MPA) who funds the operation.
- More details in Labiche & Rocamora (2009a) and Rocamora et al. (2009 in prep).

- Bird Island: a privately owned, flat coral island 101ha, c.100km North West of Mahé, with a hotel. Accessible by boat and plane. According to Merton et al., (2002) rats did not reach the island until 1970.
  - All information below is from Merton et al. 2002.
  - 1995: A feasibility study was carried out. Rodent indices and population data were obtained by cage trapping using 23 traps baited with grilled coconut pieces, sited at 50 m intervals along an index line which took in the most common habitats. Traps were opened on specific nights only. Rat density was assessed as a standard index of rat abundance.
  - Eight rodenticide bait types were tested for acceptance by rats, durability in the environment and attractiveness to non-target species, e.g. crabs, ground-feeding birds.
  - 1996 (***Chemical methods***): Poisoning was carried out after the end of the Sooty Tern breeding season, in October/November, targeting mice and rabbits, as well as rats. Three giant tortoises, livestock and dogs were confined during the poisoning, and animal food and food waste protocols were in place to avoid access by rats.
  - Wax bait blocks with 20ppm Brodifacoum were placed over the whole island using 800 bait stations placed along transect lines 50m apart (cut through the vegetation where necessary). At each bait station, groups of 3-5 blocks were placed inside plastic drink bottles cut off at one end or 400mm lengths of PVC pipe. Skinks were kept out by placing tape cross the bottom of the opening. Bait stations were tied to propped-up coconut leaves to avoid hermit crabs. 60kg of block bait was used in the first loading. Four days later, 2 blocks per station were used, after which stations were restocked at monthly intervals until April 1997 (i.e. for c.6 months). Total block bait used = 200kg.
  - In addition, Brodifacoum poison (50ppm) was used in standard 12 mm pellet form (green-dyed to make it harder for ground-feeding birds to see) and hand broadcast at 25m intervals along the transect lines. At each point, one handful (about 100g) of pellets was scattered to the North, South, East and West and at the feet of the operator, giving a cover of 4-5kg/ha. Higher concentrations were used in areas where crab take-up was more likely. Broadcasting was carried out twice, 1 week after the start of the eradication programme and again ten days later.
  - Index trappings (see 1995 feasibility study above for methods) were carried out throughout the programme. By the third week there were no signs of rats.
  - Some non-target species of introduced bird were inadvertently poisoned, e.g. Madagascar turtle dove, Barred ground dove, Indian myna (between 30-70% of the local populations of these species), and a few migrant waders.
  - Organisations involved: Environment Division, New Zealand consultants, Bird Island owners / management. Funded mainly by Bird Island owners.
  - 1998: Follow-up monitoring included regular examination of block baits in permanent bait stations, and checks for signs of rat predation in the island sooty tern colony during the breeding season.
  - By 1998 rat eradication could be confirmed. Quarantine and contingency measures were supposed to be put in place after eradication but there is no information on their efficacy.
  - 2009: There have been no further reports of rats on the island. It is not known whether rat prevention measures are still in place (no questionnaire responses were provided by Bird Island).

- Curieuse Island: a granitic island 286 ha, 1km from Praslin, accessible by boat only, managed by the Marine Parks Authority (now the Seychelles National Parks Authority).
  - 1998: A feasibility study was carried out as for Bird Island (above), including rat index trapping and bait attractiveness to non-target species.
  - 2000 (***Chemical methods***): Rat index trapping was carried out before, during and after the operation, as for Bird Island except that traps were set and checked *daily* throughout. Food storage and food waste protocols were in place to avoid access by rats. Giant tortoises were penned in where possible (n=70 =60% as they range free on Curieuse).
  - The eradication programme began in July 2000. The rodenticide 'Pestoff 20R' in the form of bait pellets (active ingredient Brodifacoum at 20ppm) were distributed evenly over the island using a helicopter with a spreader hopper slung beneath it. An experienced NZ pilot was used. The helicopter flew along transects 40m apart, calculated using a differential global positioning system (DGPS). The first application was on 2 July 2000 and the second 11 days later on 13 July 2000.
  - In total 6578kg of toxic bait was used (c.23kg of bait per hectare) on Curieuse.
  - Some non-target species of introduced bird were inadvertently poisoned, i.e. Madagascar turtle dove, Barred ground dove, Indian myna, Madagascar fody (between 10-40% of the local populations of these species), and 5 migrant Turnstone. No native reptiles (except 1 giant tortoise which seems to have died from natural causes) or invertebrates were affected.
  - No rats were caught after the eradication programme was completed. However precautions were taken by placing PestOff Rodent block baits inside 180 permanent rodent bait stations (no details of distribution on the island). No formal post-eradication measures were put in place to detect rat survival because it was considered unlikely that any individuals could escape detection for long on

an inhabited island. Moreover, rodent quarantine and contingency plans were supposed to have been developed and implemented by management and staff on the island, but this was unconfirmed.
  - Organisations involved: Environment Division, Marine Parks Authority, New Zealand consultants and helicopter pilot, Helicopter Seychelles). Finance came mainly from a Dutch Trust Fund grant.
  - All the information on the 1998/2000 eradication attempt is from Merton et al. 2002.
  - <u>2001</u>: Rats were reported from the island in August 2001 (Merton et al. 2002). Merton et al. and Climo (2004) suggest this was due to lax or absent protocols for prevention of reinvasion. But there is also a likelihood that rats could have persisted in the mangrove area, which is subject to fluctuating tide levels that could have resulted in bait being washed away and the consequent survival of the rat population in that habitat.
  - <u>2009</u>: Rats still present (from IAS Questionnaire response).

- <u>Denis Island (2000)</u>: a privately owned, flat partially wooded coral island of 143 ha, 95km north of Mahé, accessible by boat and small plane. High class tourism but also now managed partly as a nature reserve by a local NGO Green Island Foundation.
  - <u>1998</u>: A feasibility study was carried out as for Bird Island (above), including rat index trapping and bait attractiveness to non-target species.
  - <u>2000</u> (***Chemical methods***): Methodology was the same as for Curieuse. The first aerial poison bait distribution was on 2 June 2000 and the second 9 days later, on 11 June 2000. A total of 3375kg poison bait was used on the island (c.23 kg bait per hectare). All 5 giant tortoises were penned throughout the programme.
  - Some non-target species of introduced bird were inadvertently poisoned, i.e. Madagascar turtle dove, Barred ground dove, Indian myna, Madagascar fody (between 40-60% of the local populations), and about 80% of migrant Turnstone.
  - No rats were trapped after the termination of the eradication programme and follow up monitoring consisted of permanent bait stations containing block poison baits, as for Curieuse. Strict rat quarantine protocols were supposed to be in place.
  - Organisations involved: Environment Department, Denis Island owners/management, New Zealand consultant and helicopter pilot, Helicopter Seychelles. Financed by the island owners and Dutch Trust Fund.
  - All information about the 1998/2000 eradication attempt is from Merton et al. 2002.
  - <u>2001</u>: Rats were again reported from Denis Island. Merton et al. (2002) and Climo (2004) considered this to be a reinvasion due to inadequate maintenance of rat reinvasion protocols.
  - <u>2002</u> (***Chemical and physical methods***): A second eradication programme was carried out using ground application of poison bait. No details have been supplied but follow up trapping / poison baiting was carried out using a grid system (K. Beaver pers. observ. 2005) and eradication was recorded as successful in a Table in Climo (2004).
  - <u>2009</u>: The island has remained rat-free up to now, allowing the introduction of certain threatened endemic bird species.

- <u>Anonyme</u>: a small 10 ha granitic island, privately owned, only 500m from Mahé east coast, opposite International airport, with a high class small hotel resort until 2006. Rats first eradicated during the preparatory phase of the ICS-FFEM project Rehabilitation of Island Ecosystems, and for the second time in 2006 as part of same project following partial recolonisation of the island's plateau.
  - <u>2003</u> (***Chemical and physical methods***): Rats eradicated through a ground based operation combining the use of Brodifacoum blocks in 66 bait stations forming a permanent grid and cage trapping.
  - <u>2004-05</u>: Anonyme was confirmed rat free through regular survey trapping and continued refilling of bait-stations, although occasional reinvasion by single individuals - and subsequent elimination by the bait station grid - is suspected. One single juvenile Black rat was trapped in April but none during the following 250 trap nights across the island.
  - <u>2006</u>: The island was sold in July and a tourism development project planned. Refilling of bait stations was interrupted and preparations to reintroduce threatened species were stopped. Partial recolonisation of the island's plateau by rats, eradicated for the second time in October-November 2006. Refilling of bait stations and monthly trapping (20-30 trap nights) protocol resumed.
  - <u>2007-2009:</u> The island remains rat-free, except for occasional reinvasions of single rats swimming from Mahé, later poisoned through consumption of raticide, or trapped during survey trapping as with 1 juvenile Black rat in July 2007.
  - Organisations involved: Island Conservation Society, Anonyme Island resort and Pezula Island. Funding came mainly from Anonyme Island, Conservation des Espèces et Populations Animales, and Miguel Torres wineries. Regular bait station refilling and survey trapping done by ICS and funded by Anonyme Island since October 2006.
  - More details in Rocamora (2004, 2008).

- Ile aux Rats: small islet of less than 1ha belonging to government, located 700m from Anonyme, apparently named after the presence of rats (*Rattus rattus*). A few seabirds breed on the island, occasional landings of tourist boats and fishermen, no specific management. This eradication was conducted as part of the ICS-FFEM project Rehabilitation of Island Ecosystems,
  - 2003: Trapping was conducted to determine rat species identity and assess abundance.
  - 2005 (***Chemical method***): In November, a ground eradication was conducted with a single hand spreading of c.15kg of Brodifacoum 20ppm cereal bait pellets, as a precautionary measure to prevent reinvasion on neighbouring Anonyme.
  - 2007: The island appeared to be rat-free after 20 trap nights and no rats caught.
  - 2009: Ten trap nights were conducted in May and the island appears to be still rat free. Trapping to be conducted 1-2 times per year as part of the Anonyme abatement measures.
  - Organisations involved: Island Conservation Society, Anonyme Island resort & Pezula Island.
  - More details in technical FFEM project reports.

- North Island: a privately owned granitic island of 201ha, 27km northwest of Mahé and 6km north of Silhouette. Accessible by boat and helicopter. High class eco- tourism establishment.
  - 2002: A feasibility study was carried out by the New Zealand consultant, who carried out index trapping using Elliott traps baited with fresh coconut set at 50-80m intervals along established roads running east-west through a range of habitat types for the full width of the island.
  - 2003 (***Chemical method***): Rat eradication was carried out at the same time as cat eradication in September 2003. Prior to the eradication attempt, a large-scale cleanup of rubbish and construction material was undertaken to remove major areas where rats could hide.
  - Brodifacoum @ 20ppm in 10mm diameter cereal-based carrier pellets were distributed over the island by helicopter, using a spreader bucket attached to its underside. There were three separate broadcasts, applied on day 1, day 6 and day 22, at a rate of 10kg/ha for application 1 and 6 kg/ha for application 2 and 3 to ensure maximum effectiveness. A DGPS system was used to apply the poison bait along transects covering the whole island in 100m swathes (with a 20% overlap). Slightly higher applications were made over the coastline due to expected uptake of the bait by crabs (which are unaffected by the poison). There is no record of non-rat vertebrate species affected by the poison.
  - Four 10m x 10m quadrats were established in different habitats over the island to measure bait densities and rate of bait consumption after each aerial application of poison pellets.
  - Following each aerial application, hand broadcasting was done around the hotel complex and certain other areas where application rates seemed to have been uneven. Permanent bait stations continued to be checked every 3-4 days until all the aerial applications were completed. They were then required to be checked at fortnightly intervals on a regular, ongoing basis, although this apparently was not carried out properly for several weeks.
  - Index trapping for rats (using the same method as during the 2002 feasibility study) was undertaken immediately prior to and during the first poison application to help determine population densities and to obtain information on breeding status and condition.
  - Protocols were set up to prevent re-entry of rats, including a rodent-proof room, permanent bait stations etc. but in late December 2003 a rat was sighted and in March 2004 several rats were captured. Climo (2004) assessed that the eradication had been successful but rat prevention and abatement protocols were probably not followed sufficiently strictly. He notes that experiments elsewhere on rats tracked in coconut palms showed that they always come down to the ground every day or within a matter of days and could not have remained in the crowns for weeks.
  - Organisations involved: North Island management, New Zealand consultant + assistant + helicopter pilot, Helicopter Seychelles, Nature Seychelles. Funded by North Island management.
  - All information for the 2002/3 eradication attempt is from Climo 2004.
  - 2005 (***Chemical method***): As part of the ICS-FFEM project Rehabilitation of Island Ecosystems, a new protocol and eradication plan was written by the lead project expert and the same New Zealand consultant employed by ICS. Stricter rat abatement protocols were discussed and agreed with the island's management.
  - Several months of intensive preparation were required and included the refurbishment of the rat-proof room, the building of a rat-proof trailer, proper management of food waste, the elimination of a huge green waste/coconut pile, sensitisation and training of the island's personnel, setting up permanent bait stations along the coast to prevent reinvasion and around buildings, plus a 50m central grid of bait stations covering much of the plateau area.
  - This second eradication attempt was conducted in August-September and involved four different helicopter drops of Brodifacoum 20ppm cereal pellets, totalling c.40kg/ha of raticide. A DGPS system to ensure adequate coverage of the island could only be used during the third drop. Last drop was performed by a local pilot, as during previous aerial operations in Seychelles. Hand broadcasting done around buildings. Five 10m x 10m quadrats were set up in different habitats to

check adequate coverage of the pellets spread. Two index trapping lines of 25 traps were also set up for 3 weeks.
- o Non-target species and other wildlife (birds, reptiles, invertebrates) were closely monitored before, during and after the eradication as part of a long term ecosystem monitoring. High mortality was noted among the Indian Mynas; Barn Owls later appeared to have been eradicated. Some limited mortality was also recorded for a number of common native bird species which later recovered and for some of them went over their initial abundances.
- o 2005-2006: Intensive survey trapping was conducted all around the island for a full year by North Island staff with contributions and guidance from ICS experts, totalling over 8500 trap nights without any rat, after which the island was declared free of rats. NZ ICS expert was present over a period of 4 months (July-November 2005), NZ helicopter pilot over a one month period.
- o 2005-2009: Implementation by North Island management of strict abatement measures including procedures for loading barges and boats on Mahé, unloading procedures on North, and rat-proof room and trailers procedures.
- o Organisations involved: North Island management, Island Conservation Society including its New Zealand consultant and pilot, Helicopter Seychelles including local pilot. Co-funded by North Island, FFEM and smaller sponsors (ICS experts and staff, and NZ helicopter pilot).
- o 2007-2008: As a result of its rat-free status, two threatened endemic species were introduced to the island as part of the same ICS-FFEM project: the Seychelles White-eye and the Seychelles Black Mud terrapin.
- o 2009: North Island remains rat free. Considerable energy, time and expense are expended in maintaining very strict rat-reinvasion prevention and abatement protocols (NI staff, pers. comm.).
- o More details in Rocamora & Climo (2005), Climo & Rocamora (2006a), Rocamora & Labiche (2009a) and Rocamora et al. (2009 in prep), Galman et al. (2009 in prep.).

- Cosmoledo (Grande Ile, Petit Polyte and Grand Polyte): a raised coral atoll 1075km south west from Mahé, with 8 main islands, managed by Islands Development Company. The three islands are on the eastern side and are linked during low (spring) tides. On the western side is Menai, the largest island, most isolated from all the others (14km from Grande Ile and Grand Polyte), which remains rat-infested. These eradications were conducted as part of the ICS-FFEM Rehabilitation of Island Ecosystems project.
  - o 2002: During an ICS-CORDIO Expedition conducted in Nov. 2002, the presence of *R. rattus* was confirmed on both Grand Ile and Grand Polyte, as well as on Menai,
  - o 2005: A first mission was conducted on 3 of the atoll islands (Grand Ile, c.143ha; Grand Polyte, 21ha and Petit Polyte, 1ha) to conduct a ground based rat eradication, but attempt was aborted due to adverse conditions (rough seas with some rain, extreme rat densities requiring cutting 25m instead of 50m line transects in pristine vegetation) and insufficient preparation for such difficulties.
  - o 2006: A new eradication plan was designed and funding reallocated within the project to carry out an aerial operation based on helicopter spreading of Brodifacoum 20ppm cereal pellets.
  - o 2007 (***Chemical method***): Aerial eradication was carried out with important logistical support during a 17 day ICS-IDC expedition in November 2007 on 3 of the atoll islands (Grande Ile, Grand Polyte and Petit Polyte), a total area of 165ha. Two helicopter drops totalling c.30kg/ha were done. No DGPS used but visual land markings (flags) to ensure adequate coverage by the helicopter. Seven 10m x 10m quadrats (including 2 on Grand Polyte) were set up in different habitats to check adequate coverage of the pellet spread and bait consumption. Index trapping was conducted for a few nights only on 3 lines totalling 40 and 20 traps respectively on Grande Ile and Grand Polyte, until 2 nights after the first drop. This was followed by intensive survey trapping around the islands until the second drop and the end of the mission, a period during which no rats were caught.
  - o No mortality of non-target species (birds or reptiles) was recorded, but consumption by hermit crabs and other crabs was found to be very high after the drops.
  - o Wildlife (birds, reptiles, invertebrates and plants) were monitored before and after the eradication as part of a long term ecosystem monitoring.
  - o Organisations involved: Island Conservation Society, Islands Development Company, New Zealand consultant (2005), Helicopter Seychelles, co-funded by IDC, FFEM and smaller sponsors. Indian Ocean Explorer also provided logistic support.
  - o 2008: Survey trapping was conducted in Nov. 2008 by ICS, and rats were confirmed eradicated on all three islands after a total of 300 (uncorrected) trap nights conducted on Grand Polyte, 30 on Petit Polyte and 660 on Grande Ile (hence a total of c. 900, 390 and 42 trap nights without rats for each island when adding the number of trap nights performed immediately after the eradication in Nov. 2007).
  - o More details in Climo & Rocamora (2006b), Rocamora (2007), Rocamora & Labiche (2009c), Labiche & Rocamora (2009b) and Galman et al. (2009 in prep.), Rocamora et al. (2009 in prep.).

Note on the Black rat population of Aldabra Atoll (World Heritage Site)

- Occurrence: The Black rat occurs on all four major islands and most of the smaller islets at Aldabra.
- Impact: The impact of rats on the native Aldabra plants, invertebrates, reptiles and birds is likely to have been substantial after their first introduction. Rats are reported to be largely vegetarian on Aldabra, but are also important predators of eggs and chicks of passerines, particularly the Aldabra Fody (Frith, 1976), Bulbul and White eye (Racey & Nicoll 1984) and may have been responsible for the possible extinction of the Aldabra Brush warbler (Prys-Jones 1979) and in confining most seabird breeding to small islets in the lagoon (Diamond 1979). Rats also eat turtle hatchlings and hatchling Aldabra tortoises (R. von Brandis via Mortimer, pers. comm.) Predators of rats at Aldabra include coconut crabs and cats (Racey & Nicoll 1984) and flightless rails (Wanless 2003).
- Control: Most experts agree that given the large size of Aldabra (15,380 ha), the sensitivity of habitats in a World Heritage Site, and the high risk of re-colonisation, complete eradication of rats is impossible using current available technology. Instead the following types of control programmes have been implemented or attempted:
  - Throughout recorded human history on Aldabra, people have trapped rats around human settlement using a variety of homemade and purchased traps. Rats have been subjected to almost daily trapping campaigns in the vicinity of the Settlement and Research Station, and at the outlying camps when they are occupied for extended periods.
  - In 2002, the new Research Office on Aldabra proposed a rat trapping campaign to control rats in the most sensitive areas of Aldabra, by setting 300-500 Sherman live traps per day. Following discussions by the SIF Science Committee, c.50 cheaper PVC traps were acquired. A pilot control project was initiated on Malabar, with the help of several volunteers, due to concern for White-throated rails and over-abundant rats during the wet season. However, after further discussion the programme was curtailed because it was felt that rat control at Ile Malabar would not solve the rat problem, and because future trapping efforts were likely to be erratic, the rat population would rebound (SIF Science Sub-Committee minutes).
- Recommendations: In 2003, the SIF Scientific Sub-Committee recommended that: a) a pilot study be undertaken to understand the role and impacts of rats in the ecosystems of Aldabra, through looking at the effect of rat eradication on a small islet; b) use the results of the study to re-define management of rat populations on Aldabra. A full study has yet to be carried out.

Conclusions and References:

See at the end of the information on Norwegian rat (page 24).

Norwegian Rat (*Rattus norvegicus*) / Lera

Biology and ecology

- The Norwegian rat is larger and bulkier than the Black rat, probably reaching >400g, and is usually brown with a paler belly; the tail is also shorter than that of a Black rat.
- Omnivorous opportunistic feeder.
- Rarely able to climb more than a couple of metres up trees and shrubs. Nocturnal.
- Breeds throughout the year but more young are likely to be born in the wet season. In a newly colonised island they have maximum litter sizes and start breeding when very young, thereby having the potential for very rapid increase in numbers (= irruption) (Thorsen & Shorten 1997).
- Norwegian rats have the potential to devastate populations of ground-nesting seabirds, as well as having an impact on other fauna and also flora.

Presence in Seychelles

- Introduction date unknown. Found on the larger inhabited islands of Mahé, Praslin and La Digue, mainly around human habitation and e.g. the port area of Victoria.
- The only smaller islands know to have Norwegian rats have been the granitic islands of Conception and Fregate (where it was absent until July 1995) and the outer coral island of D'Arros; on all of these islands eradication programmes have been successful.

Control programmes

- Mahé: See Black rat (*R. rattus*) as both species are present and controlled by the same methods.

- Fregate Island: a privately owned granitic island of 210 ha, 55km east of Mahé, accessible by boat and small aeroplane, with high class tourism and agriculture as activities.

- o <u>1995/96</u> (***Physical and chemical methods)***: Following the July 1995 first sighting of Norwegian rats on the island and concern about their possible impact on the small, critically endangered Seychelles Magpie Robin (SMR) population, a ground-based control was started in September 1995 (Thorsen & Shorten 1997). Starting in November 1995 there was then a first ground-based eradication attempt, mainly on the plateau area where there was hotel construction. This was the first time eradication during the invasion stage of rat colonisation had been attempted (Thorsen et al. 2000) apparently anywhere in the world.
- o Trapping and poisoning took place in four phases. Note that there is unfortunately conflicting information in two reports on this programme, one unpublished (Thorsen & Shorten 1997) and the other published (Thorsen et al. 2000) with respect to the timing and certain details of methods of control that took place.
  1) *11 Sept - 28 Nov 1995*: Control was started in the plateau area (c.24ha), concentrating on the areas where rats had been seen and areas where they were likely to be e.g. around occupied buildings, small pools. Bait stations (30) made of 500mm lengths of bamboo were used, plus 150 self-set metal snap traps baited with poison (0.05g/kg of first generation anticoagulant Flocoumafen as it was the only bait poison locally available, there is no record of what the bait was), set at 10m spacing. Traps were set after 1600hrs and closed early morning to avoid trapping non-target species (e.g. SMR, skinks). A poison grid of 25m spacing was also established over the plateau but not fully implemented (Thorsen & Shorten 1997).

  Results were inadequately recorded due to computer failure but it took 3 days to capture a rat after setting up the snap traps, while bamboo/pipe traps took 45-55 days before a rat was captured (Thorsen & Shorten 1997).
  2) *28 Nov '95 - 20 Feb 1996* (First eradication attempt): Intensive trapping and poisoning mainly in and around known rat infestation areas. The central part of the 25m poison grid was used (set with 50 to 72 plastic bait stations) with 0.025g/km Difenacoum, an anticoagulant. This continued until December (no reason given for stoppage). Trapping continued but ceased on 20 Feb after a SMR was found dead in a trap (Thorsen & Shorten 1997).

  Monitoring lines of traps were set (no spacing given) on the plateau and nearby hill slopes between December 2005 and February 2006 to determine the extent of the rat infestation and to give an index of rat abundance. Traps were camouflaged by wire mesh covered with vegetation to stop SMR finding them, and set in the most likely positions of rat-runs; traps were set after 18.00 and closed by 07.00 (Thorsen et al. 2000). Trapping was largely discontinued after March 1996 because it was considered ineffective for detecting rat presence in low numbers (Thorsen & Shorten 1997) perhaps due to the plentiful supply of other food sources but also because of disturbance by giant millipedes, skinks, crabs etc.(Thorsen et al. 2000). The same was true for gnaw sticks.
  3) *21 Feb - 18 March 1996*: Poisoning using Difenacoum was intensified and the 25m poison grid re-laid and enlarged (179 bait stations) to cover a more extended area of the plateau. Poison supplies ran out 18 March.
  4) *8-27 June 1996*: Renewed funding allowed the programme to resume 8 June, using wax/cereal blocks containing 0.05g/kg Brodifacoum and cereal pellets containing 0.02g/kg Brodifacoum, over an extended area of 48 hectares (605 poison bait stations along marked transects and using c.10km of specially cut tracks, but no spacing recorded). A pre-poisoning risk analysis was carried out to determine what species might be affected by the poison and a monitoring system was set up for more sensitive species (Thorsen et al. 2000). Bait stations were fitted with wire stops to prevent lizards and crabs gaining access to the bait. They were checked daily and restocked as necessary. Bait pellets were to be distributed monthly by hand at 1.3kg/ha through the poison grid (Thorsen et al. 2000) but no method recorded. Poisoning was stopped on 27 June when 1 SMR was found dead and 3 or 4 others missing.
- o Results were poorly recorded but at least 85 rats were caught, mainly juveniles. Poisoning with Brodifacoum was stopped early because one Magpie Robin died (Thorsen et al, 2000 suggest this was probably from secondary poisoning after eating insects that had recently fed on poison bait) and three other birds were missing, presumed poisoned. By Sept 1997, island residents reported that rats had spread over the entire island (Thorsen et al. 2000).
- o Organisations involved: Birdlife International, advised by New Zealand Dept of Conservation, with assistance from Seychelles Dept of Conservation and National Parks, island/hotel management.
- o The eradication attempt of this newly establishing rat colony was unsuccessful but many lessons were learnt, including:
  - Norwegian rats exhibited extreme 'neophobia' (avoidance of any novel object), unlike rats in more established populations. Poisoning was therefore planned for three months but the deaths of the magpie robins curtailed this plan.
  - Food supplies were abundant, discouraging rats from investigating poison pellets.
  - Poison baits went mouldy, became unpalatable, and disintegrated after about 14 days.

        - Poison bait was consumed by many non-target species; therefore important non-target species must be penned or removed.
        - Funding sustainability is important. The intensified poisoning could not take place until financing was secured.
    - 1998: A feasibility study (bearing in mind the lessons learned from the previous unsuccessful attempt) was carried out to check the status of the rat population and to discuss and agree with stakeholders the details of the eradication plan and the implications for follow-up protocols. An assessment of non-target species that might be affected was also made and mitigation measures prepared, including aviaries and enclosures. Bait durability studies had already been carried out for the poison bait on Bird Island in 1995.
    - 2000 (***Chemical method***): Poisoning was carried out in May-July 2000. Rat index trapping was carried out before, during and after the operation. This was done by cage trapping (baited with grilled coconut pieces), with cages sited at 50 m intervals along an index line which took in the most common habitats. Traps were set and checked daily. Rat density was assessed as a standard index of rat abundance.
        - Most individuals of threatened species (Seychelles Magpie robin, Seychelles fody, Giant tortoise) were taken into captivity for the duration of the eradication programme. Livestock were restrained, water tanks and ponds were covered, roof-water catchment was disconnected. A population of Giant Tenebrionid beetles unique to the island, which had been greatly reduced in number while rats were present, had already been established at a zoo in UK.
        - First aerial bait application 8 June, using a helicopter with a spreader hopper with an 80m swathe slung beneath it. It flew along transects spaced at 40m, created by a differential global positioning system (DGPS). In this way poison pellets (active ingredient Brodifacoum at 20ppm) were distributed evenly and completely over the island. It was necessary to use an experienced helicopter pilot from New Zealand.
        - Second aerial bait application 5 days later - 13 June.
        - Third aerial bait application 24 days later - 7 July. A total of 7665kg poison bait was used, at a rate of 35kg/ha.
        - All threatened species released from pens and aviaries between 25 July and 22 August 2000.
        - Some non-target species of introduced bird were inadvertently poisoned: Madagascar turtle dove, Barred ground dove, Indian myna, Madagascar fody (between 50-80% of the local populations), and 90% of migrant Turnstone. No native reptiles or insects were affected.
    - Organisations involved: New Zealand Dept of Conservation, Seychelles Ministry of Environment and Transport, Fregate Island management and Birdlife Seychelles,
    - (All information from Merton et al. 2002)
    - Strict enforcement of stringent rodent quarantine and contingency protocols had to be put in place to avoid re-infestation, including a 1.1m high rodent fence at the harbour.
    - After 24 months (2002), the island was confirmed rat-free but it was noted that rat-abatement practices were not being well followed.
    - 2009: Rats have not been reported since 2000. It is not known for sure how well the protocols to prevent reintroduction of rats are being followed.

- D'Arros: A privately owned flat coral island of 150ha, in the Amirantes group of outer islands, about 220km from Mahé. Accessible by boat and small plane.
    - 2003: Rats were eradicated during a rat and cat eradication programme on the island. 150 rats were trapped and killed (U. Engelhardt pers. comm.). No details of the methodology made available.
    - Organisations involved: D'Arros island management, New Zealand expert, Nature Seychelles.
    - 2005: Eradication was confirmed successful during a follow-up survey by Nature Seychelles (U. Engelhardt pers. comm.).
    - 2009: Rats have not been reported since 2003. It is not known how well rat prevention protocols are being followed.

- Conception Island: An uninhabited privately owned granitic island c.69ha area, with no beaches and a difficult landing, situated 1.6km from Mahé. The island is home to the largest population of the (once critically) endangered Seychelles White-eye (SWE). This eradication was conducted as part of the ICS-FFEM Rehabilitation of Island Ecosystems project.
    - 2005: A rat eradication plan was produced in June but the operation was stopped in August by DoE requesting additional precautions to ensure minimum risks to the SWE population (of which an alternative transferred population had already developed on Frégate since 2001). Experiments with captive birds and observations on invertebrates provided with non toxic bait were conducted on Conception, and existing information and advice from experts were compiled, confirming the very low risk of secondary poisoning for an insectivorous arboreal species like SWE. However, it was decided to postpone the eradication until a second population was established on another island.

- 2007 (***Chemical method***): A helipad was built and the small field house was renovated by ICS in April. In July, 45 SWEs (18% of the population) were successfully transferred to North and Cousine islands.
- The eradication programme was carried out in August-September, and consisted of two aerial drops of Brodifacoum cereal pellets at 20ppm totalling c.23kg/ha, with the use of a local pilot. No DGPS used. Six quadrats of 10m x10m checked daily to control bait densities and consumption, and 3 index trapping lines (16 traps each) set up for less than a week. Intensive survey trapping conducted all over the island for another three weeks, then discontinued and repeated for a few nights about every two months. Rat abatement measures consist of six bait stations with Brodifacoum blocks around boat landing point and next to house and helipad.
- Wildlife monitoring (birds, reptiles, invertebrates) conducted before and after the eradication, and as part of ecosystem long term monitoring. No evidence of mortality of any animal species, in particular the SWE or any other birds, for which abundances remained stable or increased after the rat eradication.
- Organisations involved: Island Conservation Society, Helicopter Seychelles including local pilot, Department of Environment. Financed mainly with funds from the ICS-FFEM 'Rehabilitation of Island Ecosystems' programme, smaller sponsors and Environment Trust Fund.
- 2008-2009: The rat eradication on Conception was confirmed successful in October 2008, after a total of 1800 trap nights with no rats caught since the eradication. Since then, ICS has been conducting habitat rehabilitation and ecosystem monitoring every 1-2 months, and refills bait stations at each visit.
- More details in Rocamora (2005, 2007), Rocamora & Labiche (2008, 2009b) and Galman et al. (2009 in prep.), Rocamora et al. (2009 in prep.).

Rats (both species) - lessons learned and general control information

Lessons learned and conclusions

- If there is a new infestation of rats, it is important to act as soon as possible after rats are detected.
- Eradication is probably best carried out in the dry season, when food is less plentiful, as rats are more likely to be attracted to poison bait, and the bait lasts longer.
- Eradication of rats from small flat islands is relatively easy to do by hand broadcasting of poison bait if transects are cut. High granitic islands require helicopter spread of the poison bait.
- An eradication programme can only be successful when a systematic grid design is used for the poison application, and also for estimating the rat population prior to, during and after the poisoning.
- Likewise there needs to be a well designed monitoring system in place after the poisoning to ensure that eradication has been successful, e.g. utilising an appropriate grid coverage of bait stations, traps and detection devices (such as chew sticks). It is only through an absence of rodent sightings or signs over time that aerial operations in particular can be confirmed as successful. A waiting period of two years is the current accepted standard (Climo 2004).
- Although the advent of global positioning technology and spreader buckets has enabled aerial broadcast of rodenticides to become a routine operation, it still requires an experienced helicopter operator with a full understanding of the application process to ensure success (Towns and Broome 2003, in Climo 2004).
- Eradication of rats on inhabited islands and islands with threatened species is possible but mitigation measures are necessary to avoid sensitive non-target species being affected. A certain loss of some non-native non-target species may have to be accepted by land owners.
- Black rats (*Rattus rattus*) seem to be much more difficult to eradicate than Norway rats (*Rattus norvegicus*).
- The unsuccessful eradication attempts have either been as a result of a nucleus of rats remaining on the island (e.g. in mangroves), a tendency of adult Norwegian rats to show extreme avoidance of traps, or because of rat re-colonisation due to insufficient discipline in the application of rat prevention and abatement measures/protocols.
- Delays due to fears about poisoning of non-target threatened and native species, or due to problems with acquiring funding can affect the control programme, especially of new invasions.
- Sometimes 'knock-on' effects are unpredictable, e.g. increase of certain species due to the absence of rats which would normally have fed on them or competed with them.
- On an island where eradication has taken place, all personnel need to understand why vigilant following of rat-prevention protocols is of vital importance. Transient workers are a particular problem. As well as measures outlined below (e.g. rat-proof room, permanent bait stations), fumigation of containers may be required, and poison bait stations are necessary on all boats bringing materials to a rat-free island, plus

measures to avoid rat entry to boats prior to shipment (particularly if they are moored onshore or close to shore) (Climo 2004, North Island staff pers. comm.).

- If an island is uninhabited, or there are remote but accessible parts of an inhabited island, the danger of re-introduction by casual visitors (e.g. fishermen) is very high.

Some general information on rat control programmes and abatement protocols in inhabited areas (taken from Rocamora 2004)

- In addition to all above rat control and eradication programmes, there is an environmental health unit in the Ministry of Health which regularly conducts rat control operations around Victoria, on Mahé. Awareness campaigns are also conducted, providing information on preventive measures that people can take to limit rat populations around their houses, e.g. keeping areas clean and tidy, proper disposal of wastes. There are also several private pest control companies.
- After successful eradication programmes on individual islands, rat prevention and abatement measures have to be taken to prevent re-colonisation. These include strict control of boats landing on the island (e.g. only island boats are allowed); building a rat-proof room where all goods and materials are unpacked and checked for rats and other pests; rat traps or bait stations (with chew sticks and poison) placed around beaches and other landing points to detect any invasion so that it can be dealt with rapidly. *(Additional note from the editors: these should be permanent and serviced every 2 or 3 weeks).* In some cases a rat-proof fence around a harbour area may be required.
- Rat eradication operations are expensive, ranging from c.10,000USD (for 10 ha = 2004 prices) to 80,000USD (for 300 ha). Rat control on a specific small area using poison may cost around 100USD/ha/year. Rat control with rat traps is more demanding in manpower but is perhaps more ‘environmentally friendly’ and cheaper if done at a very small scale as there is no cost of poison involved.

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Feral Rabbit (*Oryctolagus cuniculus*) / Lapen maron

Biology and ecology

- An introduced species originally from southern Europe and now found worldwide.
- The rabbit is a medium sized grey-brown mammal with a short fluffy tail, long ears and a hopping gait.
- An herbivorous grazer, mainly of grasses and short herbs, preferring open areas but also making bushy and woody habitats for shelter.
- Largely nocturnal, coming out in the early evening to graze, but also seen during the day.
- They live communally in underground burrows and breed throughout the year, often producing litters of 8 or more young.
- They can be very destructive to plants in natural habitats.

Presence in Seychelles

- Date of introduction unknown but presumably as a food source.
- Domestic rabbits are raised as caged livestock on the main granitic islands. Feral rabbits are present on the tiny island of Recif, the flat Amirante island of Denoeufs and apparently on Cosmoledo (unconfirmed). Reputed to have been unsuccessfully introduced to a few other (un-named) outer islands in the 20th century (L. Chong-Seng 2009 pers. comm.)
- The only known place where a control programme was carried out is Bird Island, as a sideline of an eradication programme for Black Rats.

Control programme

- Bird Island: a privately owned, flat coral island 101ha, c.100km North West of Mahé, with a hotel. Rabbits were present on Bird Island by the early 1900s (Merton et al. 2002).
  - 1995: The density of rabbits was assessed visually as relatively few had been previously seen by island staff, mainly feeding in the open grassland of the runway.
  - 1996 (***Chemical method***): Poisoning was carried out after the end of the Sooty Tern breeding season, in October/November using the methodology employed for rats (see page 17 for additional details).
  - To target rabbits, as well as rats and mice, Brodifacoum poison (20 ppm) was used in standard 12 mm pellet form (green-dyed to make it hard for birds to see) and hand broadcast over the island using transects 50m apart, cut through the vegetation where necessary. One handful (about 100g) of pellets was scattered to the North, South, East and West and at the feet of the operator every 25m along each transect line, giving a cover of 4-5kg/ha. In the open areas occupied mainly by rabbits (about 30ha), where there were few rodents, a lower density (no figure given) was used. Broadcasting was carried out twice, 1 week after the start of the eradication programme and again ten days later.
  - By the third week there were no signs of rabbits.
  - 1998: Rabbit eradication confirmed (no methodology for survey given but presumably because they were no longer seen by staff). (All information from Merton et al. 2002.)
  - 2009: The island remains free of rabbits.

Conclusions

As there has only been one eradication attempt, it is difficult to make a full assessment. The poison (Brodifacoum 20ppm) successfully killed the rabbits but the initial and post-treatment surveys were not very systematic and in a different situation could have resulted in surviving rabbits being overlooked. The use of this particular poison can affect non-target species such as ground-feeding birds (see information regarding the use of this poison for rats) and should be used with this in mind.

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House Mouse (*Mus musculus*) / Souri

Biology and ecology

- An introduced species found worldwide.
- The House mouse is a small grey-brown rodent with a longish tail and comparatively larger ears and eyes than a Black rat.
- Largely nocturnal and able to climb trees etc.
- An opportunistic omnivorous feeder.
- Breed throughout the year but mainly in the wetter season.

Presence in Seychelles

- Present on many of the granitic islands (including Curieuse: S. Antha pers. comm.), often concentrated around human habitation and sometimes locally controlled by traps and glue.
- Although common on islands where they occur, few, if any, studies have been carried out on their impact and to date eradication programmes have not been very successful for this very small mammal.

Control programmes

- Bird Island: a privately owned, flat coral island 101ha, c.100km North West of Mahé, with a hotel. Mice were present on Bird Island by the early 1900s (Merton et al. 2002).
  - 1995: The density of mice was assessed visually only and relatively few were apparently present (no numbers given), but it was considered that numbers could increase significantly if the rats (present in high density) were eradicated.
  - 1996 (***Chemical method***): Poisoning was carried out after the end of the Sooty Tern breeding season, in October/November.
  - To target mice, as well as rats and rabbits, Brodifacoum poison (20 ppm) was used in standard 12 mm pellet form (green-dyed to make it hard for birds to see) and hand broadcast over the entire island along transects 50m apart, cut through the vegetation where necessary. Over most of the island, one handful (about 100g) of pellets was scattered to the North, South, East and West and at the feet of the operator every 25m along each transect line, giving a cover of 4-5kg/ha. Broadcasting was carried out twice, 1 week after the start of the eradication programme and again ten days later.
  - Mice may also have taken Brodifacoum wax blocks that were placed in bait stations above ground level (see Rat eradication programme for Bird Island on page 17).
  - By the third week there were no signs of mice (no method for surveys given, so presumably because they were no longer seen by staff).
  - 1998: Mice were again present around the hotel, having either survived the eradication attempt or reinvaded the island. (all information from Merton et al. 2002)
  - 2009: Bird Island still has mice present according to the IAS baseline study (Nevill 2009).

- Fregate Island: a privately owned granitic island of 210 ha, 55km east of Mahé, accessible by boat or small aeroplane, with high class tourism and agriculture as activities. There is no information as to when mice reached Fregate.
  - 2000 (***Chemical method***): Poisoning was carried out in the dry season, June-July. (For more detail about care of threatened endemic species on this island, see Rat control programme on page 23).
  - Poisoning as above for Bird Island, except that aerial broadcasting from a helicopter was carried out, and applied three times, the second after 5 days and the third after 24 days. For more details see Rat control programme on page 23).
  - 2002: Absence of mice confirmed (no techniques given), so the eradication was apparently successful, but rat prevention and abatement protocols (which would also affect entry of mice) were not being carefully followed (Merton et al. 2002).
  - 2009: Presumed eradicated (see IAS Baseline Data report by J. Nevill 2009) and not reported in IAS Questionnaire response from the island.

- Note on Denis Island and Curieuse Island
  - According to the IAS Baseline Data report (Nevill 2009) mice have been eradicated from these two islands but no report has been made available to confirm this for Denis. SNPA staff on Curieuse report that mice are common around habitation (S. Antha pers. comm.) although the IAS Questionnaire response from SNPA does not report this species as being a specific problem.

Conclusions

It is difficult to assess mouse eradication methods as it is not clear from the literature whether failure on small islands was due to the lack of systematic post-treatment surveying (Bird Island, Curieuse), with some mice surviving the poisoning; or whether eradication was successful but reinvasion took place, in which case the failure is due to lack of sufficiently stringent protocols. Note that the use of Brodifacoum poison can affect non-target species such as ground-feeding birds, and therefore should be used with appropriate precaution.

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Feral Goat (*Capra hircus*) / Kabri

Introduced goats have a long history as a food source in Seychelles but have not been considered a pest species except on Aldabra Atoll, a very large raised coral atoll and a UNESCO World Heritage Site 1,100km southwest of Mahé. The terrain is very difficult in many parts of the atoll as razor-sharp eroded limestone makes walking hazardous. Of the four islands that make up the atoll, only the largest, Grande Terre, and Ile Malabar had significant goat populations by the 1980s, with none on Polymnie (there probably were never any on that island) and very few remaining on Picard, the island where the Research Station is based. The atoll is managed by Seychelles Islands Foundation.

Biology and ecology

- The Goat is an herbivorous mammal believed to have been domesticated 10,000 years ago in the highlands of western Iran. Able to utilise a larger number of plant species than other livestock, goats thrive in harsh environments, and for this reason were introduced to islands to provide food for seafarers and fishermen. But they are particularly destructive in such environments and cause a huge loss in native vegetation due to their grazing habits.
- Males weigh between 45 and 55 kilos and females weigh between 25 and 35 kilos.
- Colouration is highly variable from mostly black, to various shades of brown, and from single-coloured to multi-coloured. Black anterior with brown posterior is a common pattern.
- Both sexes are physiologically capable of reproduction at about 6 months of age. They are highly social. Dominant males fight to win females. They follow a serial pattern and attend to one female after another as they come into oestrus.

History of goats on Aldabra

- First recorded by Rivers (1878) indicating goats had been introduced to Picard and the other islands, probably from Cosmoledo and Assumption.
- By 1900 the goats had “thriven exceeding”; in 1906 Dupont predicted that the goats would eventually reach the south east end of Aldabra and in 1916 he reported ‘hundreds of them’ at Cinq Cases. By 1929 Dupont reported ‘several thousands’.
- Later reports on the status of goats are contradictory. In 1968 relatively few goats were sighted, but by 1976/77 numbers were estimated at 500-600, and in 1985 at 1,300 (Coblentz et al. 1990). Out of concern for the native flora and fauna a decision was made to attempt to eradicate the goat population.
- Because no studies were made of the flora of Aldabra prior to introduction of goats in the late 1800s the true impact of goats on the ecosystems of Aldabra are impossible to quantify precisely, but are likely to have been intense (Coblentz et al. 1990).

Control programmes (***Physical methods***)

- Various methods can be used for eradicating goats, include poisoning, introducing predators or disease, or trapping (Coblentz et al. 1990), but only shooting was deemed appropriate for use in a World Heritage Site such as Aldabra.

- 1) 1987-88: Two visits were made to Aldabra totalling 11 weeks (1987: 2 trained marksmen; 1988: 3 trained marksmen). Goats were shot with small calibre centre-fire rifles. The programme was intended to reduce the population and was carried out in the areas know to be most frequented by goats. It was estimated that the total kill may have been as high as 70% of the goat population on Aldabra (Coblentz et al. 1990)
- 1989-92: Opportunistic hunting of goats by SIF field personnel. No exact figures available of numbers killed.
- 2) 1993-95 + 1996-97: An attempt was made to eradicate goats, employing the Judas Goat technique whereby the gregarious sociality of the goat is exploited by repeatedly relocating radio-collared goats and shooting the other members of their group (Taylor & Katahira 1988). The 28 Judas Goats were captured from the largest population on Grande Terre and equipped with radio transmitters but not sterilised. Two were taken for use on Picard and six for Malabar. Shooters used bolt action 0.223 calibre rifles with 3 x 9 telescopic sights. Shooters worked in teams of 2 early in the programme and then solo as numbers declined. A total of 832 goats were killed including 13 on Picard, 21 on Malabar, and 798 on Grande Terre. The overall kill rate was almost two times greater for Judas goat hunting (0.61 goats killed/ha) than traditional hunting (0.32 goats killed/ha). Follow up hunting during September 1996 to January 1997 resulted in 106 goats killed. It was hoped that the goats had been eradicated (Rainbolt & Coblentz 1999) and this proved to be so on Picard and Malabar (substantiated later as no goats or signs of goats have ever been seen since 1995 = 14 years of regular monthly monitoring trips on both islands). But evidently a few remained near Cinq Cases on Grande Terre (von Brandis 2007). (The likelihood of them having been reintroduced to this remote island by outside people is almost zero).
- 2000-2006: Opportunistic hunting on Grande Terre by SIF personnel using conventional hunting methods; c.250 goats were shot, and an estimated 100-200 remained (von Brandis 2007).
- 3) 2007- 2009: A new eradication programme has taken place using improved Judas Goat technology. Phase 1, Aug. to Dec. 2007: a team of 3 hunters and a veterinarian initiated the programme but were delayed by logistical difficulties (e.g. delays/difficulties with firearms import to Seychelles; delays in transportation to the atoll). In the 1st month, 12 Judas goats (8 female/4 male) were captured using dart guns. All were sterilised (pregnant females were aborted), and intense continuous oestrus was induced in all females to make them more attractive to male goats. Each was fitted with a tracking collar with a battery lifespan of 2-3 years. 202 goats were eliminated by the eradication team, which spent a total of 1153 hours in the field walking 2158 km. GIS was used to ensure that the entire island was systematically covered. Mean hunting success was 0.24 goats per hunting hour, with success declining steadily to the point that no goats were encountered during the final 150 hours of hunting (von Brandis 2007).
- Phase 2, 2008-09: Monitoring phase: The physical nature of the terrain and vegetation, and the huge area involved make it impossible to use ground or aerial techniques to flush any remaining goats out. Therefore SIF personnel were trained to use the telemetric gear and rifle and monitor the six remaining Judas Goats on a monthly basis for a period of two years. During the first 15 months of the monitoring phase, 14 goats were killed (6 females, 7 males and 1 of unknown sex). This phase ensures that any stray goats and all post-partum females and kids are located (the latter may stay in the bush for up to a year).
- Phase 2 extended to 2011: The monitoring programme has recently been extended from 2 years to 3-4 years to ensure success. This appears likely but depends on the diligence of Seychelles Islands Foundation personnel, the successful replacement of batteries in the tracking collars and survival of the operational Judas goats (SIF personnel pers. comm.).

Conclusions

Eradication has only been attempted on Aldabra Atoll and no other Seychelles islands are known to have had significant problems with feral goats. Although the attempt appears to be close to success, in such an extensive and difficult terrain it will be some time before the final results are known. The use of neutered Judas goats and a very systematic approach to the eradication over a longer period of time certainly seems more likely to be successful than previous attempts using shooting alone or Judas goats with only limited time available for the control programme.

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2. INVASIVE BIRDS

Several alien birds were introduced soon after human settlement of the islands, e.g. Indian Myna, Madagascar Fody. Others were introduced more recently, e.g. Barn Owl, Domestic Pigeon. Yet others arrive accidentally, e.g. Indian House Crow, House Sparrow. Many of these alien birds reproduce more rapidly than native birds as they have evolved in a mainland situation where resources are ample, whereas native birds have adapted to living on islands with limited resources. Some alien birds are predatory, others agricultural pests and some have become invasive, competing with native species and becoming dominant, thereby threatening native bird populations, e.g. Indian Myna. Certain widespread and populous alien species such as Madagascar Fody and Barred Ground Dove are not considered a threat by most Seychellois, whereas Indian Mynas are considered a pest by for example farmers. Several of these birds are now so widespread that control or eradication is difficult except perhaps on small island nature reserves, but even there it is complicated by the need to find a method that does not also affect native bird species. Recolonisation of such species to islands where control has been attempted is a continual threat. With the relatively new or repeating introductions, e.g. Ring-necked Parakeet, Indian House Crow, it may still be possible to keep their populations contained or at least under control.

Indian House Crow (*Corvus splendens*) / Korbo Endyen

Biology and ecology

- A now widespread Asian species.
- Large black bird with greyish patch on the back of the neck and round to the breast.
- A social omnivorous scavenger, very wary of humans. Learns quickly.
- A threat to native birds as it may take eggs and young, and also to other native organisms as it eats insects, lizards, plant buds, fruits and seeds, etc. (can also be a pest to farmers by eating fruits, possibly chicks, etc. and a health risk due to its feeding habits in rubbish dumps). Opportunistic feeder.
- Produces 4-5 eggs per clutch, once or twice a year.
- Capable of dispersing between islands.

Presence in Seychelles

- First arrived at Mahé on a ship in 1977 (5 birds); the 2 that survived bred successfully so that by 1986 there were c.25. The crows often settled around the rubbish dump at Anse Etoile until this was closed, after which they dispersed. Other crows were seen on Silhouette, Moyenne and Bird Island (Ryall 1986) but did not establish. Probably successfully eradicated from the granitic islands in 1994.
- Reintroduced to Mahé probably accidentally in 1998, presumably only one bird that was shot, but there have been sightings post-2000, possibly new introductions or natural arrivals. These have either been shot or have dispersed. The most recent new sighting was late July 2009 (R. Fanchette pers. comm.).
- Reintroduction via ships is likely to continue because of two main factors:
    a. On cargo boats, if a crow joins the ship, Parsee crew members will feed the crow as it is considered sacred in the Parsee religion. When arriving at the next port the bird usually flies off (L. Chong-Seng pers. comm.).
    b. Indian House Crows are now established in the Gulf of Aden, from which many ships continue on to Seychelles or pass close by, so the likelihood of new arrivals has increased (C. Ryall pers. comm.).

Control programmes

- Granitic islands (mainly ***Physical methods***): 1977: Of the 5 birds which arrived on a ship at Mahé, 2 were shot (Ryall 1986).
- 1977 and 1986: 9 more birds were shot (Skerrett et al. 2001).
- 1986-1994 (***including Chemical method***): Advice given in 1986, when there were c.25 birds, not to shoot the birds when they were together, was apparently not followed (C. Ryall pers. comm.). Of 3 dispersed birds that were found roosting together at Glacis, 1 was shot by a police marksman with a .22 rifle, 1 was probably injured and 1 survived. Later 12-22 crows were seen at Machabée. Attempts were made to poison them using alphachloralose (which is slow to act so does not make other individuals wary straight away) - first by pre-baiting with chicks set out on a rock to attract the crows, then adding poison. It was not very successful (only 2 crows poisoned) as the local dogs found the bait and had to be chased away (L. Chong-Seng pers. comm.).
- Efforts to eradicate included a SR500 bounty on a dead house crow, and publicity to encourage the general public to report any sightings. One person brought a crow chick and 2 dead ones were brought in.

- Sighted birds were shot when possible (by a good police marksman, as only police and army personnel are normally licensed to have firearms); Between March 1992 and November 1993, 4 were shot (government records: R. Fanchette pers. comm.). By 1994 eradication was probably complete as no other birds were sighted anywhere on the islands.
- 1998: A new introduction was probably only one bird and this was shot. The general public was made aware of the need to report any new sightings of crows.
- Post-2000: other birds have been sighted - but have either left of their own accord or been shot (3 birds shot between 2002 and 2005 according to government records, R. Fanchette pers. comm.).
- 2009: At least two birds sighted and 1 shot so far this year. Media article appeared in local newspaper. Vigilance is still required and the general public is encouraged through the media to continue to report any birds seen to the Conservation Section in the Dept of Environment. The SR500 bounty remains in place.
- Time and cost factors unreported but consisting of man-hours plus cost of transport fuel and ammunition. Also the SR500 bounty for each dead bird.

Conclusions

Shooting individual crows is effective, particularly if they are solitary. Poisoning (at least with alphachlorolose) does not seem to be effective as non-target species are likely to be affected. The Indian House Crow is likely to reinvade and vigilance is required by all. Shooting by a qualified marksman still seems to be the best way to deal with new invasions.

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Ring-necked parakeet (*Psittacula krameri*) / Kato ver (kolye roz)

Biology and ecology

- An Asian and North African species.
- Unmistakeable large green parakeet with long tail and hooked red bill. The red-pink collar only develops in adult male birds.
- Often gregarious and roosting together.
- Feeds on seeds, fruits and flowers, becoming a pest for fruit tree owners in some areas of Mahé. It could perhaps also disperse certain invasive plants.
- Capable of dispersing between islands.

Presence in Seychelles

- Almost certainly introduced (1 sighting 1974 and noted throughout the 1980s). Reached Silhouette in 1995 (Matyot in Skerrett et al. 2001)
- New introduction in 1996 of 2 pet birds, one of which escaped (the other reportedly died). According to Skerrett et al. (2001), other birds may have arrived on board ships but this is considered unlikely by Fanchette (pers. comm.).
- 2006: 1 parrot was seen on Praslin (R. Fanchette pers. comm.) but has not been seen since (M. LaBuschagne pers. comm.)
- Numbers have significantly increased over the years, with small flocks seen in many places around Mahé. Environment staff recorded 84 birds roosting in a bamboo at Jardin du Roi (Anse Royale) (R. Fanchette pers. comm.) and estimated a population of <200 (M. Athanase pers. comm.). A French volunteer did some field work and estimated only c.70 birds.
- 2009: so far the population does not seem to have spread to islands other than Mahé, but the Parakeet represents a possible competitor for the native Black Parrot on Praslin if it gets there.

Control programmes

- Granitic islands (***Physical method***): Some awareness-raising was carried out by the Ministry of Environment and people were encouraged to phone the ‘Greenline’ number if they saw flocks of birds. Some shooting was carried out but the stock of suitable ammunition ran out. There has been limited ongoing visual monitoring.

- 2009: Possible projects are being considered by the Department of Environment.

Conclusion

Shooting may appear to be the most effective way to deal with the Ring-necked Parakeet, but because this bird tends to fly in flocks, individuals may well become gun-shy quickly and possibly be more likely to disperse to other islands. However, some action is urgently required for this species, to prevent it spreading, in particular to Praslin, and to eradicate the current Mahé population. No particular methods can be recommended at this stage.

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House sparrow (*Passer domesticus*) / Mwano

Biology and ecology

- Very widespread, having been introduced into many countries.
- Small brown bird, slightly striped, similar to a female Madagascar Fody. Male with more distinctive black and white markings on the head when breeding.
- Frequents human habitations, social and gregarious.
- Feeds mainly on seeds (and insects when breeding) but will take flower buds, food scraps, etc.
- Can be quite aggressive, so likely to complete with native species, especially small passerine birds on protected islands in Seychelles.

Presence in Seychelles

- Introduced into the Amirante islands some time in the past and now present on several of those islands. Origin unknown but possibly off a ship (or possibly via Mauritius).
- A questionable report of a small flock of sparrows on Mahé in 1965.
- Several new introductions occurred on Mahé in the 1990s and 2000s, presumably coming off international vessels but also possibly on local inter-island ships coming from the Amirantes islands. Usually such introductions have been controlled before they dispersed far but in 2002 a small breeding population was discovered in the Port Area of Victoria.
- Currently assumed to have been eradicated as there have been no further reports, but reinvasion from boats is likely (Hill & Currie 2007).

Control programmes

- Amirante islands: No known attempt to eradicate in the Amirantes, where they are known to compete with the Madagascar Fody (also an introduced species!) around human habitation.

- Mahé: 2002 (***Physical methods***): A small newly established breeding population in the Port Victoria area on Mahé was estimated at 10-20 individuals by staff of the Conservation Section in the Division of Environment.
- Various trapping methods were tried at feeding sites. Mist nets, bait stations comprising rat glue spread on cardboard with coconut as bait, and food bait under a propped-up crate or net system, were variably successful (1 caught in a mist net, 2 with rat glue and 5 [all juveniles and sub-adults] with feeding traps).
- The breeding site was located as regulator holes of fuel storage tanks at the power station. A specially designed wire and net trap 15cm x 30cm was fitted over the nest hole entrance when a bird was inside. Eight adults and 2 juveniles were caught in this way.
- Over a period of 11 months, most of the birds were killed, leaving only 2 adults, one of which was shot a few months later, leaving a lone male that it was assumed would eventually die. (All information from Fanchette 2003)
- Occasional new arrivals have also been dealt with by Division of Environment personnel. Reports of new arrivals depend mainly on port workers or other observant people. There is a certain amount of public awareness, with people being asked to phone the Greenline if they see any unknown animals.

Conclusion

The House Sparrow could well invade again, so vigilance is required by all. The various methods tried were eventually effective in eliminating this species, particularly through targeting nest sites and trapping young birds. These methods could be tried again if more than 1 or 2 birds arrive but need to be used systematically.

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Barn owl (*Tyto alba*) / Hibou

Biology and ecology

- Introduced from East Africa (it is the sub-Saharan race *affinis*). Other races are widespread around the world.
- Large light brown bird with pale underparts and a large head with a flat white face.
- Nocturnal and rarely seen during the day time.
- Feeds on small mammals (rats, mice, tenrecs), fairy terns (and other terns), lizards, frogs, large insects.
- Capable of dispersing between islands.

Presence in Seychelles

- Barn owls were introduced deliberately to Seychelles as a biological control agent for rats (*Rattus rattus*) in coconut plantations (copra being the chief export crop at the time).
- Introduced first to Platte Island (3 birds) in 1949 but failed to survive. Two subsequent releases on Mahé in 1951 and 1952 (a total of 27 birds) were more successful and by 1956 the birds were breeding successfully. They were reportedly feeding mainly on rats (80%) but also on fairy terns (*Gygis alba* 20%) which were easily spotted by the owls at night because of their white plumage.
- By 1958 owls had spread to Praslin, Silhouette, North Island and Aride (a seabird island where there was a greater choice of terns to feed on). By the early 1970s it was present on most inner islands.
- Currently present and breeding on most of the larger granitic islands (populations unquantified), but it also visits other islands to feed, and regularly recolonises smaller islands where it has previously been eliminated and is now subject to control measures, e.g. Aride, Cousin, Cousine, North.

Control programmes

- Central Granitic islands: Because the Barn owl was found to prey on fairy terns and to have a relatively small impact on rat populations, its status became one of pest instead of useful biological control agent.
    - By 1969 a bounty had been raised on its head - SR 5 per bird. 22 owls were caught in 1969 and 29 in 1970 (Government Agriculture annual reports).
    - The bounty was raised to SR 30 in c.1990. Occasionally people have captured and killed the endemic Scops owl (*Otus insularis*) by mistake.
    - Record keeping may have been falsified in some years in order to obtain the bounty money (L. Chong-Seng pers. comm.) as no physical records, e.g. beaks of dead birds, were kept.
    - Currently when a dead Barn owl is handed in, the bounty money and a receipt are given. There is still no collection of the beak or other part as proof of death (R. Fanchette pers. comm.).

- Aride Island: a small granitic island 73ha, 8 km north of Praslin, managed as a nature reserve since 1975; now managed by a local NGO, Island Conservation Society. Landing is by means of the island's small boats only. Barn owls are attracted due to the presence of very large populations of nesting seabirds, including fairy terns and roseate terns, which are easy prey.

  Physical methods
    - 1996: Survey of population, including roosting and nesting sites, and eradication programme started. 18 birds (including 6 breeding pairs) were recorded and 16 killed or found dead, out of a population estimated at 20 birds. Larson traps and noose carpets used (thin nylon fishing line loops tied to wire mesh over a box containing live bait). Noose carpets also placed in nest sites.
    - 1997-1999: Three nesting attempts recorded in 1997, 2 in 1998 and none in 1999. All known barn owls were eliminated (5 in 1997, 4 in 1998, 2 in 1999) as part of the continuing eradication/control programme, with continuous reinvasion suspected from Praslin (8km away). A captive barn owl was used to attract isolated individuals until it died in 2001.

- 2000-2002: One nesting attempt reported in 2000. Continuous reinvasion from Praslin, and a total of 15 owls killed or found dead (4 in 2000, 3 in 2001, 8 in 2002).
- 2003-2004: Continuous reinvasion from Praslin reported. 4 birds shot in 2003, 4 shot between August and November 2004 (2 had mice in the stomach) (Aride annual reports 2003 & 2004).
- 2005-2009: Work to control Barn owls carried out through the ICS-FFEM 'Rehabilitation of Island Ecosystems' project. 2005: At least 1 bird found dead (Aride annual report 2005); 2006: Three owls killed and 1 found dead. Over 50 adult Roseate terns killed by barn owls, plus a number of Fairy and Bridled terns (Aride annual report 2006); 2007: 3 owls killed and 1 found dead. 20 adult Roseate terns killed by Barn owls (Aride annual report 2007).
- 2008: 2 birds killed. Specific project started to survey the whole island, revisit all potential Barn owl nests and roosting sites, and eliminate all nests and individuals found. Serious difficulties due to problems in obtaining authorisation from Police to renew licence for a new gun.
- 2009: New gun available and in good working condition by March and tape-luring sessions conducted across the island in April/May. Only 1 owl found and killed (May) and no other birds believed to be present. However, at least one owl present in July when 20 Roseate terns were found killed, probably following recent reinvasion. Long term protocol for control and eradication reviewed and recommendations to improve it.
- Despite regular reinfestation from Praslin, and the fact that surveys are difficult to carry out during the main seabird breeding season (May-September), this programme successfully controls the owls and prevents the re-establishment of a breeding population. Protocol ongoing, with regular checks and surveys of known nesting sites to be conducted every year. Tape-luring and fire arm, or noose carpets with live bait will be used to destroy the owls.
- More details in Rocamora & Jean-Louis (2008, 2009), Yeandle (2009).

- North Island: a privately owned granitic island of 201ha, 27km northwest of Mahé and 6km north of Silhouette. Accessible by boat and helicopter. High class eco- tourism establishment.

  Incidental deaths (physical and chemical)
  - 2003: A few Barn owls were known to exist on North Island prior to the 2003 rat and cat eradication attempt. Two dead Barn Owls were collected during the eradication attempt period, probably affected by secondary poisoning after feeding on dead or dying rats (Climo 2004)
  - 2005: A few Barn owls were still present and 2 were found dead during or immediately after the second rat eradication (September) carried out through the ICS-FFEM 'Rehabilitation of Island Ecosystems' project. It is believed that any remaining owls died incidentally due to secondary poisoning or from starvation due to lack of food (Climo & Rocamora 2006).
  - 2006: Subsequent reinvasions (presumably from Silhouette) resulted in the death from starvation of 2 additional owls in September (one found dead & one in bad shape). No shooting was necessary (L. Vanherck pers. comm.).
  - 2009: one additional bird found dead, possibly from starvation. Subsequent recolonisation from Silhouette is likely to continue in the future but currently there is little food for Barn Owls on North Island as rats have been eradicated and sea birds are not common (Rocamora & Jean-Louis 2009).

- Cousin and Cousine
  - ***Physical method***: one resident Barn owl believed to be present on Cousin in 1999, and birds were occasionally seen on Cousine (Dunlop et al. 2005). On both these small islands reinvading Barn owls are apparently currently successfully controlled by shooting.

- Time and cost factors

  Unknown but regular surveys require effort on small steep islands where owls are controlled. Cost of gun and ammunition. Time, effort and fee to acquire appropriate licences.

Conclusions

On small islands with seabird populations, newly invading Barn owls are best dealt with by rifle shooting, but this has to be done by a licensed marksman. However they can also be controlled using noose carpets or nets in conjunction with a decoy, taped calls and/or live bait. There are no reports of how birds were/are captured and killed on the main granitic islands in order to claim the bounty.

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Indian Myna(h) / Common myna (*Acridotheres tristis*) / Marten

Biology and ecology

- Originally from the Indian sub-continent but now more widespread in the tropics due to introductions.
- Medium sized dark brown bird with a yellow beak and eye patch, and a noticeable white patch on each wing.
- Common around human habitation but wary of humans. Learns quickly.
- Often roosts communally in noisy colonies (particularly when there are large populations), except when breeding.
- Somewhat aggressive towards other birds. Competes with some native birds for nest sites. Breeds mainly in the wet season (October to March). Lays 2-4 eggs, often raising 2 or 3 young.
- Omnivorous, feeding on fruits, seeds, insects, small reptiles, carrion, and may take small bird eggs from nests. Opportunistic feeder. Competes with certain native birds for food sources. Disperses seeds of several native and alien plant species. Also a pest to farmers and fruit growers.
- Capable of dispersing between islands.

Presence in Seychelles

- Introduced to Mahé from Mauritius in the late 18th or early 19th century (Millett et al. 2004).
- Common on most of the central granitic islands, and also the inner coral islands of Bird and Denis.
- Considered a particularly problematic species for the survival of the Seychelles Magpie Robin which was previously the most threatened bird of Seychelles.
- Eradicated on Cousin, Cousine and Aride with reinvading birds being shot. Some control has taken place on Fregate and Denis, as well as North Island.

Control programmes

- Fregate Island: a privately owned granitic island of 210 ha, 55km east of Mahé, accessible by boat or small aeroplane, with high class tourism and agriculture as activities.
    - 400-600 Mynas estimated to be present before control (Millett et al. 2004 but no method given).
    - 1992 (***Physical and chemical methods***): A BirdLife International feasibility study took place in which several control methods were tested, of which Chardonneret traps and clap traps proved ineffective, and mist nets and Larsen traps with live decoys had only limited success. Snares with live or dead decoys and call playback were also not effective.
    - Baits of different types were tried, with raisins being preferred over fish, rice, papaya and coconut. Food offered on the ground was successfully taken but not from food tables.
    - Alphachloralose (a stupefactant) at 2.5% was trialled on captive birds but the palatability of the food was reduced and aversion occurred, so its effectiveness was reduced. Other poison could not be considered as there were endemic species that could have taken the poisoned bait. Therefore shooting was subsequently the preferred method of control (Millett et al. 2004).
    - 1993-1997 (***Physical method***): Shooting with a .22 calibre rifle was started in 1993 during occasional visits by a police marksman, and went on until 1997. During this time 326 birds were

killed (Millett et al. 2004) but lack of consistent effort reduced the overall impact on the myna population.
  - 1998-2002 (***Physical methods***): An air rifle fitted with a silencer and telescopic sight was acquired in 1998 for permanent use on the island (by experienced Nature Seychelles staff managing the threatened Seychelles Magpie Robin population). Regular shooting (using domed tip pellets) was carried out between August 1998 - November 2000 and June 2001 - June 2002, with the interim period affected by lack of skilled staff, during which time the number of birds again increased. Efforts were concentrated at feeding and roosting areas (often shooting from hides), and at known territories in the early morning and late afternoon, depending on the season. A total of 394 birds were killed and by the end of 2002 only 8 birds were thought to remain (Millett et al. 2004, no method given).
  - In 1999, nest trapping was also trialled, using bundles of 6-8 fish-line nooses fixed inside the entrance of nest boxes known to be inhabited by Mynas (boxes originally set up for Magpie Robins but often used by Mynas). These were effective at capturing adults once young birds were in the nest.
  - 2002: Conservation management of the Seychelles Magpie Robin was handed over to the island management (Millett et al. 2004).
  - 2009: Myna numbers have increased significantly again and are starting to impact native bird populations (E. Payet pers.comm.). Control is still by shooting but details not available (IAS Questionnaire).

- Aride Island: a small granitic island 71ha, 8 km north of Praslin, managed as a nature reserve since 1975; now managed by a local NGO, Island Conservation Society. Landing is by means of the island's small boats only.
  Physical method
  - 1993-1994: Control of Mynas was carried out by the Royal Society for Nature Conservation (RSNC) using shooting. A police marksman shot 16 out of 17 birds, leaving one lone bird (Millett et al. 2004) (fate unknown).
  - 2001: Two birds which arrived in 2001 were immediately shot. Eradication recorded as complete (Millett et al. 2004).
  - 2009: Occasional birds fly in, probably from Praslin, but often fly off again and do not settle (Aride Island Warden monthly reports). However vigilance is required. One gun remains on the island for contingency purposes.

- Cousin Island: a small granitic island of 28ha, 4km to the south west of Praslin, a special reserve since 1975 and managed as a nature reserve since 1968; now managed by a local NGO, Nature Seychelles. Landing is by means of the island's boats only.
  - 2000-2002 (***Physical methods***): Population of Mynas estimated at 6-10 birds (no method given). Control programme using nest trapping and shooting with a .22 calibre air rifle at known feeding sites. A competent marksman was used and concerted effort. The last bird was killed in 2002 (Millett et al. 2004).
  - Dunlop et al. (2005) regarded the myna as eradicated form Cousin. The island is small so any bird is quickly seen by nature reserve staff.
  - 2009: No further information made available but assumed that any birds that reinvade are shot as soon as possible as this is a bird reserve.

- Cousine Island: a privately owned small granitic island of 25ha, 5km from the southern coast of Praslin, accessible by boat (landing is only by the island's boat) and helicopter. Managed as an unofficial nature reserve with very small scale high class tourism.
  Physical methods:
  - Before 1995 there had been an irregular control programme in place which included shooting and trapping (with a bounty system in place) (Millett et al. 2004).
  - 1999: 1 bird sighted and recorded in the island (Hill 2002).
  - 2001: At least 3 pairs remaining on the island, all gun-shy. Millett et al. (2004) claim that the lack of eradication success was due to inconsistency of effort, use of a poor firearm and less skilled staff.
  - Post 2002: Dunlop et al. (2005) record the ongoing presence of Mynas on the island, with control by shooting. The authors also mention that there is a constant possibility of reinvasion from Praslin (for some reason this seems more common on Cousine than Cousin, 2km distant), so constant vigilance is necessary.
  - 2009: No further information on control/ eradication made available but further attempts presumably successful as the Questionnaire response from Cusine Island states that birds only arrive occasionally and are shot on sight.

- Denis Island (2000): a privately owned, flat coral island of 143 ha, 95km north of Mahé, accessible by boat and small plane. High class tourism but also managed partly as a nature reserve by a local NGO Green Island Foundation.
  - Commonly seen on the island prior to 2001 (Hill 2002). Millett et al. (2004) quote 300-350 birds in early 2001.
  - 2001 (***Chemical and physical methods***): Control carried out as part of a GEF funded Avian Ecosystems Restoration Project). Tests showed that boiled rice and grated coconut were acceptable baits. Pre-baiting for one week in areas frequented by Mynas was followed by poison baiting for a further 7 days (using 2.5g DRC1339 per kg bait). All uneaten bait was removed before nightfall as a precaution to protect native species. The only endemic bird present at the time was the Blue Pigeon which eats small fruits on trees but not other food and very rarely from the ground.
  - After significant reduction of Mynas visiting these areas, poisoning was extended to other areas, using bread spread with butter into which DRC1339 was mixed and also spreading the butter mix on papaya fruits.
  - Shooting (as for Cousin and Fregate - see above) was the follow-up method but the project was terminated towards the end of 2001 due to the renewed presence of black rats on the island, which reduced the possibility of the island being used for endemic bird reintroductions.
  - Overall, 75-90% are estimated to have been killed, with about 40-60 birds remaining at the end of the programme (no estimation method given).
  - All information from Millett et al. 2004.
  - 2009: No further information available except that Mynas are still present and Seychelles Magpie Robins have been introduced (amongst other introductions following successful rat eradication) (http://denisisland.blogspot.com).

- North Island: a privately owned granitic island of 201ha, 27km northwest of Mahé and 6km north of Silhouette with high class tourism resort. Access by boat and helicopter. This eradication attempt was carried out as part as the ICS-FFEM "Rehabilitation of Island Ecosystems" project.
  - 2005: After the successful rat eradication in August 2005, where Brodifacoum pellets were used during aerial applications, the myna population (estimated at 850 individuals) was found much reduced (by over 50% between August and December). A 3-phase Myna eradication plan was drafted by ICS-FFEM experts and NI environment staff. Unfortunately, too much time was left between the rat eradication and the subsequent targeted myna eradication, due to which the numbers had gone up considerably again by the time Phase 1 started.
  - 2006: Phase 1 = ***Chemical method*** using DRC1339 (3-chloro-4 methyl benzenamine hydrochloride, tradename: Starlicide) which is highly toxic to Mynas, at the rate of 2.5gram per one kg of bait [LD_{50} estimate 1-5mg/kg]). Death is caused by renal failure, is passive and considered humane. Total cost: 480 Euros.
  - Extensive pre-baiting trials revealed that Mynas were more attracted to kitchen/canteen food waste than to the baits tested, e.g. coconut + rice, papaya, raisins + cheese, so this was used instead. Bait stations were 50cm diameter round bin lids with holes for drainage, partially buried in the ground, after it was confirmed that raised feeding tables did not attract Mynas. Bamboo and coconut containers were not effective.
  - After several days of pre-feeding, DRC1339 was applied to the bait, using different stations around the plateau at places where birds were seen in large groups or occurred regularly. All visitations to the stations by birds were monitored. In one area, where food waste was dumped on a regular basis, no pre-baiting was necessary but all previous food waste was covered with sand. Protocols were followed during both pre-baiting and baiting phases.
  - Poisoning was continued on and off in March/April 2006, although the number of Mynas visiting bait stations reduced considerably by the second month, allowing a small number of non-target species (almost entirely non-native species) to find the bait. The Myna population was estimated from simultaneous counts on the plateau to have been reduced by about 70% to c.80 birds, although this was never corroborated by point count results that gave a much higher figure. 400 Mynas were seen taking poisoned food but only 52 were found dead. Poisoning was stopped when its efficiency reduced dramatically due to bait-shyness of Mynas and increased attraction of non target species.
  - Phase 2 = ***Physical methods***: Shooting. The eradication plan recommended that shooting should start only when the population has been significantly reduced by poisoning. Shooting is carried out using a .22 air rifle with a 7x or 8x telescopic sight. The rifle must be used by an experienced marksman who knows well Myna behaviour. It is crucially important to shoot only single birds or pairs (not groups, as this leads to gun-shyness amongst the survivors), in the morning or early evening, in different places each time and preferably under cover.
  - Unfortunately it took a very long time (c.2 years) to get the necessary authorisation from Seychelles authorities to use the rifle and as a result the population of Mynas built up again after the poisoning stage. As a stop-gap, in March 2007 the additional Stage 3 method = nest box trapping was tried. 36

nest boxes were set up at various places on the eastern plateau and around the kitchen waste dump site on the west side, and checked every month. Once nesting material was found inside, nests were checked more regularly. Very few boxes were inhabited and only chicks/eggs destroyed as no nooses were placed to catch the adult birds. Outside the breeding season, boxes were left on the trees with their entry holes blocked off. This method was rated ineffective (at least at this point as it should have been employed at the very end of the eradication after completion of the shooting phase) due to its labour intensiveness and small catching success (10 young and 9 eggs destroyed in 22 months) and all nest boxes were closed off end January 2009. A decoconutter, contracted every 3 months, however, continues destroying nests found in coconut trees.

- o ***Chemical method***: Poisoning with DRC 1339 was carried out again in May 2007 and July 2008, with limited success, whilst awaiting authorization of the rifle. During the last effort, it became clear that the technique could no longer be used due to the risk of poisoning non-target species which were less shy than the Mynas and approached the bait first (mainly Madagascar turtle doves and Moorhens, the population of the latter having substantially increased after rat eradication). Some experimenting with little success has been done with trapping methods (trap door over pit with bait, nooses on the ground).
- o 2008-2009 (***Physical method***): Because of the problem with obtaining the gun permit, the Myna population increased again to at least 250-300 birds. A North Island staff member licensed to use a rifle started shooting in November 2008 and 144 birds were shot by June 2009. North Island is continuing the eradication/control efforts after the conclusion of the project as numbers have not been brought down sufficiently. The nest boxes may be reopened during the next breeding season, with nooses to also catch the parent birds (North Island staff, pers.comm.).
- o The number of Mynas killed since 2006 lies between an observed minimum of 263 and a more likely maximum of 611. Total eradication may not be achieved; hence control may be the more practical solution bearing in mind some reinvasion will always occur from Silhouette.
- o More details in Bristol (2006) and in FFEM project progress reports (provided by L. Vanherck, G. Wepener, S. and G. Rocamora).

- Conclusions:
  - o The learning ability of Mynas necessitates careful choice of control methods as they easily become wary of anything suspicious.
  - o DRC1339 poison (at 0.25% applied in food bait such as grated coconut and cooked rice) is very effective on islands with large Myna populations, but cannot be used where there are ground feeding endemic birds that could take the poison bait (unless these are kept isolated in some way).
  - o Alphachloralose (stupefactant) is not very effective in warm climates.
  - o Shooting with some kind of air rifle can be effective on small islands if it is done consistently but carefully by a skilled marksperson, otherwise the birds become wary of people.
  - o Nest trapping or nest-box noosing is not very effective on its own but can be used as a follow up method to trap birds that have become otherwise wary.
  - o Small islands close to islands where Mynas are established are liable to be reinvaded.
  - o On large islands, eradication from one area of the island is probably not possible due to constant reinvasion from non-controlled areas.
  - o In Australia, where this species has also become a pest, new types of traps have been devised, which aim to provide 'a home away from home' for several days before actually trapping the birds. Food, shelter and perches are provided in special open cages, allowing other birds to be attracted and to roost inside. After some time the cages are closed and the birds killed with carbon dioxide (ISSG 2009). However, this can only ever control Myna populations, not eradicate. It may be worth experimenting with such traps in Seychelles for certain situations.

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Red-whiskered bulbul (*Pycnonotus jocosus*) / Merl konde

Biology and ecology
- Originally from the Indian sub-continent to southern China, but widespread due to introductions.
- Medium sized brown bird with white underparts, an erect black crest and scarlet ear patch.
- Usually solitary, often territorial, frequenting bush areas.
- Mainly insectivorous, but also feeding on small reptiles and birds.
- Probably capable of dispersing between islands.

Presence in Seychelles
- Introduced to Assumption from Mauritius probably in 1976, apparently along with Barred Ground dove, Mozambique serin and Madagascar fody, and in contravention of Seychelles law according to Prys-Jones et al. (1981). Red-whiskered bulbul increased from c.6 birds in 1977 to c.200 in 1986, to c. 1,000-1,500 birds in 1997 (Prys-Jones et al. 1981).
- The presence of the Red-whiskered bulbul (RWB) on Assumption presents a threat to the native bulbul and other birds at the World Heritage Site of Aldabra which is only 27km distant.
- Not recorded from other islands.

Control programmes

- Assumption Island: a large raised coral island 1171ha, c. 1000km from Mahé and c.27km south east of Aldabra, managed by the Island Development Company. Access is by means of an airstrip or by boat. Previously mined for guano.
- There have been several proposals to initiate eradication of all four invasive birds on Assumption (viz. Red-whiskered bulbul, Barred ground dove, Mozambique serin and Madagascar fody) due to the relative closeness of Aldabra, e.g. Roberts 1988, SIF 2005. None have materialised.
  - 2005 (***Physical method***): The only known attempt at control was a somewhat misguided experiment in early 2005 to get workers on Assumption to kill as many RWBs as possible on being offered a bounty of SR75 per bird. The method used was to capture individual birds at night after locating them at roosting places using a head torch with a red filter. No proof (e.g. beak) was required for the death of each bird.
  - By mid-2005 the SIF Science Committee requested that the culling of RWBs be stopped and a feasibility study done to prioritise the four alien bird species and also assess the possible effects of removal of one species on the other three.
  - In August 2005 it was reported that a bounty had been claimed for more than 220 RWBs killed by workers on Assumption and they were paid in accordance with a prior agreement, but the culling had stopped.
  - G. Rocamora said that shooting would not be sufficient and nets/poison would be necessary. It was agreed that a survey is required first (Seychelles Islands Foundation Feb. 2005).
  - 2009: A further RWB eradication proposal is to be worked on soon.

Lessons learned

- Delay in removing alien birds, particularly the red-whiskered bulbul resulted in large increases in the population (which may also be a result of changes in vegetation structure on Assumption). With increased time and numbers, the chance of birds flying off, or being swept off by strong winds, and landing on Aldabra becomes greater and greater.
- Any attempts at control require feasibility studies and systematic follow-up.

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Other bird control programmes:

Cattle egret (*Bubulcus ibis*) / Madanm paton

Although this is a native species, the authorities decided to reduce the numbers feeding at the municipal land-fill and rubbish dumping areas because there were a couple of air strikes involving planes at local airports. Airports at both Pointe Larue (Mahé) and at Amitié (Praslin) were implicated because the landfill / rubbish dump is within the flight path of the runways.

Poisoning (no name given) was tried but was not very successful, presumably because there is too much choice of other food. Control is carried out by shooting at the rubbish dump, and more recently at the communal breeding site on Mahé, which is at Ile Hodoul, near Victoria.

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3. Other invasive animals

Alien animal species still occasionally arrive on ships in the Port Victoria area. Usually they have been recorded, killed e.g. by the veterinary services, and pickled. Pickled specimens exhibited at the annual Agricultural and Horticultural Show raise a lot of interest in the general public and help to create awareness of the dangers of new introductions. In some cases these accidentally introduced species have colonised an area or an island. Major examples have been the Crazy Ant (*Anoplolepis gracilipes*) and more recently, the Crested Tree Lizard (*Calotes versicolor*).

In addition there have been introductions of exotic animals as a result of politically-expedient gifts / exchanges, usually short-term but occasionally requiring interventions.

Another source of alien species is through illegal personal introductions of pet and aquarium animals.

Crested Tree Lizard (*Calotes versicolor*) / Lezar sinwan

Biology and ecology

- Originally from South and South East Asia, but widespread due to introductions. Found also in Reunion and Mauritius.
- Prefer somewhat open areas, e.g. of grassland and disturbed habitats, although also found in wooded areas, but only with open canopy.
- Large active lizard with a long tail and a 'crest' of evenly placed spines running from the neck down the front part of the spine. An agile climber, with long toe claws. Often spend time on tree trunks or rocks.
- Colour variable, dull brown, grey or olive, with brown bands across the back. Colour can change to red-black, particularly on the head. When breeding, the male has a bright red throat with a black stripe above.
- Adults are territorial but juveniles often forage more widely. They like to sun themselves, often taking a more upright stance with the forelegs stretched. Active in the early morning and late afternoon. More active in the wet season, becoming less obvious during the dry season (Fanchette 2006).
- Can multiply rapidly, females laying up to 16 or so eggs. Females can also retain sperm, so a lone female may still be able to lay fertile eggs; she can also retain eggs for some time until there are suitable conditions for laying (Matyot undated). Locally found to make a nest about 7cm deep in loose soil for egg laying. Breeding is in the wet season and lizards are more often seen at that time (Fanchette 2006).
- Mainly insectivorous (e.g. large moths, grasshoppers, crickets, mantids), but also feeds on small reptiles and birds (locally, caged lizards ate endemic *Phelsuma* day geckos but were not seen to eat these in the wild, Fanchette 2006). May threaten native insect species. May also harbour parasites that could affect native lizards.
- Although they may be predated by rats, snakes and the Seychelles kestrel, these are unlikely to have much effect on Crested Tree Lizard populations.

Presence in Seychelles

- First seen in 1982, when one specimen was captured and killed on Mahé. In 1985/86 a Seychellois on Mahé had two adults which he tried to sell to a visiting herpetologist but he refused to state their origin (Matyot undated, Fanchette 2006). It is not known what happened to these two but Hill and Currie (2007) suggested that a population could have established on Mahé. However, there is no evidence for this.
- Towards the end of 2003, another specimen was found on Mahé, apparently having been captured on Ste Anne Island and brought across to Mahé. Although the lizard escaped it was recaptured about 500m away. Presence on Ste Anne was confirmed in 2003. They are thought to have been introduced with container cargo from Mauritius in the early 2000s during the hotel resort construction. Control was carried out but the population remains (Fanchette 2006).
- 2009: There have been no further reports of sightings from Mahé since 2004 so perhaps the population is currently restricted to Ste Anne, but with increasing likelihood of accidental transfer (see below).

Control programmes

- Ste Anne: A granitic island 219ha, c.5km from Victoria, Mahé. Currently with one high class tourism establishment. Access by boat (but not open access).
  - 2001: Crested lizard first observed on the island near where construction materials were offloaded.
  - 2003: A survey by Conservation Section personnel on Ste Anne found 20-25 mature adults around the jetty area.

- 2004-2006 (***Physical and chemical methods***): Population estimates (surveys in known territories and around the hotel complex) in 2004 showed an increase to 40-45 individuals (Fanchette 2006). In January the government announced a bounty of SR50 on each dead lizard (Matyot undated). Subsequently there were several attempts to control/eradicate the Crested tree lizard using various methods - rat glue, nets, manual removal (Fanchette 2006) and the use of pre-baiting, followed by baiting with added poison (type not revealed) and a scoop net used at lizard sunning spots (M. Athanase pers. comm.). A trap designed by a government conservation worker (baited with live insects and with several holes for lizards to enter), was never implemented due to the departure of the worker overseas for studies (brief description of trap in Fanchette 2006).
- At the start, alternating teams of people carried out control 4 times per day, one week with control and one week without (M. Athanase pers. comm.).
- Following the introduction of the SR50 bounty, many lizards were caught by the hotel staff, mainly by pursuing and capturing the lizard, so that animals became very wary of humans. As a result, it seems that the lizards moved away from their preferred open areas to more wooded areas (M. Athanase pers. comm.), although this could have been also partially natural behaviour during the dry season (Ed).
- During the 2 years of control about 80 individuals (48 adults, 32 juveniles) were killed but in March 2006 at least 4 adults remained and possibly juveniles. However, surveys (method unrecorded but probably by sight) indicated that the population remained around the hotel complex and had not spread to other areas of the island (Fanchette 2006).
- There was good cooperation between the government and the hotel resort management. However the main problem seems to have been lack of manpower and resources to carry out a proper control programme (Fanchette 2006).
- 2006-2009: No sightings were reported (M. Athanase pers. comm.).
- 2009: There have recently been new sightings on Ste Anne and 1 specimen brought in (M. Athanase pers. comm.).
- The only precautionary measure taken at present to reduce the likelihood of lizards reaching Mahé is the inspection of worker's belongings when leaving the island. However, it appears that there is a greater risk of transfer through waste material transported off Ste Anne (R. Fanchette pers. comm.)

Conclusion

Little action following the intitial discovery of the Crested tree lizard invasion on Ste Anne reduced the likelihood of a successful eradication. Lack of capacity seems to have affected the implementation of the control programme but much local knowledge of the best methods and times to capture the lizards was gained. However, it will be important to find new methods of control/eradication that do not impact other animal species. It is imperative that containment protocols are improved to prevent this species from invading other islands.

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Crazy Ant (*Anoplolepis gracilipes*) / Fourmi maldiv

Biology and ecology

- Origin unsure (probably Africa), but now very widespread in the tropics.
- A medium sized ant (body 4-5mm), usually yellow or light brown in colour, with long antennae and legs and very rapid movement, often with many changes of direction.
- Often occupy semi-disturbed areas with a mixture of open and shade, e.g. around houses, forming nests under leaf litter, rocks, dead wood etc, but also in coconut palms. Also found in wooded areas.
- Colonies have many queens (average c.40), with new colonies forming by 'budding' from an older colony. Also forms super-colonies with huge numbers of workers.
- Mainly scavengers of dead invertebrates, but they irritate and eventually overcome small animals such as crabs and small juvenile birds. Also may take seeds and plant material.
- They also tend scale insects and mealy bugs living on trees, in order to feed on the sugary secretions (honeydew), which often results in dark mould on the upper surface of leaves, thus interfering with the plant's photosynthesis.

- Food foraging usually takes place in the cooler parts of the day.

Presence in Seychelles

- Introduced accidentally to Mahé in about 1962, but only officially recorded in 1968. It remained fairly limited in distribution until around 1969, after which it spread to most lowland areas. By the late 1970s it had reached pest status and a control programme was initiated.
- Crazy ants reached Praslin and Félicité in the 1980s, and by 2000 they were present on at least 9 of the central islands.
- The outbreak on Bird Island is well documented. It was first reported in 1991 but remained localised until 1997, when a large part of the island became infested with much higher densities of ants than on the main granitic islands (Hill et al. 2003). By 1998 the whole island was seriously affected, including the breeding colony of Sooty Terns, causing severe ecological disruption, with the death of tern chicks, crabs, various insect species and also changes in skink distribution. Several studies were carried out and Hill et al. (2003) suggested that the high ant density was related to high scale insect densities in the foliage of the native *Pisonia* trees, but only minor control was carried out. The population was said to have reduced by 2002.
- Crazy ants were found on Cousin in small numbers from 1999 on (Dunlop et al. 2005).
- Recent confirmation (September 2009) of crazy ants on North Island (L. Vanherck pers. comm.) possibly brought in with cut flowers or construction material.

Control programmes

- Granitic islands (***Chemical methods***): 1969: control trials were initiated using Dieldrin baited with fish, with inconclusive results (Dept. of Agriculture 1969).
- 1976: Haines & Haines (1978) carried out extensive research into suitable methodologies using toxic bait and sprays:
    - Baits needed to have the following properties if possible:
        - Attractive to ants from a distance
        - Carried to nest when found
        - Act slowly to allow transmission to colony before poisoning occurs
        - Low mammal and fish toxicity
        - Effective for some time
        - Biodegradable toxicant
    - The toxin found to be most effective was 1% Aldrin (unfortunately a persistent insecticide and toxic to mammals), used at a rate of 10kg per hectare. 90% of ants were killed in the first few days and population recovery was only after 3-12 months. More than 20 less-toxic poisons were tried but none were as effective as Aldrin. A few possible poisons were unavailable and therefore not tested.
    - The bait chosen for carrying the toxin was made from sieved coir waste (very readily available from the coconut industry at the time), yeast extract, animal fat (to carry the fat-soluble poison), salt/sugar, propionic acid to preserve the bait. A few other insects showed interest in the bait, e.g. other ants, some cockroaches, woodlice.
    - Technique used: scatter the bait evenly over the area, with better results in dry weather. Poultry to be avoided because of possible contamination of eggs or meat. The method was found to be more effective in relatively open vegetation areas, particularly when households were affected. It was not good to use the bait during the rainy season due to break down of the bait.
    - Costs: Aldrin and yeast extract had to be imported; all other ingredients were locally available. Materials = 27 pence/kilo; labour = 6 pence/kilo. Total per kilo = 33 pence. If used once or twice per year at 10kg/hectare the cost was £4-£8 /hectare/annum.
    - Toxic sprays were also researched for use in infested public buildings (and for emergency control of new outbreaks on other islands). Gamma-BHC (persistent organochlorine) and Chlorpyrifos were suitable for outside walls and Bendiocarb for inside walls, both to be applied by professionals only.
- NOTE: at the time (1976), the long-term effects on the environment of the above toxins were not realised. In 1994, all use of these poisons was banned in Seychelles. It was recommended to use Dursban (active ingredient Chlorpyrifos) but foreign exchange problems prevented importation. Crazy ant control was left to private pest controllers (W. Dogley pers. comm.).
- 2009: Local private pest control companies are apparently currently using Dursban (banned in USA since 2001) which is now known to have harmful effects on aquatic life (fish), birds and mammals.
- One operator searches for and destroys the nest (G. Gill pers. comm.) and advises better sanitation of the area (e.g. removal of dry grass, piles of coconut husks). The problem is reputed to be worse in the dry season.

- Bird Island: a privately owned, flat coral island 101ha, c.100km North West of Mahé, with a hotel. Accessible by boat and plane
    - 1998-2003 (***Chemical methods***): Feare (1999) noted that a chemical company supplied samples of untreated bait (no name given) to test on the island and it was shown to be non-attractive to non-target species such as crabs, lizards, ground-feeding land birds. The company also supplied samples of poison bait containing hydramethylnon, a slow-acting stomach poison which has very low toxicity for birds and mammals. No authors report on these tests.
    - The control carried out was apparently minimum: insecticide (no name given) was sprayed around the hotel complex and in the open area of the sooty tern colony to keep ant numbers down. Gerlach (2004) recommended that the coconut plantation should be thinned out to open up the canopy, and suggested the population may reduce when ant predator populations build up (paussine beetles and ant-lion). Apparently some of the beach vegetation (presumably *Pisonia grandis*) was thinned also.
    - 2009: Hydramethylnon may still be in use (G. Gill pers. comm.) but no other information has been available on the status of Crazy ants on Bird Island.

Notes

- Feare (1999) wondered if the outbreak of Crazy ants on Bird Island in 1997/1998 was in any way linked to the eradication of rats on the island in 1995. Gerlach (2004) suggests that it could have been influenced by the spread of *Pisonia grandis* (Bwa mapou) trees.
- Following the Bird Island outbreak, Cousin Island took precautions to ensure that the presence of any large Crazy ant colonies would be picked up quickly by staff (Hardcastle 2006).
- Fipronil, a slow-acting poison that is now commonly used for ant bait worldwide is now available in bait form. This poison bait along with Hydramethylnon and Pyriproxifen are apparently now being used with success to control Crazy ants in other parts of the world.

Conclusions

- Crazy ants have been kept under control on the main islands to a certain extent, mainly using chemical poisons mixed with bait material that the ants carry to their nests thus affecting large numbers of the colony. Most of these poison baits have non-target impacts and should be used with caution.
- The applicability of poison baits used successfully in Australia and the Pacific should be investigated.
- New infestations are possible with increased movement of goods between islands, particularly islands not yet affected (note the latest confirmed report is from North Island, September 2009). Therefore protocols for prevention, early detection and intervention should be adopted by all islands currently without Crazy ant infestations.

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Other ant species

There have been reports of other species of ants becoming a problem on certain islands, e.g. *Pheidole megacephala* on Cousine Island in the last couple of years. Experiments with poison will be reported soon (J. Henwood pers. comm.). The likelihood of other ant species arriving with materials in containers is quite high, so certain ant species (e.g. *Solenopsis invicta*, the Fire ant, which is apparently present in Singapore and Malaysia (ISSG database), from where goods are frequently imported) should be placed high on the biosecurity blacklist.

The Coccid *Icerya seychellarum* on Aldabra

Note that, in spite of its scientific name, this is NOT an endemic Seychelles species but a widespread tropical pest species.

Biology and ecology

- This Coccid (Mealy bug/'Lipou blan'), has 3 larval instars before adulthood. Adult has reddish body covered with a white waxy secretion which extends out into fine white 'hairs'.
- All stages have piercing mouthparts and suck plant sap. Sugary secretions often result in mould on the leaves which reduces photosynthesis. Coccids are often attended by ants.
- Easily spread by the wind during the first larval instar.
- Coccid infestations may cause significant early leaf fall and eventual death of the host plant, especially when other stress factors are present, e.g. drought, browsers (Johnson & Threadgold 1999). No natural enemies or parasites of *Icerya* have been found on Aldabra (Newbery & Hill 1985). The presence of latex in a plant does not reduce the likelihood of infestation.

History on Aldabra

- First seen on Picard, Aldabra in 1968 on 2 plant species, presumably accidentally introduced earlier on contaminated plants or fruits. In 1969 it was found on 2 other species.
- 1972: There was a significant infestation on 3 new species and by 1975 the infestation had reached a very high level all over the atoll.
- The level reduced in the next few years. By 1980, five main species were affected - *Avicennia marina, Euphorbia pyrifolia, Ficus lutea (nautarum), Scaevola sericea (taccada)* and *Sideroxylon inerme*.
- 1983: There was greater infestation in the South East than the North of the atoll (Newbery & Hill 1985) and it was affecting some rare species.
- 1989: New outbreaks were in both the North West and South East. Differing distribution is related to ecological, climatic and stress factors (Gery 1989).
- A visit by French botanist Francis Friedmann during the 1980s (Friedmann 1986) revealed that a number of very rare plants were being badly infested, with the threat of their possible extinction (not necessarily entirely due to coccids).

Monitoring of infestation on Aldabra + post-biological control

- 1979: A monitoring programme was set up using 7 transects around the atoll. In total, 30 marked trees of each of the five main species affected were monitored, once in the dry season and once in the wet season.
- 1987: Monitoring discontinued due to difficulties with the transect location and replacing dead monitoring trees.
- 1994: Monitoring restarted. By 1998 one transect was no longer in use and one species (*Scaevola*) dropped from the monitoring programme (Beaver & Gerlach, 1998). No reason is given.
- After 1999 monitoring was also carried out for ladybirds (see below). The programme continued (although is possibly not complete - see various Aldabra Research Officer Annual Reports) until 2004, when the Seychelles Island Foundation Aldabra Science Review advised discontinuing the programme (Beaver 2004). The results have not been compiled or analysed fully due to difficulties resulting from small changes in the methodology over the years and absence of data for 1988-1993 (SIF 2009 pers. comm.).

Biological control of *Icerya seychellarum* using the ladybird *Rodolia chermesina*

- Aldabra is a very large raised atoll c.1,100km southwest of Mahé, with a total land area of 153km^2, and total overall area of 346km^2. Managed by Seychelles Islands Foundation. A UNESCO World Heritage Site.
- 1989-1990: Methodology (Gery 1991):
  - Selection of 3 possible biological control agents (made easier by the lack of native predators and parasitoids) - *Rodolia chermesina, R. cardinalis, Cryptochaetum monophlebi*. (*R. chermesina* had been introduced to Seychelles from Réunion in 1880, *R. cardinalis* had been introduced to Seychelles from Mauritius in 1939, *Cryptochaetum* would have had to be introduced from Mauritius.)
  - *Rodolia chermesina* chosen because already seen to be the most effective agent against *Icerya sechellarum* on the granitic islands, present there in abundance, and known to feed only on *I. sechellarum* there.

- o *R. chermesina* adults collected from various sites on Mahé and multiplied up in an insectarium, with appropriate quarantine measures, plus suitable sex and genetic crossings with identification of resulting offspring.
- o The multiplication was continued on Aldabra, feeding the ladybirds with coccids from a number of different plant species. Further details are given in Gery (1991).
- o Releases of *R. chermesina* on Aldabra were at sites chosen to maximise their chance of survival and spread (food supply, protection from high winds, etc)
- o In 1989, three releases were carried out in the South East of the atoll, in the Cinq Cases and Bassin Flamant areas: 27-03-1989 (227 ladybirds); 9-05-1989 (470 ladybirds); 17-06-1989 (745 ladybirds). (Gery & Serrett 1990)
- o When the ladybird populations were surveyed in early July 1989, they appeared to be multiplying successfully and spreading (Gery & Serrett 1990).
- o By 1990, adult ladybirds were found at the opposite end of the atoll in the North and North West, so further releases were made in the South West and South of the atoll, at Anse Mais, Dune de Blanc, Dune d'Messe and in the Takamaka Grove area, between May and September (Gery 1991).
- o No long-term follow-up was possible by the researcher but continuing the coccid monitoring was considered to be the best way to follow the effect and success of the *Rodolia* introduction.
- o During the 1990s the coccid population is reported to have decreased significantly except in mangrove areas (Johnson & Threadgold 1999), and in 2004 the coccid monitoring was terminated, partly due to the apparent success of the control programme.

- Organisations involved: Seychelles Islands Foundation; Seychelles branch of ORSTOM; Seychelles Agriculture Division (Crop Support Services); University of Rennes, France.
- Personnel: Raoul Gery carried out this work for his PhD thesis between 1989 and 1990, including first surveys on Aldabra between March and July 1989 (assisted by the Seychelles Agriculture Division). Initial work was carried out on Mahé.

Conclusions

- Coccids are easily spread by the wind during the first larval instar.
- Typical of many predator-prey relationships, infestation levels of the coccid may rapidly build up to severe proportions before being knocked back as the predator population builds up in response to the outbreak.
- Factors other than coccid infestation were increasing the likelihood of the death of trees on Aldabra.
- Gery (1991) notes that the predator-prey relationship is complex and success in acclimatisation of the introduced ladybird does not necessarily result in long-term control of the coccid, especially in a large area that is differentially infested with the coccid.
- The coccid *Icerya seychellarum* appears to have been successfully controlled on Aldabra Atoll using the ladybird *Rodolia chermesina* as a biological control agent. The introduction methodology was systematic. However, there has been no complete scientific study to determine a) the exact level of control offered by *Rodolia*, and b) the possible effect of *Rodolia* predation on any native insect species, partly due to the apparent success of the introduction of the biological control agent.
- A possible follow-up study to assess the populations of both *Icerya* and *R. chermesina* is planned (SIF pers. comm.).

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Some records of other accidental introductions

- July 2003: Baboon spider (*Harpactira chrysogaster*) - killed and pickled.
- 2007: Tokay gecko (*Gekko gecko*) from Thailand at New Port - killed and pickled.
- 2007: Slow Loris (*Nycticebus sp.*) found at Mont Buxton - a journalist reported seeing 2 creatures, 1 was uncovering a cooking pot. Environment personnel found 1 dead one but the journalist said that was not the one she saw. Status remains unknown.
- March/April 2009: Large toad/frog (possible Cane Toad?) found underneath a container on a ship from France. Killed and pickled.
- December 2009: unconfirmed report of a Cane toad arriving in a container at Port Victoria.

Examples of gift introductions

- Ile Platte (late 1970s/early 1980s): ostriches and impalas introduced from Tanzania. Ostriches later died; impala presumed died or removed.
- Mahé (1980s): 3 flamingos from Singapore Bird Park introduced into the Victoria Botanical Garden. One died early on and the other two were eventually killed by stray dogs.
- Mahé: There has possibly been more than one introduction of peacocks, with one lot temporarily escaping.
- Some outer islands (1970s and 1980s): various birds (perhaps to add variety, as many native birds were reduced by human activities such as guano mining) and animals, such as rabbits and deer were introduced as an extra item in the diet of residents. In some cases the animals survived, in other cases the introduction failed.

Examples of pet and aquarium introductions

- **Red-eared slider (*Trachemys scripta elegans*):** Hatchlings of this aggressive omnivorous freshwater terrapin were presumably imported for aquarium use and when they are no longer welcome as pets, released into the wild. Individuals have been found in several marshes at different times. Some have been collected, brought to the Ministry of Environment and killed. Specimens identified in aquaria are removed and killed. There is no official control programme and confiscations have been carried out more as a public awareness exercise.
- Certain small aquarium fish have been released into rivers on Mahé and possibly other main islands, e.g. ***Poecilia reticulata*** or **Guppy / Milyon** which probably feeds on the eggs of the endemic Killifish (Gourzon) and reproduces prolifically. Ministry of Environment carried out a public awareness campaign in 2007 or 2008 when released individuals were found in one river.

<u>Conclusions</u>

- The likelihood of accidental introductions increases with increased trade and traffic at port and airport zones. Vigilance is continually required. The Biosecurity aspect of this GEF project will address this issue.
- The escape or release of introduced pet or aquarium animals remains a threat to natural biodiversity if they spread further afield. This needs to be addressed.

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4. MARINE SPECIES

The Seychelles Islands are susceptible to marine invasive species because of their geographical isolation. The supply of commodities by ship necessitates many vessels from all parts of the world entering Port Victoria every year. This, along with the large number of private yachts and cruise ships visiting Seychelles, leads to the increased likelihood of marine species introductions. The remoteness of the islands mean that marine biota and ecosystems have evolved in relative isolation and it is difficult to assess the number, identity, distribution and impacts of non-indigenous marine species in Seychelles waters. Alien species can have adverse ecological impacts such as competition with, or predation/grazing on, native species; and hybridization with, or parasitism of, native species. Some marine alien species actively modify the physical environment through altering habitat structure.

NO CONTROL PROGRAMMES so far undertaken for any alien marine species (but see below for control programmes for problematic native species).

2005 Baseline survey around Port Victoria

- So far only this one study has been carried out in Inner Seychelles to provide baseline data of native, non-indigenous and cryptogenic marine species in two high-risk areas (Abdulla et al. 2007). The participants in this survey were IUCN, SeaSphere and SCMRT-MPA.
- The study was extremely limited in its scope (11 sites in a small area near Victoria) and in a very short period of time (c. 9 days) albeit with methods that maximized the likelihood of revealing invasive species (sampling methods were based on protocols developed by the Australian Centre for Research on Introduced Marine Pests - CRIMP.
- Analyses of samples were carried out by regional and international taxonomic experts. 411 species of high taxa were identified, consisting of 246 native species, 3 non-indigenous species and 38 cryptogenic species (Category 1 = widespread species unable to determine their original native distribution + new species with invasive behaviours; Category 2 = recently discovered species with insufficient information). 124 species were 'indetermina'.
- However, the results of the study indicate that Port Victoria and its surroundings are relatively free of marine invasive species, which is similar to other tropical port areas.

Alien species information

None of the non-indigenous marine organisms collected have previously been recorded from Seychelles waters. The three species are:

- *Ericthonius braziliensis,* a detrivore amphipod in the family Ischyroceridae. It is tube-dwelling, creating cement tubes in marine sediments up to a depth of 20cm, as well as among algal filaments. Its predators are flatfish, eels, juvenile fish, crustacea and grey whales. Reproduction is sexual with the female carrying eggs in a brood pouch until hatching, when they stay in the pouch until maturity. It is a cosmopolitan species. During the survey it was collected at three sites.
- *Stenothoe valida*, an amphipod in the family Stenothoidae, is a wide-spread tropical species that lives among fouling assemblages. Its reproduction is similar to that of *E. braziliensis*. It occurred at one sampling site.
- *Mycale* cf *cecilia,* a small sponge. It is a filter feeder that often grows on reefs or artificial structures in shallow water. Species of *Mycale* have large active swimming larvae and are therefore often prolific in their local and regional distribution. In the survey, *M.* cf *cecilia* occurred at two sites.

These three non-indigenous species were probably introduced accidentally by international shipping, e.g. through hull fouling assemblages. It is believed that many of the non-indigenous species that arrive with shipping vessels do not stay alive long enough to create local populations. The low numbers of non-indigenous species found in Seychelles is similar to findings from baseline surveys in other tropical countries.

Recommendations

At the time, the distribution of these three alien species appeared restricted. However, there is neither quantitative information on their distribution nor information about their impacts on the marine environment. Management should therefore aim to prevent their spread to other locations. Eradication of the two amphipods is probably not possible due to their small size and high mobility. In general, most non-indigenous species eradication by physical removal or chemical treatment has not been cost-effective. Therefore, because of the transportation of non-indigenous species through hull fouling, a risk assessment approach was considered appropriate so as to manage possible threats in order to maximise the use of scarce institutional resources.

Alien species are likely to continue being introduced to Seychelles waters by shipping, especially considering the lack of management options for hull fouling and sea chest introductions. There is a therefore a need to continue monitoring marine alien species in port environments to: 1) allow for early detection and control of harmful or potentially harmful non-indigenous species, 2) provide on-going evaluation of the efficacy of management and biosecurity activities, and 3) allow trading partners to be notified of species that may be potentially harmful (Abdulla et al. 2007).

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***Caulerpa cf. bikinensis* outbreak**

- *Caulerpa* species are green seaweeds with a rhizome-like base that spreads out over the substrate, held in place by small rhizoid-like structures. Upright branches vary in form depending on the species - from small globular structures to feather-like, leaf-like or strap-like fronds. Often used in aquaria but when released into the environment, *Caulerpa* can cause enormous damage, e.g. in the Mediterranean.
- Reported around Astove in 2002 as monospecific areas of several tens of square metres at depths of 25-65 metres (B. Stobart et al. in Wendling et al. 2003).
- In 2003 *Caulerpa* was also found at depths of 15-45 metres and appeared to be expanding. The identification as *C. bikinensis* required further validation (Wendling et al. 2003).
- None recorded in 2005 at Aldabra. Astove not visited due to rough seas (Aldabra Marine Programme 2005).
- No species obvious around the Aldabra group in 2007 (Tamelander 2007)
- No control attempted.

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Native marine species that can be problematic in Seychelles

There are several native marine species which can become problematic on coral reefs as a result of massive population increases largely resulting indirectly from human-induced effects. For some of these species, control programmes have been set up when appropriate.

Crown of Thorns starfish (COT) (*Acanthaster planci*)

- A very large spiny starfish which feeds on live corals. COT has been observed in Seychelles for a long time and is considered a native species.
- However, COT populations can sometimes increase to plague proportions and cause the death of large areas of coral. Localised outbreaks, particularly around Mahé, were observed in 1996, up until 1998.
- <u>1998</u> (***Chemical method***): a control programme was set up with WWF and ETF funding. The eradication method used was the injection of at least 6 ml (3 x 2 ml) of saturated sodium bisulphate (a common swimming pool chemical called 'Dry Acid') solution into different points of the central disc of each starfish. The injected animals were left on the reef to die, and the salt solution, when eventually released, did not damage the surrounding environment (D. Rowat pers. comm.).

- Many reefs in the NW bay region were treated in this way but it was not possible to evaluate the efficiency of the technique as the major coral bleaching of 1997/1998 took over too quickly, resulting in massive death of corals (D. Rowat pers. comm.).
- 2009 (***Physical method***): populations have again increased around Mahé and a further control programme took place at two sites in the North West, using volunteers and simply collecting the COT and having the local waste disposal company (STAR) treat them as hazardous waste. Further control is planned for South Mahé (D. Rowat pers. comm.).
- Costs: The cost of COT removal is basically site specific, as it will depend on the cost of boats etc and also the level of the COT infestation. Sodium bisulphite and agricultural injection guns are not particularly expensive but are not available in Seychelles. Sea water corrodes the injection guns. It is unknown whether or not COT can release eggs after being injected but before dying. If so then the removal method is a more efficient approach.
  - At commercial Dive Centre rates it would cost around € 350 for 8 divers plus equipment per dive, but the net rate would be closer to € 100 using volunteers doing the dives and COT removal.
  - In terms of efficiency, assuming the sodium bisulphite does kill all the injected animals, then there would be no real difference between the two systems, as both rely on divers locating COT while diving.
  - All information from D. Rowat (Marine Conservation Society of Seychelles, MCSS) pers. comm.

Conclusion

Physical removal and disposal of (native) Crown of Thorns starfish appears effective and cheap if volunteers can be used, although chemical methods can also be effective if materials and equipment are available.

Black Spined Urchin (BSU) (*Diadema sp.)*

- Sea urchins with extremely long black spines. They graze on reef algae.
- After the mass bleaching event of 1997/1998, algae covered the dead corals, so the BSU populations built up. This helps to keep the algae down so that new coral recruits can settle and grow. However when feeding in large numbers on the new algal growth, BSU can also cause bioerosion by removing reef substrate and incidentally feeding on the new coral recruits. The density of BSU populations on a reef is therefore a significant factor in reef recovery.
- In 2000, populations of BSU increased significantly in North Mahé (up to 500 individuals per 250m^2, which is more than 10x the level on a healthy reef) (Wendling et al. 2004). A pilot study was set up, partly to assess different methods of BSU control (Wendling et al. 2004).
- ***Physical method***: Control should only take place where densities of BSU are at least 200 BSU/250 m^2 and there is significant coral recruitment. Areas should be 20-50m wide and 100-500m long. Excess BSU are destroyed *in situ* using metal tools, leaving around 10-20 BSU/250 m^2. Recovery to 25-35 urchins / 250 m^2 is preferred, so populations require regular monitoring to ensure they do not go above this level (by natural increase or invasion from outside the area. Monitoring of coral recruits is also required. (Wendling et al.)
- Costs: there is no information available but presumably, as for COT, the main costs would be for boats and divers and will be site-specific depending on the level of BSU infestation.

Conclusion

Black Spined Urchin populations (native) can be controlled by physical means to an appropriate level if a systematic method is used.

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Cushion star *(Culcita sp.)*

- Cushion-like starfish that feeds on small coral colonies.
- No control programmes have been tried in Seychelles.

Snail (*Drupella sp.* particularly *D. cornus*)

- Small gastropod snail which feeds on live corals. Population explosions can cause extensive damage to hard corals.
- Apparently documented in various older reports of attacks on Seychelles corals (D. Rowat pers. comm.)
- No control programmes have been tried in Seychelles (D. Rowat pers. comm.).

<u>References for both these species</u>

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5. AGRICULTURAL PESTS

In most countries where agriculture has been the normal method of acquiring food, the first organisms to be considered as pest species were animals, diseases and weeds that affected crop plants. Sometimes these pests were native species that simply took advantage of a ready food supply; but especially more recently, increasing movement of humans and goods around the world has led to an increasing number of pest transfers from one agricultural zone to another. The transfer of an organism into an area where there are no predators or parasites or diseases to keep it under control often results in population explosion, leading sometimes to total loss of crops, which can be disastrous for farmers. In Seychelles many such introductions have been accidental, e.g. through transfer of eggs on deliberately introduced plant material used for crop improvement. Occasionally the radical alteration of habitat due to human intervention has enabled a formerly minor species to become apparently invasive, e.g. the spread of the native *Melittomma* beetle after coconut plantations were created.

Note that the distinction between ‘agricultural pests’ and other pests is also not at all clear cut, as agricultural pests can also affect native plants, e.g. African giant snail, scale insects, white flies; and some of these have become established in natural or semi-natural ecosystems and affect the native biodiversity there. Likewise, rats (described in the ‘mammals’ section of this report) can be a serious pest to farmers, as well as causing disruptions to native ecosystems and being a health hazard to humans.

Much of the control of agricultural pests has been through the use of pesticides, the choice of chemical changing with the times as certain chemicals were found to induce pest resistance or to damage human health and the environment. Biological control was also enthusiastically taken up in the mid-20th century, with variable degrees of success and sometimes unwanted side effects. The latter has led to a degree of fear and resistance within the country for further use of this control method, which is perhaps unfounded now that screening methods have been vastly improved to ensure that a species is safe to introduce. However,s biological control still requires considerable expertise and capacity. Other methods have been used by cultivators, including hand-removal and natural alternatives to chemicals. Increasingly, Integrated Pest Management (IPM) is being encouraged, using a mixture of control methods.

Coccids (Scale insects and Mealy bugs) / Lipou, Bernik, Lipou blan

<u>Biology and Ecology</u>

- All coccids have an outer covering of waxy structures (mealy bugs) or scale-like structures (scale insects) that the female secretes. The head, thorax and abdomen are fused together.
- Females are always wingless and either slow-moving or immobile, whereas males are short-lived, do not feed and usually have wings.
- Scale insects and mealy bugs have piercing mouthparts and cause injury by sucking plant fluids from leaves, stems and sometimes roots. Coccids can also transmit plant diseases while feeding.
- The lifecycle of scale insect and mealy bug species varies but in general the eggs hatch within 1 to 3 weeks and the newly hatched nymphs (known as ‘crawlers’) are mobile until they find a suitable feeding site on the plant. Some crawlers can be blown by the wind to new sites.
- They excrete large amounts of honeydew which contains sugar and provides an excellent growth medium for a black fungus (sooty mould), which interferes with the photosynthesis process and slows plant growth.
- The honeydew is also favoured by ants, which will protect the coccids from some kinds of predators.
- Heavy infestations normally lead to extensive leaf yellowing, premature leaf drop (defoliation), wilting and stunting, and may eventually result in death of the plant.

<u>Native Range and Occurrence in Seychelles</u>

- There are numerous species of scale insects and mealy bugs known to attack many vegetables, fruit trees and various crops such as cinnamon, coffee, tea, citrus, mango, pineapple, pawpaw and avocado in Seychelles. Some of them are non-natives and they could have been introduced with their host crop.
- A review of control methods for individual species of scale insects and mealy bugs present in Seychelles is not possible due to lack of taxonomic information in the literature. These pests have mostly been controlled using the same or similar methods, especially for chemical control (Young 1981, Dogley 2004).
- Scale insects, in particular, and mealy bugs were identified by survey participants (see Annex 1) as being problematic in spite of control programmes.

<u>Control/Management Options</u>

Biological Control

- The first documented bio-control agents to be introduced in the Seychelles were probably entomogenous fungi species in 1911, and according to Lionnet (1959) one of the fungi, *Cephalesporium lecanii,* was very successful in controlling the Coffee green scale *(Coccus viridis)* in high altitude mountain forests.
- Around 1930, Vesey-Fitzgerald introduced a coccinellid (ladybird), *Rodolia cardinalis,* from Mauritius to control the mealy bug *Icerya seychellarum* on fruit trees and ornamentals, but this was not entirely successful (Lionnet 1959).
- During 1937 and 1938, Vesey-Fitzgerald introduced four species of coccinellid predators from East Africa *(Chilocorus distigma, Chilocorus wahlbergi, Exochomus ventralis, Exochomus flavipes)* and one species from India *(Chilocorus nigritus)* to prey on the scale insects attacking coconut palms. According to Vesey-Fitzgerald (1953) *Chilocorus nigritus* was the most successful, having firmly established on six islands (Mahé, Praslin, La Digue, North, Silhouette and Platte). It was observed feeding on most of the known coconut scale insects: Black thread scale *(Ischnaspis longirostris),* Coconut scale *(Pinnaspis buxi)* and Florida red scale *(Chrysomphalus ficus)*.
- Nye (1961) reported that the introduction of predatory coccinellids by Vesey-Fitzgerald had proved entirely successful, with only occasional outbreaks of the pests which were brought under control within a few months.

Chemical Control

- At the beginning of the 1980's, there was an increase in the use of insecticides to control scale infestations, mainly on agricultural lands growing fruits and vegetables. Young (1981) proposed spraying with two insecticides, Ultracide (methidathion) and Rogor (dimethoate), at 20 to 30 day intervals as an effective means to control scales on mango and citrus trees and to remove the sooty moulds.
- He also mentioned the use of summer oil or kerosene soap emulsion.
- 2000s: According to Dogley (2004) insecticides seem to be very effective against scale insects and mealy bugs. He added several others kinds: Orthene, Neem extracts, Carbaryl, Decis, Malathion, Ambush and Confidor, but also gave some management options such as pruning off the infested branches, decreasing plant density in an area, and avoiding the use of too much fertiliser.

Conclusions

- Studies have not been conducted recently to determine the effectiveness of the biocontrol agents introduced in the early 20th century. Furthermore, it is not known whether these species, many of which are generalist predators, have had impacts on non-target species.
- It is very likely that increased use of chemicals has affected the biocontrol agents but no in-depth scientific research has been conducted. According to W. Dogley (pers. comm.) a comparative study between sprayed and unsprayed fruit trees showed that constantly sprayed plants were usually more susceptible to future re-invasion by the pests, leading to long-term dependence on insecticides. He added that these pests are also more likely to develop resistance to the insecticides, especially if the same product is used regularly for a long period of time.
- Insecticides are effective, but there is a need to rotate them and use other management options or control methods simultaneously (= IPM). To protect beneficial non-target organisms, it is important to monitor properly and apply selective insecticides (i.e. those that are toxic to the Coccids only). An example would be to use products with systemic rather than contact action - contact poisons kill upon contact with any susceptible organism whereas systemic poisons are absorbed from the plant as the insect is sucking sap, thereby saving non-sap-sucking organisms (W. Dogley pers. comm.).

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Diamondback Moth *(Plutella xylostella)* / Lay (moth adult), Senir (moth caterpillar)

Biology and Ecology
- The adult Diamondback moth *(Plutella xylostella)* is small (8-9mm in length), slender, greyish-brown in colour with a characteristic diamond-shaped pattern on its back.
- Females live slightly longer than the males, about 16 and 12 days respectively.
- In warm humid climates they breed throughout the year, more than ten generations annually. Life cycle typical of moths consisting of egg, caterpillar, pupa and adult.
- The moths are known for their migratory tendencies although they are weak fliers, usually flying 2m off the ground, they are readily carried by the wind.
- The species feeds only on plants belonging to the family Brassicaceae, e.g. cabbage, cauliflower, chinese cabbage and watercress and causes serious damage to the crowns or growing point of young plants.
- The pest is known to be incredibly destructive as it feed on all parts of the plant and has the capacity to develop resistance to any control measures very rapidly (Facknath 1998).

Native Range and Occurrence in Seychelles
- The Diamondback moth could have originated from Europe because the cultivated brassicas are considered of European origin (Kfir 1998).
- It is the most serious pest of cruciferous vegetable crops in many countries, particularly to farmers in the warm, humid tropics (Facknath 1998, Oke 2008) even though there are reports of highest infestations in spring and early summer months from September to December (Smith & Villet undated).
- It could have been introduced to Seychelles in the early 1960's (Savy 1962) but was only confirmed to be present in 1968 (Lionnet 1969).
- Despite the effort to effectively control the moth using newly available chemical pesticides, damage caused by the caterpillars continues to cause serious economic losses to farmers annually in the Seychelles (Oke 2008).

Control/Management Options

Biological Control
- Several natural enemies such as ground beetles, syrphid fly larvae, spiders, wasps, lacewings and various bugs are mentioned by Dogley (2004) as being effective in controlling the populations of this pest.
- However, only one commercial biological control agent, *Bacillus thuringiensis* (Thuricide), has been tested for its effectiveness (Oke 2008).

Chemical Control
- 1960s: Insecticides have been used in the Seychelles since the early 1960s and spraying with Agrocide was effective in controlling the yellowish caterpillar of the pest (Savy 1962).
- In the early 1980s, Young (1981) and Kingsland & Shepard (1982?) discovered that the pest was developing resistance to certain insecticides such as Decis, and the application of insecticides during the pupal stage of the pest was not effective. Therefore, they recommended other insecticides such as Dipel, Lannate and Thuricide (*Bacillus thuringiensis*), to be sprayed alternately at 7 to 10 day intervals. Around the same time, similar observations were being made elsewhere and by 1985 most of the synthetic insecticides being used in Mauritius were reported to be ineffective against the moth (Dunhawoor & Abeeluck 1998).
- 1990s: Several chemical insecticides began to fail in their effectiveness around this time, some becoming almost ineffective (W. Dogley pers. comm.).
- 1994: Research conducted by Dunhawoor and Abeeluck showed that a strain of *Bacillus thuringiensis* (Xentari) was most effective in controlling the moth in Mauritius (Dunhawoor & Abeeluck 1998).
- 2007: A more recent in-depth study conducted by staff at the Vegetable Evaluation and Research Station, Anse Boileau, using two chemical insecticides: Lufenuron (Sorba 050 match) and Teflubenzuron (Monolt), and a bio-insecticide *Bacillus thuringiensis* (Thuricide), over a period of four months, showed that Teflubenzuron was the most effective insecticide to be used for the control of Diamondback moth in the Seychelles and *Bacillus thuringiensis* was the least effective (Oke 2008).
- According to W. dogley (pers. comm), Teflubenzuron was also tested for efficacy, but based on information provided by SAA extension officers, farmers are currently using mainly Thuricide, Nomolt, Decis and Ambush.

Physical/Cultural Control

- Simple control methods include avoiding periods of the year with high pest prevalence, good hygiene / sanitation (removal of infested plant material before and after harvest, weeding, etc.), netting, intercropping or mixed cropping, crop rotation (for those with a larger farm); even simply hand picking and squashing of larvae (for gardeners with only a few plants).
- Resistant varieties can be selected.
- Some research has also been conducted with home-made low-toxicity natural or botanical products such as capsicum and neem. (All information W. Dogley pers. comm.)

Conclusions

- Diamondback moth is still troublesome to crucifers (especially cabbage and Chinese cabbage) in some areas. Insecticide resistance is common for this pest, making control more difficult, with some locally used pesticides becoming almost ineffective in the 1990s.
- Although there has been no formal IPM programme, many non-chemical control options have been promoted but often farmers prefer rapid toxic insecticide methods. As pesticide resistance started to develop at least some farmers agreed to rotate chemical pesticides with a commercially available biological control agent: *Bacillus thuringiensis* (Thuricide).
- Relaxation of insecticide use can probably return Diamondback moth to a minor pest status by favouring survival of beneficial biological control agents. However, success depends greatly on the efforts of individual farmers (W. Dogley pers. comm.).

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Banana Root Borer *(Cosmopolites sordidus)* / Makabe (adult), Lever bannann (larva)

Biology and Ecology

- The adult Banana root borer *(Cosmopolites sordidus)* is a very shiny weevil, dark brown to grey black in colour, about 12mm long with a long snout.
- It can survive on moist substrates without feeding for several months and an adult's lifespan can be as long as two years, within which a female lays, on average, one egg per day. The life cycle is typical for a beetle with egg, larva, pupa and adult.
- The adult is nocturnal and feeds on all parts of banana suckers and established plants, with a preference for decaying banana corms. The larva causes more severe damage by creating extensive tunnels in the corms, thus weakening the plant and making it more susceptible to attack by pathogens.
- Although adults have well developed wings, they rarely fly and normally walk from plant to plant or are spread by the transportation of infested planting materials.

Native Range and Occurrence in Seychelles

- The Banana root borer is native to Southeast Asia, namely Malaysia and Indonesia but it has spread throughout the banana-growing areas of the world.

- This pest is very likely to have been accidentally introduced in the Seychelles with its host plant and according to W. Dogley (pers. comm.) its population has increased in recent years.
- In Seychelles some varieties of banana are more resistant to attack by the pest (Lionnet 1967) but Hord & Flippin (1956) reported that all varieties of banana are attacked, although they did observe some preferences (in Woodruff 2006).

Control/Management Options

Biological Control
- 1952-1954: While on a working visit to the Seychelles in 1952, F.J. Simmonds brought a consignment of 511 adults of two small Tiger beetles (now known as Hister beetles), *Leionata* [now *Hololepta*] *quadridentata* and *L. columbiana),* imported from Trinidad to be tested against the pest. The trial was positive and the predators readily attacked and devoured the Banana root borer larvae.
- Subsequently, other consignments in 1953 and 1954 were liberated directly into infested banana plantations in Les Mamelles area on Mahé. The consignment which came in 1954 included another predatory species of Hister beetle *(Plaesius javanus).* This predatory beetle was introduced throughout the Pacific and although they were able to establish populations, their effectiveness against the pest was considered to be minimal and they are not specific predators of the Banana root borer (Mau & Kessing 2007).
- Nothing is known about the current status of the *Leionota* species; nor whether they had any effect on non-target species.

Chemical Control
- 1960s: To reduce the damage caused by Banana root borers, Lionnet (1967) recommended the application of an insecticide (Dieldrin) to the banana suckers before they are planted. However, Dieldrin and Aldrin are now considered ineffective in several areas of the world since the pest has developed resistance to these insecticides (Mau & Kessing 2007).
- 1980s onwards: Since the early 1980s other insecticides such as Primicid, Carbofuran and Nemacur are being used by farmers in the Seychelles and they have been reported to be effective in controlling the pest (Young 1981, Dogley 2004). Either the young plants and corms are cleaned and dipped in insecticide before planting, or the Nemacur or Carbofuran is applied around the plants in already established plantations.

Management Options
In addition to chemical control, Dogley (2004) recommended field sanitation measures, including removal of the outer leaf sheath of infected banana suckers before planting, trimming of the corms to remove the pest eggs and young larvae, and avoiding transport of infested plant material on site and off the site.

Conclusions
It is likely that the biocontrol beetles have had non-target impacts, but early dependence on highly-toxic non-selective pesticides could also have destroyed the biological control agents. In other parts of the world emphasis has been laid on sex pheromone traps and microbial biocontrol. According to W. Dogely (pers. comm.) local reticence with respect to new introductions of biological control agents and the recent foreign exchange problems have apparently made it difficult to introduce new control methods. IPM programmes are based mainly on sanitation, using clean planting materials, avoiding already-contaminated fields and using insecticides.

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Citrus Blackfly *(Aleurocanthus woglumi)* / no common Kreol name

Biology and Ecology

- The Citrus blackfly *(Aleurocanthus woglumi)* is a member of the whitefly family although the adults have a dark, slate blue appearance. The male is slightly smaller than the female, about 1.35mm and 1.7mm in length respectively.
- A female lays more than 100 eggs in a very characteristic spiral pattern, attached underneath the leaves. The eggs develop into nymphs which are not very mobile. After several moults the nymph produces a puparium in which the adult develops.
- In tropical conditions all stages of the pest can be found throughout the year.
- Damage is caused by the blackfly nymphs sucking nutrients from foliage which weaken the plants.
- They attack a wide host range, mainly citrus trees such as orange, lemon, 'bigarad' (cumquat) and other fruit trees such as guava, mango, avocado which may be nearby.

Native Range and Occurrence in Seychelles

- Citrus blackfly is native to Southeast Asia and has spread widely to many countries in tropical and subtropical regions of the world, where it is a serious pest of *Citrus* spp (CABI and EPPO undated).
- The pest was recorded in the Seychelles for the first time in 1954 after a serious infestation which caused the death of many citrus trees around Victoria area, and it was presumed to have arrived on citrus fruits imported from East Africa or India (Jefferiss 1955).

Control/Management Options

Biological Control

- 1955: A biological control programme began, undertaken by the Department of Agriculture. Several consignments of the parasitic Eulophid wasp, *Eretmocerus serius,* a parasite primarily of nymphs of the genus Aleurocanthus, were imported from Jamaica between 1955 and 1956. This tiny yellow predatory wasp was very effective. Citrus trees which were formerly black and unhealthy, recovered within months. Though the wasps are able to disperse on their own, during 1956 they were deliberately distributed around Mahé and on other granitic islands by means of citrus twigs with leaves bearing the parasitized *Aleurocanthus* nymphs (Lionnet 1969, 1971).
- The programme was considered a complete success, as in less than three years, although there were occasional outbreaks of the pest after 1957, these were quickly brought under control by the Eulophid wasps (Lionnet 1969, 1971).
- 1958: The Eulophid wasps were introduced to two outer islands, Poivre and Alphonse.

Chemical Control

- 1950s: As a preliminary control measure the Department of Agriculture recommended the use of a home-made mixture "kerosene and soap" or "proprietary white oil emulsions" to be sprayed on a regular basis (Jefferiss 1955).
- Although chemical control is possible using insecticides such as Monocrotophos, Phosphamidon or Acephate, biological control is more economic and has been proven to be very effective in several parts of the world (Heu & Nagamine 2001, CABI and EPPO undated).

Conclusion

- Although a formal, quantitative evaluation has not been carried out to confirm efficacy of the biocontrol agent, it appears that this programme was successful. In more recent literature this pest has not been mentioned (Young 1981, Kingsland & Shepard undated, Dogley 2004). This could indicate that the pest is not a problem in the Seychelles and is still controlled by the Eulophid wasps.
- However, this parasite has been known to attack other species of whitefly such as *Bemisia*. The known *Bemisia* species in Seychelles (*B. tabacci*) is an introduced pest that attacks various plants. Not much information is available about native *Bemisia* species.

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African Rhinoceros Beetle *(Oryctes monoceros* / Makabe (adult), Bef bannann (larva)

Biology and Ecology

- The African rhinoceros beetle *Oryctes monoceros* is similar to its Asian relative *Oryctes rhinoceros* which is shiny black or reddish black in colour, stout and quite large (14-21mm breadth and 30-50mm long) and possesses a characteristic cephalic horn.
- The African rhinoceros beetle can live for about 5 months, of which between 2-3 months are spent as a larva.
- Eggs are laid in rotting coconut trunks or other decomposing vegetable matter. Larvae are large and whitish-cream. After several moults a pupa is formed after which the adult emerges.
- Adults feed inside unopened leaves and meristems of palms. When the leaves emerge they have characteristic V-shaped cuts on either side of the midrib.
- The adult rarely kills an adult palm but severe infestation in young palms can be fatal since the growing point may be reached or bud rot may develop and this can kill the juvenile palm.

Native Range and Occurrence in Seychelles

- *Oryctes monoceros* is an African species which could even be native to the Seychelles.
- It is a serious pest in coconut and oil palm plantations in Western Africa but in Seychelles it has been more or less a minor coconut pest except on two islands, Praslin and La Digue, where in the early 1950s it was an obstacle to the reestablishment of coconuts.
- Since the fall of the coconut industry in the 1980s the pest is no longer an economic problem. In fact, on some privately owned islands such as Denis, it is regarded as an ally in the control and eradication programme of coconut palms which are considered as an invasive plant species (Nevill 2009).
- Although the Rhinoceros beetle does not normally attack native Seychelles palms, there has been recent evidence of attacks on young native palms, even if the beetles are not always very successful at gaining entry to the growing tip (K. Beaver & Environment Division workers pers. comm.).

Control/Management Options

Management Options and experiments with chemical control

- Pre-1949: Prior to the biological control programme, sporadic outbreaks were partially controlled by collecting larvae from decomposing vegetable matter, e.g. fallen coconut trunks, (but not piles of coconut husks, which were apparently not attractive breeding sites). Piles of rotting cinnamon leaves left after cinnamon oil distillation seem to have been particularly attractive for adult *Oryctes* to lay eggs.
- Good management practices were recommended, such as plantation hygiene and control of likely breeding places in areas where coconut palm replanting was carried out (Government of Seychelles 1949, 1955, 1957).
- 1962: Because the biological control programme (see below) was not entirely successful, experiments were carried out on Praslin using paradichlorobenzene in coconut palm leaf axils. The results were not satisfactory, with 50% of the palms being eventually attacked (Government of Seychelles 1962).

Biological Control

- 1949: Even though the pest was not a serious problem on all islands, the Department of Agriculture initiated a biological control programme in 1949, starting with the introduction of a Scoliid wasp, followed by an Elaterid beetle, a nematode, a Carabid beetle and finally a virus. All information below taken from Government of Seychelles Annual Agriculture Reports 1949-1970.
- Using Scoliid wasps
    - The first consignment of 25 Scoliid wasps (*Scolia ruficornis,* a parasite of *Oryctes* larvae) was imported from Zanzibar and these were kept for a breeding programme at the Agriculture Research Station.

- Other consignments of these parasitic wasps came from Zanzibar in 1950 and 1951 and were released directly in heavily infested areas on Mahé and La Digue respectively. However, the 48 wasps released on La Digue were not observed during two consecutive field visits in 1952 and 1953.
  - On the other hand, the breeding programme was successful and a pair of the parasitic wasps was released on North Island in 1954. By 1956, a colony of the Scoliid wasps had firmly established on the island, the number was increasing and good field sanitation was presumed to be the reason behind this successful establishment.
  - During 1956 and 1957 adult Scoliid wasps from North Island were released on Praslin and La Digue, and in 1960 on the outer island of Poivre, where Rhinoceros beetle infestation was reported in 1959.
  - By 1961 the parasite had become established on Mahé, Praslin and Silhouette, and on La Digue by 1966, but they were not considered very effective against the African rhinoceros beetle. However on North Island, *Scolia* still appeared to be controlling *Oryctes* in 1969.
- Using other organisms
  - Two consignments of a large luminous predatory Elaterid (click-beetle), *Pyrophorus pellucens,* were imported in 1954 from Trinidad. They were released on Mahé, Praslin and La Digue islands but none were found subsequently.
  - A beneficial nematode of the genus *Rhabditis* was imported from Fiji in 1958 but they lost their virulence during the breeding programme at the Agriculture Research Station and were not released.
  - During 1960 and 1961 two consignments of a large Carabid beetle (no further identification given) were obtained from East Nigeria and were released on Praslin, Curieuse, and later on La Digue and Poivre. As there are no further records, it is presumed that they did not survive and were not effective.
  - At the beginning of the 1970's, the virus *Rhabdovirus oryctes* was used in the biological control programme. The virus was imported from Western Samoa in 1971. In 1972, a consignment of *Oryctes* larvae infected with *Rhabdovirus oryctes* was imported from Mauritius (Skidmore 1974).
  - Another virus *Baculovirus oryctes* which was known to be effective against the Asian rhinoceros beetle *(Oryctes rhinoceros)* was introduced in the Seychelles during 1981-1983. However, even if the infection rate was relatively high on the islands of St. Anne, Mahé and Praslin, the beetles were able to maintain a breeding population (Lomer 1985).

Conclusion

There has been no work since the 1980s to confirm the presence of all the natural enemies introduced to Seychelles, to evaluate non-target impacts, or to evaluate the efficacy of these biological control programmes. As the coconut/copra industry declined, very little importance was placed on the protection of coconut palms. In fact many coconut plantations have been destroyed intentionally and the land put to other uses. Some environmentalists consider coconut as an invasive species that needs to be controlled. The impact of the Rhinoceros beetle on endemic palms needs to be evaluated.

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Coconut Trunk Borer *(Melittomma insulare)* / Melitoma

Biology and Ecology

- The adult Coconut trunk borer *(Melittomma insulare)* is a beetle with a slender, dark-brown body and varies in length from 8mm to 18mm.

- The life of an adult is extremely short (about a week). Adult beetles emerging from a palm trunk remain close to it, as they are poor fliers, thus limiting the spread of this pest.
- Females lay their eggs in cracks of the palm's trunk, usually at the base and the larvae can live for at least a year.
- The larvae bore into the base of the palm and feed on fluid from the plant tissues. It is the associated bacteria and other micro-organisms that cause extensive rotting of the tunnels, particularly at the ground-level, which eventually results in the palm falling.

Native Range and Occurrence in Seychelles

- The lymexylonid coconut trunk borer *(Melittomma insulare)* is a native species to the Seychelles and the north-west region of Madagascar.
- It was first discovered in 1904 and Dupont (1911) gave a detailed account of the damage caused by this major coconut pest, which was present on several granitic islands such as Mahé, Praslin, Cerf Island, La Digue, Felicité, North Island, Marianne and Frégate.
- This pest is no longer considered a big problem because of the demise of the coconut industry, and there is no report of it attacking any native palms. However, there was a concern in 2000 when the pest was found attacking two ornamental palms in Victoria Botanical Garden (Seychelles) which prompted the Department of Environment to seek help from CIRAD in La Reunion.

Control/Management Options

Biological Control

- 1952: F.J. Simmonds visited the Seychelles, after which he travelled to Mauritius, East Africa and Trinidad in search of a predator of the pest.
- Based on the information he had gathered on the world species of Lymexylidae, he recommended that the most likely possible predator was *Rhizophagus dispar*, a small monotomid beetle which feeds on the eggs of another lymexylonid beetle, *Hylecoetus dermestoides* occurring in Britain.
- A breeding programme was started by H. Hansen in England and several consignments of four *Rhizophagus* species, mainly *Rhizophagus dispar,* were sent to the Seychelles in 1955 and released on Mahé and Cerf Island.
- The predatory beetles were not seen during consecutive field visits in the areas where they were released and this was an indication that they had been unable to establish themselves under the local conditions and may have been preyed upon by ants (Lionnet 1959).

Physical and Chemical Control

- 1910-13: P. Dupont recommended a treatment using excision (removal of infected tissue) and tarring of the wound, along with good field sanitation (destroy fallen palms and remove the larvae from palms still standing), as effective in controlling the pest (Skidmore 1974).
- 1926: Dupont reported that effective control of the pest had been achieved by walling-in and earthing-up the coconut palm stem-bases to trap and kill the beetles inside (Skidmore 1974).
- 1940s: Vesey-Fitzgerald recommended that destroying major breeding centres of the pest and fumigating the source of the larval air supply using paradichlorobenzene (PDCB) was more effective (Vesey-FitzGerald 1941).
- 1953-1958: A pilot scheme was launched on Praslin in 1953 by the Department of Agriculture to treat some 77011 coconut palms using the paradichlorobenzene (PDCB) treatment. The four year programme of PDCB treatment was assessed in 1959 by Nye (1961 a, b) and it revealed that 13,473 coconut palms which were treated fell within a week, and about 53% of the coconut palms still standing remained infected. Therefore he concluded that the control was only partially effective.
- As a result, Nye (1961 a, b) recommended a new method: gouging the infected coconut tissues and coating the exposed surfaces with a 60:40 Creosote/Coal-tar mixture.
- 1970s: Mathias (1971) investigated the control measures being undertaken at the time and could not find an alternative to the gouging proposed by Nye. However, he recommended that the chemical treatment with creosote/coal-tar be applied 3 to 5 days after gouging and not before, as the chemical method was useless against an active tissue fermentation process (Mathias 1971).
- Mathias also carried out spraying trials with various pesticides including dieldrin, gamma BHC, aldrin, **d**ichloro**d**iphenyl**t**richloroethane (DDT), chlordane and chlorfenvinphos and recommended a preventative spraying programme based on dieldrin + BHC in water to be implemented on Praslin.
- 1990s: All of the above pesticides were banned as they are persistant organic pollutants. Up to the early 1990s various teams of labourers used to visit all coconut plantations, boring holes into infested palms and applying Creosote to prevented further attack. The teams were all disbanded around 1995. No other pesticides were applied (W. Dogley pers. comm.).
- 2000s: Dick (2001) reported that *Melittomma insulare* was attacking two ornamental palms, Talipot palm *(Corypha umbracalifera)* and Oil palm *(Elaeis guineensis)* within Victoria Botanical Garden (Seychelles).

He added that the initial treatment with Confidor (an insecticide) and CAC Balsam (a fungicide) after they had physically removed the infected tissue was only effective on newly infested palms.

- The international consultant G. Wuster from the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in La Reunion who visited the Seychelles in April 2001 recommended the use of two insecticides Decis and Karate (Wuster 2001).

Conclusion

A combination of physical and chemical treatment (mostly not insecticides), together with proper field sanitation seems to have been the most successful control measure against the coconut trunk borer so far.

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Spiralling Whitefly *(Aleurodicus dispersus)* / Mous blan

Biology and Ecology

- The adult Spiralling whitefly *(Aleurodicus dispersus)* resembles a tiny white moth approximately 2mm long with a fine white powdery wax over its wings and body.
- Adult females lay eggs on plant foliage and fruits in a characteristic spiralling oviposition pattern. The generation time from egg to adult is about three weeks.
- It is a major pest of many fruit trees, vegetables and ornamental plants and the damage is mainly caused by direct feeding on the plant sap. It may act also act as a vector for disease.
- This pest is known to thrive in warm, dry weather conditions and as a result its population size is temporarily reduced during heavy rains and cooler temperatures.

Native Range and Occurrence in Seychelles

- Whitefly of unknown species were first documented in the Seychelles by Young (1981) and Kingsland & Shepard (undated) in the early 1980's but no information was given on which species was/were present and it was assessed as being a common insect pest.
- Spiralling whitefly *(Aleurodicus dispersus)* was first recorded in March 2003. By 2004, according to Dogley (2004), it was already a serious pest of many vegetables and fruits and a major problem to the agricultural sector.
- This polyphagous pest is native to Central America and the Caribbean region where it is not regarded as a pest.
- In Seychelles it has spread rapidly and it is now found, for example, on the outer island of Alphonse and on island nature reserves such as Aride and Cousin which are under strict management.
- Although *A. dispersus* appears to attack mainly exotic plants, a number of native plants do show signs of being affected, e.g. Kokomaron (*Curculigo sechellensis*), even though not to a great extent (K. Beaver pers. observ.).
- It was identified as the most problematic pest by survey participants (see Annex 1).

Control/Management Options

Physical Control

- According to D. Doudée (2009, pers. comm.) improvement of plant hygiene by regular pruning of leafy plants and applying a strong stream of water onto the underside of infested leaves can reduce the pest population.

- Dogley (2004) also proposed a trapping technique using light traps covered with Vaseline coating to trap the adults. The efficacy of this method is not recorded.

Chemical Control

- The Natural Resources Department has proposed several methods of controlling the pest using systemic insecticides such as Malathion, Rogor, Ultracide, Decis, Vertimec, Confidor (Dogley 2004).
- Alternative methods include use of a dilute solution of detergent (e.g. one teaspoon of household liquid soap in a gallon of water) and/or spraying with tobacco or sisal extract, neem oil, and petroleum oil (Dogley 2004). These are effective only when used in combination with a wider IPM programme. For people with very small areas (gardeners) or those who dislike toxic chemicals, they may also be useful (W. Dogley, pers. comm.).
- At the Seychelles Biodiversity Centre they are using petroleum oil “Caltex” twice per week to effectively control the pest (D. Doudée pers. comm. 2009).
- However, chemical control is described as impractical and not economical because of the pest’s broad host range and widespread distribution in the Seychelles archipelago, including in several protected areas where the use of insecticides may not be possible (Dogley 2004).

Biological Control

- Dogley (2004) mentioned several natural enemies of the Spiralling whitefly in Seychelles, such as ladybirds and parasitic wasps but they were not considered very effective at controlling pest populations.
- On North Island there is report of the newly introduced Seychelles White-eye on the island feeding on the pest (L. Vanherck pers. comm.) and other birds such as Seychelles Sunbird and Madagascar Fody will also take them (K. Beaver pers. observ.).
- However, the pest has increased in numbers over the past couple of years and the best option for a sustainable solution will be the introduction of natural enemies from its native range, such as the aphelinid parasitoids *(Encarsia spp.)* (W. Dogley pers. comm.).
- A biological programme in Tropical Africa was described by Neuenschwander (1996), in which two exotic hymenopterous parasitoids were introduced. These helped control *A. dispersus* populations, with indigenous coccinellids playing a minor role. *A. dispersus* was observed in Benin for the first time in 1993, along with the parasitoids *Encarsia ?haitiensis* and *E. guadeloupae*, which were thought to have been accidentally introduced. Between 1993 and 1996, these parasitoids helped control *A. dispersus* populations on guava (D'Almeida et al., 1998). *E. ?haitiensis* has been successfully introduced into Queensland as part of the biological control of *A. dispersus* in Australia (Lambkin, 1998, 2004).

<u>Conclusion</u>

Chemical control (even simple methods) linked with suitable field sanitation can help to reduce Spiralling whitefly numbers but is not overly successful. A suitable method of controlling Spiralling whitefly still needs to be found in Seychelles. Biological control seems to show the most potential and has been successfully used in other parts of the world.

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Coconut Whitefly *(Aleurotrachelus atratus)* / Mous blan

Biology and Ecology

- An adult Coconut whitefly *(Aleurotrachelus atratus)* has similar characteristics and habits to the adult Spiralling whitefly but the females lay their eggs in a non-spiralling oviposition pattern.
- They feed on palm sap and excrete honeydew, on which sooty mould fungi normally develop, thus affecting the palm's ability to photosynthesize.
- This pest is known to attack mainly palm trees, including Seychelles endemic palms (*Deckenia nobilis, Nephrosperma vanhoutteanum, Phoenicophorium borsigianum, Verschaffeltia splendida*).
- In Seychelles it poses a major threat to our biodiversity and tourism industry because the heavily infested palms are disfigured from the black, sooty mould and in severe cases the plant dies.

Native Range and Occurrence in Seychelles

- Coconut whitefly was first described from coconut palms in Brazil in the early 1900's but has spread extensively, especially to tropical islands.
- In the Indian Ocean region, it was first recorded in La Reunion in 1996 and then spread to other islands, notably the Comoros in 2000 where the economic damaged was estimated to be around €3 - 5 million.
- The pest was confirmed to be present in Seychelles in March 2007 by CIRAD of La Reunion, based on samples sent by the Department of Natural Resources. Upon the visit of a French entomologist Nicholas Borowiec from CIRAD in July 2007, the pest was found to be present on Mahé, Praslin, Silhouette and Ste Anne but had not reached La Digue.

Control/Management Options

Management options

- As a way of controlling the spread of Coconut whitefly between islands in the Seychelles archipelago, the Department of Environment imposed a ban on the movement of all palm species in mid 2007.
- In addition a warning was issued to concerned stakeholders against the slash and burn method (removal and burning of badly infected leaves from coconut trees) as this would only encourage the movement of adults to other host plants in different areas.

Biological Control

- No known biocontrol agent has been introduced to Seychelles even though N. Borowiec in July 2007 did propose a similar biocontrol programme to the one that has been implemented by CIRAD in the Comoros since September 2005 with promising preliminary results. The natural enemy being used there is *Eretmocerus cocois* (CIRAD 2007a, b).
- However, during a survey in mid-2009 a parasitoid was discovered that appears to be a new species (still undescribed as at November 2009). It is not known whether this was a naturally occurring species or was introduced at the same time as the coconut whitefly (B. Petrousse pers. comm.).
- Pest population size has been shown to be closely correlated with the degree of parasitism by this parasitoid (large whitefly populations on Mahé being linked with a low degree of parasitism; low populations on La Digue being linked with high degree of parasitism). Further research is required to understand more about the parasitoid's behaviour and ecology, but currently the coconut whitefly appears to be successfully controlled by the parasitoid (B Petrousse pers. comm.).

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Mediterranean Fruit Fly *(Ceratitis capitata)* / Mous fri

Biology and Ecology

- An adult Medfly *(Ceratitis capitata)* is slightly smaller than the common housefly (3.5 to 5mm long) and has a yellowish body with a tinge of brown, especially on the legs and some markings on the wings.
- The adult female can lay several hundred eggs in its adult lifespan which may last from two to six months or more under favourable conditions of food (fruit, honeydew, or plant sap), water, and temperature.
- The Medfly is one of the world's most destructive fruit pests and it is known to attack over 260 different fruits (e.g. citrus, star fruit, guava, mango and pawpaw), flowers, vegetables and nuts.
- The larvae of Medfly are the most destructive stage of the life cycle as they feed on developing fruit and vegetables and cause extensive damage to immature fruits. It is possible that some native fruits are also attacked.

Native Range and Occurrence in Seychelles

- The Medfly is native to the Mediterranean region and northern Africa.
- By 1999 it was the most widely spread fruit fly species in the Indian Ocean region, occurring in Mauritius, La Reunion, Seychelles, Madagascar and possibly the Comoros (Joomaye & Price 1999).
- This pest has been recorded in Seychelles since the 1980's. It was the only introduced fruit fly collected during a trapping programme conducted on the main island of Mahé around 1981. It is found on all islands around Mahé and could be on outer islands also but there is not much information available.
- Medfly was found to be more active from April to August/September which coincides with the dry season locally (Shepard & Young 1982).

Control/Management Options

Physical/chemical Control

- 1980s: A trapping programme carried out for a period of 13 months on Mahé by the Department of Agriculture around 1981 used a suitable and efficient plastic 'sandwich container' trap containing the attractant Trimedlure and a block of insecticide-impregnated resin (Dimethyl-Vinyl Phosphate or Dichlorvos (DDVP) (Shepard & Young 1982).
- This Male Annihilation Technique (MAT) using pheromone traps was recommended by the Department of Agriculture for monitoring the pest population size (Dogley 2004). According to Broughton and De Lima (2009) this control method does not control the adult population sufficiently but it will help to reduce the number of Medfly offspring.

Chemical Control

- 1980s: Young (1981) proposed the use of a chemical cover spray treatment using the insecticides Diazinon or Dipterex in fruit orchards. However this method was later described as being harmful to natural enemies of the pest and less economical (Dogley 2004).
- 2000s: Consequently, Dogley (2004) recommended the Bait Application Technique (BAT) using bait sprayed with protein hydrolysate liquid attractants and an insecticide such as Malathion, to be applied as a spot treatment on the foliage of host plants or trees. This control method is considered to be more effective in suppressing the adult Medfly population.
- However, for an effective eradication programme Dogley (2007) recommended a combination of BAT and MAT. Moreover, for the chemical method to be really effective, proper field sanitation measures should be undertaken on a regular basis.

Management Options

- Good field sanitation measures can be effective in controlling the pest population, including destruction of the fruit fly's breeding ground, i.e. burying all infected fruits (at a depth of 3 feet under the soil surface) and proper disposal of crop residues immediately after harvest (Young 1981, Dogley 2004).
- Another very effective preventative measure is to wrap developing fruits in protective cover such as old newspapers, paper bags or polythene sleeves (Dogley 2004).
- Biosecurity measures to prevent spread including early warning system.

Conclusion

Until such time as definitive control methods can be found, Integrated Pest Management using good field sanitation, pheromone attraction traps and appropriate chemicals will reduce the impact of this pest. Medfly has been successfully eradicated in Australia on several occasions using a combination of intensive trapping and monitoring, spot baiting with Spinosad: GF-120 NF Naturalyte Fruit Fly Bait, and Sterile Insect technique.

In the Galapagos, they are currently using Spinosad in combination with trapping, and physical control methods with success (C. Causton pers. comm.).

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Melon Fruit Fly *(Bactrocera cucurbitae)* / Mous melon

Biology and Ecology

- An adult Melon fly is about the size of a common housefly (6 to 8mm long) with an orange-brown body and some brownish spots along the veins of otherwise clear wings.
- The female can lay about 15 eggs per day and up to 1000 eggs in its lifetime which varies from one to five months.
- It becomes more abundant when temperatures fall below 32°C and relative humidity is around 60% to 70% (which generally corresponds to the dry season in Seychelles).
- Melon fruit fly infests primarily young, green, soft-skinned fruits and the larvae develop inside the fruit while pupation normally occurs in the soil beneath the host plant.
- Melon fruit fly is the most destructive pest of melons and related crops such as cucumber, pumpkin, bitter gourd and courgette and it is known to attack over 125 different host plants worldwide.

Native Range and Occurrence in Seychelles

- The Melon fruit fly is native to Asia but has become widely distributed in temperate, tropical and sub-tropical regions of the world (Dhillon *et al.* 2005).
- Uuntil mid 1999, it was present only on Mauritius and La Reunion Islands in the Indian Ocean region (Joomaye & Price 1999).
- The pest was observed for the first time in November 1999 on Mahé Island in a surveillance trap near the International Airport and it was probably accidentally introduced through aircraft food meals containing fresh fruits or vegetables which were improperly disposed of upon arrival at Point Larue (Dogley 2007).
- The pest is currently known to have established breeding populations only on the islands of Mahé, Praslin and La Digue.
- From initial data collected by the Department of Natural Resources, the production losses of cucurbit crops in the Seychelles is about 60% (Dogley 2007).
- It attacks at least 125 plant species in Seychelles (Knight 2008).

Control/Management Options

Physical/chemical Control

- 2005-2007: A suppression and eradication programme was launched, based on a feasibly study conducted in July 2001 by E.S.C. Smith from Landell Mills Limited (a UK-based consultancy firm). The programme was financed by the Government of Seychelles and a Financing Agreement with the European Union worth €1.1 million for a period of 2 years.
- Field monitoring and suppression was conducted by 2 technicians of the Plant Protection Section within the Department of Agriculture under the guidance of an international technical team based at Imperial College, London (Dogley 2007). This included establishing a trapping network on the basis of a 1 km² grid, with one trap placed in the centre of each unit, to delimit the extent of the infestation.

- The international technical team concentrated only on the Male Annihilation Technique (MAT) using MAT blocks impregnated with the parapheromone Cuelure plus an insecticide Malathion. This was in preference to adopting the widespread application of the Bait Application Technique (BAT) in combination with the MAT blocks, which was recommended in the feasibility study.
- According to Dogley (2007) several thousands of MAT blocks were placed all over Mahé, Praslin and La Digue and several other small islands in 2006. The blocks were given freely to farmers and gardeners in a national campaign which also included the use of media (radio, TV and newspaper).
- The Melon fruit fly eradication programme using MAT blocks was effective in suppressing the pest population but the overall eradication objective was not achieved. This was possibly because the chemical treatment using the BAT was not used sufficiently during the programme (Dogley 2007).
- 2009: Since the MAT programme ended in 2007 the pest population has increased on the islands of Mahé, Praslin and La Digue (W. Dogley pers. com. 2009).

Chemical Control

- Even if the Melon fruit fly eradication programme did not include the BAT, many local farmers were using the BAT or applying the chemical cover spray treatment using different insecticides such as Malathion, Decis (Deltamethrin) or in one case Spinosad, with the latter providing greater levels of control but at a much higher cost (€258.90/litre) (Knight 2008).
- A more in depth study was conducted in 2007 over a period of three months by staff of the Vegetable Evaluation and Research Station, Anse Boileau, using two insecticides, Lambda-cyhalothrine (Karate zone) and Deltamethrines (Decis) in controlling the pest on cucumber (Oke 2008).
- The results showed that both insecticides were effective in controlling the pest but Lambda-cyhalothrine was found to be better, as its spray reduced the Melon fruit fly pupae and increased the quantity and quality of harvested cucumber.

Biological Control

- There is no report of successful use of bio-control agents in other parts of the world, except that *Opius fletcheri* Silv was reported to be a dominant parasitoid of the pest but had not been tested under field conditions (Dhillon *et al.* 2005).
- In Seychelles, a feasibility study was conducted by Knight (2008) for the use of the Sterile Insect Technique (SIT) which involves releasing a population of sterile male Melon fruit flies into the wild that will mate with wild females and eventually cause the species extinction. However, this control method is considered expensive and complicated and will require considerable preliminary research before the sterile male method can be used in the Seychelles (Dogley 2007).

Management Options

- Good field sanitation measures, which include destroying the fruit flies' breeding ground, burying all infected fruits (at a depth of 3 feet under soil surface) and proper disposal of crop residues immediately after harvest, can be effective in controlling the pest population (Dogley 2004).
- Another very effective preventative measure is to wrap the developing fruit in protective cover using old newspapers, paper bags or polythene sleeves, or to harvest early mature green fruits (Dogley 2004, Dhillon *et al.* 2005).
- Biosecurity measures to prevent spread including early warning system.

Conclusion

Currently the best option for control of Melon fruit fly is Integrated Pest Management, using good management practices, appropriate insecticide application and a continuation of the MAT and BAT techniques, and a trapping network to delimit the extent of infestation and detect newly infested areas. However, for an eradication to be successful, efforts need to be intensified and coordinated, with appropriate biosecurity measures employed to prevent spread.

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Giant African Land Snail *(Achatina fulica)* / Kourpa

Biology and Ecology

- The giant African land snail *(Achatina fulica)* has a pointed conical shell which is generally reddish-brown in colour with light yellowish axial streaks. On average the adult shell is 12cm in length and 6cm in diameter but may exceed 20cm in length.
- The adults are obligate out-crossing hermaphrodites, having both male and female sexual organs, with the male organ reaching maturity earlier, sometimes as young as five months.
- They can live for 5 to 7 years and sometimes longer, up to 10 years. Although their productivity declines after the second year, they can lay up to 1000 eggs within 5 years.
- They are known to be a major agricultural pest and a vector for several pathogens and parasites. The snails are more active during the night, particularly on cloudy days, and remain hidden from heat and bright light during the daytime.
- Giant African Land snails attack a wide range of plants but feed primarily on living plants, seedlings and herbaceous plants, some ripe fruits and on decaying matter.

Native Range and Occurrence in Seychelles

- The giant African land snail is native to East Africa, namely Kenya and Tanzania.
- It has been introduced purposely (as a source of food, or for medicinal or research purposes) and accidentally into most regions of the humid tropics, including the Indian Ocean Islands.
- In Seychelles the pest was introduced around 1839 (Milsum 1950). Currently it is found on most of the granitic islands: Mahé, Praslin, La Digue, Silhouette, Fregate, Félicité, as well as on some outer islands e.g. D'Arros, Desroches. The species has become extinct on Cousin and Cousine Islands.
- This snail is a serious pest in commercial vegetable gardens and home gardens in the Seychelles.

Control/Management Options

Physical Control

- On a small scale, particularly in home gardens, the pest can be controlled by collecting adult snails and destroying their eggs and hiding places daily. In fact, Milsum (1950) reported that children were paid to collect the snails *(Achatina fulica and Achatina immaculata)* in the 1950s. This method is widely used and it has been reported to be effective in many places around the world such as in Guam, Hawaii, Japan and Sri Lanka (Raut & Baker 2002).
- Other effective methods include establishing various physical barriers, such as constructing slit-trap trenches around the vegetable plots (Milsum 1950) or copper barriers around susceptible plants and/or simple barriers using dry wood ash or sawdust and scattering pieces of broken eggshells around the plants (Dogley 2004).
- For the horticultural industry, vulnerable seedlings can be ringed with a strip of cardboard that has been dipped in a suspension of the molluscide methaldehyde (Raut & Baker 2002).

Chemical Control

- Bran-based baits containing methaldehyde (commonly known as snail pellets) have been used in the Seychelles since before the 1950s (Milsum 1950). However, even if this poison bait was controlling the pest, it had limited effect on snail populations (Lionnet 1962).
- Nevertheless, 'Sluggit' or snail pellets containing methaldehyde are still being recommended by the Seychelles Agricultural Authorities. Farmers are advised not to use the bait in excess as it can be harmful to non-target and beneficial organisms (Young 1981, Dogley 2004).
- Dogley (2004) also suggested that sprinkling Epsom salt (magnesium sulphate) on the ground near the problem area was effective, and indeed the most popular way of getting rid of slugs and snails. But common salt is not to be used as it increases soil salinity.

Biological Control

- 1950s: Towards the end of the 1950s a biological control programme by the Department of Agriculture was carried out with the introduction of two species of predacious snails. In 1957 a consignment of the carnivorous snail *Gonaxis quadrilateris* was imported from Kenya and liberated on Cerf Island. By 1959 the predator had established a breeding population and was reportedly controlling the African Land snail population on that island (Lionnet 1959).
- Another consignment of *Gonaxis quadrilateris* was imported in 1958 and released on Mahé and Praslin.
- Around the same time another predacious snail, *Euglandina rosea,* was imported from Mauritius (Savy 1962). This species has been nominated as among 100 of the world's worst invaders, but in the Seychelles it is present in limited numbers on Mahé and possibly St Anne Island (Gerlach 1987, 2006).

Conclusions

A combination of both physical and chemical methods appears to keep the African giant snail under control but requires consistent application. The predatory snail species (*Gonaxis* and *Euglandina*) have had limited effect in controlling the pest and are now considered a threat to endemic snail species.

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6. INVASIVE PLANTS (General)

Many of the plant species that have become invasive were introduced intentionally, for example as timber trees, to help combat erosion or as ornamentals. However, a few are native species that have become invasive because of human-induced alterations to vegetation, e.g. Bracken fern and possibly *Merremia*. The best known invasive plant in Seychelles is Cinnamon, which was introduced as a spice tree very early in the history of settlement and was subsequently spread by frugivorous birds. Because the native forests of the granitic islands were exploited for all good timber and later for cinnamon bark and oil, forest habitats were often cleared, allowing easy access by invasive species. Also, after forest depletion, fires and subsequent erosion, the tree species introduced for reforestation were sometimes so successful that they started to invade other areas, e.g. Albizia, *Tabebuia* (Kalis dipap). Some of these species remain on the legal Protected Species list because of their value as timber, even though they are now considered invasive, e.g. *Alstonia* (Bwa zonn), and therefore require permits to remove.

Many of the plant IAS are trees and shrubs, and most have not been controlled in any systematic way therefore do not appear in this report, although some should be included in a later Field Guide. For the most part, mechanical means have been used, such as felling and ring-barking, occasionally with the additional use of herbicide paint or spray. Herbaceous species likewise have mostly been dealt with by landowners using simple mechanical methods as the need has arisen, or using herbicides in an agricultural situation. Creepers and wetland species are considered in separate sub-sections of this report.

Bracken fern *(Dicranopteris linearis)* / Fouzer / Grif Lyon

<u>Biology and Ecology</u>

- Bracken fern *(Dicranopteris (Gleichenia) linearis),* synonym for Gleichenia-brake, is a branching fern with thin wiry stems and small elongated fronds, often in pairs, and narrowing towards the tip, with deeply separated pinnae (leaflets).
- It can form thickets over 2m high and grows in open areas, particularly where there has been fire or erosion in the past.
- It forms a thick root mat (up to 1m deep) on the ground, which prevents the establishment of other plant species.

<u>Native Range and Occurrence in Seychelles</u>

- Bracken fern *(Dicranopteris linearis)* is now considered native to the Seychelles (Beaver 2000, G. Rouhan pers. comm.). The same and/or similar species exist in South East Asia and other tropical countries and reproduce by spores which are easily carried in the atmosphere. However, earlier records stated that it is possibly an introduced plant species (Vesey-Fitzgerald 1940, Swabey 1960) probably because of its apparently invasive character in deforested zones.
- Vesey-Fitzgerald (1940) stated that Bracken fern was occupying considerable areas of deforested mountain land on Mahé but was less common on Silhouette and Praslin Islands in the 1930s. In the mid 1950s several destructive bush fires occurred on the island of Mahé and the fern, being highly inflammable, was seen as the source of the fires, and this prompted the Forestry Division to take immediate action.
- It is still widespread on many granitic islands particularly on Praslin, where it may be a significant element of the habitat of the newly discovered Sooglossid frog (*Sooglossus cf sechellensis*) on that island (L. Chong-Seng pers. comm.).

<u>Control/Management Options</u>

Physical Control

Only the cutting back method has been tried in Seychelles. It is known to be quite effective but very labour intensive and therefore not necessarily the most cost effective.

- <u>1958-1960</u>: The Bracken fern eradication scheme was initiated in 1958 by the Forestry Division (within the Department of Agriculture at that time). The purpose of the scheme was to reduce fire risk by 75%. Cutting back was used because the fern is said to be susceptible to subsequent cut of all re-growth. The eradication scheme was launched in 1959 with a target of 500 acres to be cleared, and just for the month of December some 230 acres of crown land were cleared by forestry workers. In 1960 the campaign was extended to private land and the Government gave a subsidy of SR15/acre to landowners who undertook such activity on their properties. The eradication campaign was meant to end within 2 years.
- <u>1960-1968</u>: An additional 1996.5 acres was cleared of Bracken fern by Forestry Division personnel on crown land and some 2573 acres were cleared by landowners on private land.

- Additionally, Forestry Division and private landowners undertook some 6171 acres of second and third cut on both crown and private lands.
- The subsidy became too costly for the Government, so in 1966 an Ordinance (No. 3) was passed which obliged private landowners to eradicate Bracken fern on their properties and this was supervised by Forestry Division personnel.
- However by 1968 the cost per acre of Forestry Division clearance had risen to SR17 for first cut and SR8 for re-growths. This was due to the fact that work was carried out further away from forestry stations and in less accessible areas.
- So after 10 years the scheme was stopped because it was too costly to be sustained by the Government.
- During the 10 year period some 4799.5 acres of both crown (state) and private lands were cleared of Bracken fern and in addition some 6171 acres of re-growth (including second and third cut) was undertaken.

Conclusions
Only the cutting back method has been tried in Seychelles. It is known to be quite effective but very labour intensive and therefore not necessarily the most cost effective. If it is proven that this native fern is an important part of the habitat of one of the endemic frogs of Seychelles, the control of this fern may have to be limited in some way.

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Gazontrelle *(Panicum parvifolium)* / Gazontrel

Biology and Ecology
- Gazontrelle *(Panicum parvifolium)* is a stoloniferous grass which forms a dense low mat on the ground.
- A light-loving species and a very good colonizer of degraded land where it gradually replaces other vegetation.
- Inflorescence stems to 15cm high with small panicles in the shape of an inverted pyramid, with small green spikelets.

Native Range and Occurrence in Seychelles
- Gazontrelle *(Panicum parvifolium)* is possibly a native of South America, introduced into the Seychelles in the early 1930s and it was found spreading over worn-out land behind Victoria on Mahé Island (Vesey-Fitzgerald 1940).
- By the 1950s Gazontrelle had became widespread on Mahé and it was already a great concern to Forestry Division staff who recognised it as a notorious weed on forested land because it competed with introduced timber trees for nutrients.
- Records of its existence on other islands could not be found.

Control/Management Options

Physical Control
- 1951: The Forestry Division started a weed control programme to eradicate this species within forestry plantations. Various planting techniques were used, primarily based on the fact that the species is not shade tolerant. The spacing of newly planted timber trees was very important and they first tried (6 x 6 ft) or (7 x 7 ft) distance but the grass gradually came back and within 2 years it was already recolonising the area.
- 1953-1955: “Spot weeding” was tried but this was not effective as the grass quickly grew back again. As a result in 1954 the distance was reduced to (3 x 3 ft) or (4 x 4 ft) = “close planting” method. Thickening of the existing low density planting by “direct sowing” was also carried out to achieve more rapid ground cover. This proved to be more effective by reducing weeding cost.
- 1956: To further cut costs mulching was started. In 1958 it was reported that mulching had other beneficial properties such as improving humus deposition, lowering soil temperature and more importantly increasing bacteria in the soil which kill harmful weed growth.

Chemical Control

- 1955: A weed control trial was carried out using Tecane on a plot (48ft x 48ft) of thick Gazontrelle. Two treatments were used: 2½ lbs of Tecane/ 5 gallons of water in a single application and 1¼ lbs/ 5 gallons of water in two applications with 14 days interval, using knapsack sprayers. The rate of application was 50 lbs of Tecane/acre and both treatments were very effective in the short term (approx. 8-9 months) but after that re-infestation started. This meant a continuous application of the treatment over a period of several years. The cost per acre of using chemical was determined to be more expensive than hand labour and therefore it was not feasible.
- 1966: Another herbicide trial using a paraquat compound known as Gramoxone proved very effective against Gazontrelle but no information was given on its cost effectiveness.

Conclusion

Both physical and chemical methods appear to control Gazontrelle but after 1966 there are no reports of this species, so it is not known whether this species still requires control or has become less problematic.

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Cinnamon *(Cinnamomum verum)* / Kannel

Biology and Ecology

- Cinnamon *(Cinnamomum verum)* is a small evergreen tree 10m to 15m in height, with an aromatic bark.
- The stiff green leaves have three prominent main veins. Young leaves are red in colour and soft.
- Sprays of small cream coloured flowers with 6 tepals (petal/sepals). Fruits are dark blue-grey oval berries about 1cm long in a cup-shaped ‘calyx’ (persistent tepals).
- Many seedlings are often found in forest undergrowth but may remain dormant until a gap opens up in the canopy, after which there is rapid growth.
- The roots produce a chemical which is said to be allelopathic (i.e. preventing other species from competing readily with the cinnamon).
- The leaves are used to produce Cinnamon oil, the bark is used in powder form as food flavouring and ‘cinnamon quills’ made from the bark of small branches are similarly used as flavouring.

Native Range and Occurrence in Seychelles

- Cinnamon is native to the Western Chats of Sri Lanka and India and it was introduced into the Seychelles in 1772 from Ceylon (Sri Lanka) as a spice plant. It spread throughout the forests of the granitic islands, aided by the endemic Seychelles Bulbul and Blue Pigeon which feed on the berries.
- The distillation of cinnamon oil from cinnamon leaves started in Seychelles in 1905 and by the mid 1910s, P.R. Dupont reported that most of the wild cinnamon trees were fast disappearing and all available trees were barked to sustain the growing Cinnamon Industry (Skidmore 1974).
- However, in 1940 Cinnamon was frequent in the mountain forests (Vesey-Gerald 1940) and by the 1960s it had became the dominant species in the secondary forests of Mahé and Silhouette Islands (Lionnet 1961).
- More recent vegetation studies have shown that Cinnamon remains the most abundant invasive woody species in the submontane and montane rain forests and we now have a better understanding of the negative impacts of the species on the islands’ ecosystems (Gerlach 2004, Kueffer 2006, Senterre et al. 2009).

Control/Management Options

There hasn’t been any large scale programme to control or eradicate the species as this is believed to be impossible. However, one experiment investigating possible control measures was undertaken by A. Carlström in 1995-96 (Anon. 1996):

Physical Control

- During the experimental work, three types of mechanical control were tried: uprooting by hand; cutting or felling using machete, axe and chainsaw; and ring barking using machete and axe.
- Hand removal (uprooting) of Cinnamon seedlings within a 10m x 10m plot was reported to cause dramatic degradation of vegetation cover due to the extensive root system below the ground.
- Felling of mature trees (10m x 25m plot) was not effective as the stumps re-sprouted and showed excellent growth after a year. In addition when large trees were felled, they caused considerable damage

to endemic trees and shrubs underneath and the moss cover and filmy ferns were severely affected by direct sunlight.

- Cutting of young trees (juveniles) was not effective as they re-sprouted within a few weeks.
- Ring barking of trees with a diameter above 10cm within a 10m x 25m plot was also not effective since new bark was formed after a year.
- However, on Silhouette it is reported (J. Gerlach pers. comm.) that ring barking can be effective if done thoroughly, with regular follow-up to remove all new shoots, although it is very labour intensive.

Chemical Control

- Treatment with a systemic herbicide (Round up) applied to different parts of the plant, using five dosages (5ml, 10ml, 15ml, 20ml and 25ml), was also tried during the experiment in 1995-96.
- The surface treatment in which leaves of 5cm width were painted with the herbicide during dry weather conditions was not effective. Even though some of the small plants did drop their leaves when treated with a concentrated solution of the herbicide, leaves re-sprouted from the trunk and branches within a year. In addition, with the wet conditions of the higher altitudes this control method is not suitable.
- When the stumps of Cinnamon trees were treated with a concentrated solution of the herbicide, re-sprouting was prevented but the root shoots continued to grow.
- The injection method using a special tree borer to drill into the tree and then inject a concentrated solution of the herbicide was more effective. Most of the trees treated with a 15ml concentrate or more died. However, in some cases endemic shrubs and trees close to the injected trees were affected, which could indicate a root to root contact of unrelated species below the ground. The cost of this method using an injection of 20ml concentrated solution of the herbicide per tree was estimated at SR 1.14.

Biological Control

There has been no attempt at biological control of Cinnamon in Seychelles (Kueffer & Vos 2004).

Conclusion

Physical control is possible on a very small scale but is very labour intensive. Use of herbicide is possible but in humid/wet conditions the chemical can spread to other non-target plants.

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Strawberry or Chinese guava *(Psidium cattleianum)* / Gouyavdsin

Biology and Ecology

- Large shrub or small tree to 7m with smooth reddish-brown peeling bark.
- Dark green shiny opposite leaves, about 5cm x 3cm.
- Flowers solitary in the leaf axils, whitish with many stamens.
- Rounded fruits 2-3cm, dark red when ripe, containing numerous seeds and edible.
- It produces numerous suckers and often a mat of surface rootlets in wet conditions in humus.
- It prefers tropical moist forest and is shade-tolerant but able to grow in variable conditions.

Native Range and Occurrence in Seychelles

- Strawberry guava is native to Tropical America namely Brazil. It has become naturalised in moist tropical montane forests in Hawaii, tropical Polynesia, the Mascarenes, Seychelles, Norfolk Island and Florida, and is listed among 100 of the "World Worst" invaders.
- This invasive woody shrub was introduced into the Seychelles in the 1850s, possibly as a fruit tree.
- In recent studies it is considered to be a habitat-altering weed that poses a serious threat to the montane rainforests on Mahé and Silhouette Islands because it competes with the endemic flora for light and for soil nutrients (Fleischmann 1997, Gerlach 2004, Kueffer 2006).

Control/Management Options

There hasn't been any large scale programme to control or eradicate the species as it has become so widespread. However, one study undertaken by A. Carlstrom in 1995-96 looked at possible control measures (Anon. 1996).

Physical Control

- Three types of mechanical control were tried, including uprooting by hand, cutting or felling using machete, axe and chainsaw, and ring barking using machete and axe.
- Hand removal (uprooting) of Wild guava seedlings within a 10m x 10m plot was reported to cause dramatic degradation of vegetation cover due to the extensive root system below the ground.
- Felling of mature trees was not effective as the stumps re-sprouted and showed excellent growth after a year. In addition when large trees were felled, they caused considerable damage to endemic trees and shrubs underneath and the moss cover and filmy ferns were severely affected by direct sunlight.
- Cutting of young trees (juveniles) also proved ineffective as re-sprouting occurred within a few weeks.
- Ring barking of trees with a girth above 10cm within a 10m x 25m plot was also not effective since new bark was formed after a year.

Chemical Control

- Treatment with a systemic herbicide (Roundup) applied to different parts of the plant using five dosages (5ml, 10ml, 15ml, 20ml and 25ml) was tried during the experiment in 1996.
- The surface treatment in which leaves of 5cm width were painted with the herbicide during dry weather conditions was not effective. Even though some of the small plants did drop their leaves when treated with a concentrated solution of the herbicide, leaves re-sprouted from the trunk and branches within a year. In addition, with the wet conditions at higher altitudes this control method is not suitable.
- When the stumps of Wild guava trees were treated with a concentrated solution of the herbicide, re-sprouting was prevented but the root shoots continued to grow.
- The injection method using a special tree borer to drill into the tree and then inject a concentrated solution of the herbicide was more effective. Most of the trees treated with a 15ml concentrate or more died, however, in some cases endemic shrubs and trees close to the injected trees were affected, which could indicate a root to root contact of unrelated species below the ground. The cost of this method using an injection of 20ml concentrated solution of the herbicide per tree was estimated at SR 1.14.

Biological Control

There has been no attempt at biological control of wild Guava in Seychelles (Kueffer & Vos 2004).

Conclusion

Physical control is possible on a very small scale but is very labour intensive. Use of herbicide is possible but in humid/wet conditions the chemical can spread to other non-target plants.

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Albizia *(Falcataria moluccana)(/* Albizya

Biology and Ecology

- Albizia *(Falcataria moluccana,* syn*. Paraserianthes falcataria* syn*. Albizia falcata)* is one of the fastest growing tree species in the world, reaching 35m in height within ten years. It has whitish grey bark and a spreading open rather flat-topped crown covering some 200m².
- The leaves are large with many small oblong leaflets c.1cm long and pointed at the tip.
- Clusters of small white flowers with numerous longish stamens. Fruits are papery pods containing small flat seeds which are easily dispersed by wind.
- It can start reproducing after 3 to 4 years and produces large quantities of seeds. Although Albizia is unable to establish in closed canopy forests, its seedlings are deep-shade tolerant and they can colonise and grow rapidly in forest gaps.
- Albizia is a potential ecosystem transformer species as it has the ability to fertilise the soil by fixing nitrogen and can grow in nutrient-poor soil.

Native Range and Occurrence in Seychelles

- Albizia is native to the Moluccas, Indonesia, Papua New Guinea and the Solomon Islands and it has been planted throughout the humid tropics as an ornamental or afforestation tree species.
- In Seychelles, it was introduced around 1910 to reafforest degraded lands and improve the poor soil conditions for future timber plantations of other species.
- It normally grows in mid-altitude forests particularly along the river ravines on Mahé and Silhouette Islands.
- It is not a prized commercial timber tree in terms of timber quality, and has a market value of US$ 19/m³. But Albizia is still being exploited to a limited extent by timber merchants. It currently remains a protected tree species under the *Breadfruit and Other Trees Protection Act (29th December 1917).*

Control/Management Options

Physical Control

- 1990s: A control and eradication programme was undertaken by staff of the Forestry section to remove Albizia within important water catchments areas on Mahé because the tree species is believed to lower the water table (INDUFOR 1993, Kueffer & Vos 2004).
- About 2000 large trees were ring barked under the programme and in a comparative study conducted by Wiederkehr & Anderegg (2001) the current mechanical control methods were found to be quite effective. However, they did mention some disadvantages of using both the clear cut and ring barking methods:
  - Clear cut or felling of Albizia trees with large canopy cover (200m²) using a chainsaw can cause significant damage to the surrounding vegetation and create huge forest gaps which increase light levels and favour the establishment of other invasive plants.
  - Ring barking or stripping off the bark on the lower parts of the stem (about 1m high and 30cm in width) will allow the tree to die gradually within six to seven months but prior to dying the tree produces a large quantity of seeds which can colonise the forest gap.
- In their conclusion, Wiederkehr & Anderegg suggested that the ring barking or girdling method is more appropriate since the gradual disintegration of the tree meant longer shading period for shade dependent native species to re-establish themselves within the area. However, this method should not be used in public areas such as along roadsides or footpaths or near habitations for safety reasons.

Biological Control

The Albizia borer *(Xystrocera festiva* - Cerambycidae*)* and a yellow pierid butterfly *(Eurema blanda)* were mentioned by Wiederkehr & Anderegg (2001) as possible bio-control agents; however both insects are not host specific and do not kill the tree.

Conclusion

Physical control by ring barking seems to be very effective in forest situations but needs to be used with caution in public areas because of the possibility of falling branches.

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Koster's Curse *(Clidemia hirta)* / Fo Watouk

Biology and Ecology

- Fo watouk *(Clidemia hirta)* is a coarse perennial shrub up to 3m tall. The stems are covered with reddish bristly hairs.
- Leaves in pairs, hairy and with 3 prominent veins arising at the base.
- Short sprays of whitish to mauve flowers 2cm across. Hairy bluish-black berries are primarily dispersed by frugivorous birds but they also can be accidentally spread by humans, e.g. attached to shoes.
- It flowers and fruits throughout the year in wet conditions and a single large individual can produce over 500 berries (each containing 100-300 seeds) per year. Seeds can remain in the soil for a long time; seedlings are tolerant of deep shade and can reach maturity within six months.
- Reproduction can also be through apomixis (the formation of seed without fertilisation from tissues of the parent plant).

Native Range and Occurrence in Seychelles

- Fo watouk is native to the lowlands of Central and South America and the Carribean Islands where it is found in naturally and anthropogenically disturbed open areas but does not occur in forest understorey, possibly due to the strong pressures of its natural enemies.
- However, in its introduced range it grows also in gaps in the understorey of undisturbed old-growth forests.
- Fo watouk was first reported from Silhouette (Seychelles) in 1987 and since then it has gradually spread in all forest habitats across the Island (Fleischmann 1997, Gerlach 1996, 2004).
- On Mahé, a single plant was first recorded (and uprooted) in 1993 around Le Niole. In 1999 a small patch was discovered along the Mt Sébert footpath by K. Fleischmann (in Kueffer & Zemp 2004).
- This extremely invasive shrub is currently widespread on Mahé (particularly along the Sans Souci road which cuts across Morne Seychellois National Park) and Silhouette. Small patches are also present on North Island (Gerlach 2004, J. Mougal and K. Beaver pers. obs.).

Control/Management Options

Physical Control

- Late 1990s: A control and monitoring programme was undertaken by the National Park staff within the Morne Seychellois National Park on Mahé. Localities such as Dans Bernard, Vingt Cinq Sous-Mare Aux Cochons, Salazie and Congo Rouge (areas where the plant had been previously recorded) were visited on a monthly basis by three park rangers. Single individuals and small patches of Fo watouk were uprooted and the plants were left hanging in trees or on rocks to dry. This method was very time consuming and labour intensive.
- 2003: The Forestry section adopted a community based approach for controlling this species along roadsides and in sensitive areas. The media (newspapers, TV and Radio programmes) and flyers were used to educate the general public about the environmental impact and control measures of Fo watouk.
- Following this awareness campaign there were several outings organized by the Ministry of Environment, notably at Mt Sébert (Cascade) and around the historic site of Mission Lodge, whereby school children and staff from private companies participated in an eradication programme.
- Although this programme was quite successful since large groups of people were mobilized to remove large patches of Fo watouk during the outings, it was not always easy in terms of logistics (coordination and transportation). Also, follow up activities, including rehabilitation and maintenance of cleared areas by staff of the Forestry section, were not always possible. As a result the species quickly re-established itself after four to six months, sometimes forming even larger patches, possibly due to soil disturbance caused by the uprooting of large individuals.

Chemical Control
Chemical control has not been tried in Seychelles but Weber (2003) mentioned that Glysophate (Roundup) is an effective herbicide when used as a foliar spray on the plant (Kueffer & Zemp 2004).

Conclusion
Physical control is possible on a very small scale but very labour intensive and needs to be systematic, including post-control monitoring programme. Proper disposal of all plant material is required otherwise plants may regenerate. It was not successful in containing the spread of Fo watouk on Mahé.

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7. INVASIVE CREEPERS

Creepers have only become a significant problem in recent years, judging from reports. This is almost certainly because of the increasing number of horticultural introductions, either legal or illegal, and the expansion of housing development which creates high level disturbance of natural habitats. In some cases creepers have been deliberately planted in areas that have subsequently been abandoned, allowing the species to spread. Indeed most invasive creepers are found in disturbed habitats and possibly currently form less of a threat to native species in Seychelles than is popularly believed. In intact forest there is less of a problem, although once creepers gain access through forest gaps next to roadsides for example, they can spread into the forest. The ability of creepers to spread up and over other vegetation is particularly worrying for native species in vegetation rehabilitation situations as young plants can be smothered. Moreover, various creeper species have become problematic in many island countries e.g. in the Pacific, and are proving difficult to control.

In Seychelles there are numerous species present. Earlier introductions, such as the group of creepers known locally as Philodendron (even though they belong to a number of related genera), are particularly noticeable in old growth areas and are difficult to eradicate because of the ability of even small sections of stem to regenerate. They are also difficult to remove from tree canopies as the plant continues to grow if there is sufficient moisture in the atmosphere. In fact many creepers are able to regenerate from small stem sections or underground storage organs. The usual method of control is currently mechanical and there can be problems with subsequent removal and disposal of the large quantities of plant material, which includes seeds and small stem sections.

Liane d'argent *(Merremia peltata) / Lalyann darzan, Lalyann torti*

Biology and Ecology

- A vigorous climbing vine 20-30m long with underground tubers, broad cordate or orbicular (heart-shaped) leaves, peltately attached to the smooth stems.
- Produces attractive creamy white or yellowish funnel-shaped flowers in clusters on stalks 15-30cm long. Seeds are borne in capsule about 15mm long.
- Disperses in two ways, either vegetatively, by spreading into neighbouring areas and rooting from its nodes, or by seeds. Stem fragments are able to re-sprout and root.
- Occurs mainly in disturbed areas along the roadsides or at the fringe of lowland and mid-altitude forests (up to 500m) where it can strangle vegetation and from where it can invade forest stands.
- It may provide rapid ground cover following land disturbance, reducing erosion and nutrient loss. It may possibly support native shade-tolerant species when growing in the canopy of alien invasive trees. In a balanced natural ecosystem it may be a normal component of native rainforest regeneration.

Native Range and Occurrence in Seychelles

- Widely distributed from the Indian Ocean region throughout Malesia (Malaysia, Indonesia and the Philippines), northern Australia to the Pacific region (Paynter et al. 2006, ISSG 2009)
- Lalyann d'argent *(Merremia peltata)* is native to Madagascar, Mauritius, La Reunion and Pemba Island in the Indian Ocean region (ISSG 2009) and very likely to be native in Seychelles (Robertson 1989, B. Senterre pers. comm.) although there are contradictory reports on the species status, e.g. Friedmann (1994) considers it to be probably introduced, Kueffer et al. (2004, in Paynter et al. 2006) mention it as an exotic problem weed in the Seychelles.
- Presently known on only two islands: on Mahé, the creeper is considered a major problem (B. Esther pers. comm.) but on Silhouette it is only a problem along the roads and footpaths (J. Gerlach pers. comm.).

Control/Management Options

Physical Control

- Mahé 1999: A field trial to eradicate Lalyann d'argent was carried out at one pilot site at Intendance, Takamaka by Forestry staff and gave good results. According to Kueffer & Schumacher (2005) cutting of the lower part of the stems and uprooting the remaining bits was an effective way of eradicating the creeper. To avoid re-sprouting or re-growth, all plant material was burnt or left to dry on rocks on site.
- To ensure complete eradication, the actions mentioned above had to be repeated two to three times by 3 field workers at intervals of about 3 months.
- To prevent re-invasion of the creeper on cleared sites, Kueffer & Schumacher proposed a rehabilitation programme with native trees and shrubs to be carried out immediately after clearance. They also

suggested that the eradication programme should be re-directed towards areas of high biodiversity, particularly around or within the Morne Seychellois National Park.
- 1999-2001: Following the successful field trail at Intendance, ten sites were selected for further eradication. They included lowland forest at Cap Ternay and sub-montane forest c.400m at L'Exile and the activity was contracted out to local contractors on nine sites and carried out by Forestry staff on one site.
- According to M. Vielle, c.26.4ha of forest area previously heavily invaded by the creeper was cleared between 1999 and 2001. The cost per hectare for the site eradicated by Forestry workers was between US$ 1200 to US$ 1500 (Kueffer & Vos 2004).

Conclusion
Physical control seems to work well for eradicating Lalyann d'argent at site level although a cost-analysis has not been done. A similar control measure has been undertaken by The Ecotourism Society of Seychelles (TESS) at Sweet Escott, Anse Royale and if any budding plant is found it is immediately nipped, allowing the site to be 'almost' cleared of the creepers (J. Rath pers. comm.).

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Devil's Ivy (*Epipremnum pinnatum* cv. 'Aureum') / Filodendron

Biology and Ecology
- Often mistaken as a Philodendron species.
- A high-climbing liana or hemi-epiphyte usually growing on trunks of trees.
- Thick stems, often with aerial roots, and large broadly ovate-lanceolate or cordate leaves with irregular yellow markings.
- Reproduces easily from cuttings and detached pieces of stem root. Disperses in two ways, either vegetatively, by spreading into neighbouring areas, or by seeds (this is less common in Seychelles).
- Occurs mainly in disturbed areas along the roadsides, abandoned fruit trees orchards or forestry plantations in the mid-altitude forests.

Native Range and Occurrence in Seychelles
- Devil's Ivy (*Epipremnum pinnatum* cv. 'aureum') is native to the Solomon Islands and it has been widely introduced as an ornamental plant in the tropics, where it is now considered a threat to native ecosystems in Hawaii, Samoa and Niue (PIER 2009).
- Very likely to have been introduced into the Seychelles as an ornamental and it is found on most of the inhabited inner islands: Mahé, Praslin, La Digue and Silhouette.

Control/Management Options

Physical Control
- Vallée de Mai, Praslin 1980-1988: A control programme against alien plant species was in place in Vallée de Mai World Heritage Site on Praslin Island during this time, using cutting and hand pulling. Amongst the species controlled was the creeper *Epipremnum sp.* (later identified as *E. pinnatum cv. aureum*) (Beaver 1996).
- 1988-1996: This programme was interrupted, with less regular control leading to a considerable increase

in abundance of the creeper near the entrance of Vallée de Mai (Beaver 1996).

- 1997-2002: A 2-year programme was initiated in 1997 under a grant from the Dutch Ministry of International Corporation (Frugte 1998).
    - A general study was made of all invasive and alien plants in Vallée de Mai, with suggestions for management of these, including an experimental approach for *Epipremnum* control (Beaver 1996).
    - Awareness-raising was carried out, e.g. to inform tour guides so that visitors to the World Heritage Site would understand the need for removal of the creeper (Beaver 1997).
    - Monitoring plots (8) were set up in the affected areas of the site in order to test various control methods but after a few months were just routinely checked for regrowth as the requirements for the suggested treatments (including painting of dilute herbicide on cut stems) were not fulfilled by management (Beaver 1997).
    - Considerable effort in terms of man hours was expended in cutting epiphytic *Epipremnum* on trees (particularly Coco-de-Mer palms) and removing all creepers covering the ground, starting with the latter.
    - Above ground, creepers were first cut at 1m all round palm and tree trunks. Later they were removed from as high up as possible by hooking and pulling. The remaining sections in the crowns of palms and other tree canopies were thus deprived of a ready supply of nutrients, particularly in the dry season and eventually died. But during the rainy season, the creepers were often able to survive and sent down new adventitious roots which therefore had to be cut on a regular basis to ensure they did not reach the ground (Beaver 1997).
    - Because of re-sprouting of pieces of stem left on the ground, there had to be regular checking and removal of all remaining creeper material (Beaver 1997).
    - Problems arose with the removal and disposal of the large quantities of plant material as it had to be taken off site and dumped or burnt at a special waste disposal site on Praslin. Weight of material removed was recorded at the time (but not currently available) (Beaver 1997).
    - As well as Vallée de Mai staff, numerous groups of volunteers helped with the programme, with suitable supervision.
    - Organisations involved: Seychelles Islands Foundation (managers of Vallée de Mai), Forestry Section of the Environment Division, several NGOs, community organisations and older school students.
    - Costs: not recorded but assumed to be cost of labour, supervision and monitoring, transport of plant material and sometimes volunteers, plus supervision and incentive bonuses for workers.
    - By 2002 the need for physical control was greatly reduced and the creeper was almost completely eradicated within Vallée de Mai (Kueffer & Vos 2004).
    - Note: this programme was successful because there were staff who could carry out (and or supervise) the work regularly over a longer period of time in a relatively confined area (Vallée de Mai total area is c.19ha and *Epipremnum* was only dense in an area of a few hectares).

- Mahé Island: According to Kueffer & Schumacher (2005) cutting of the lower part of the stems and uprooting the remaining bits was not effective as the creeper *Epipremnum pinnatum* cv. 'aureum' has the ability to produce aerial roots that grow back down to the ground, thus confirming the observations made at Vallée de Mai.

Chemical Control

- Mahé Island (2003): Some initial chemical treatments conducted by Forestry staff using salt water and the herbicide Roundup (Glysophate) were not effective against the creeper *Epipremnum pinnatum* cv. 'aureum' (Kueffer & Schumacher 2005).
- As a result, another herbicide Vigilant, with the active ingredient picloram (50g/kg) as the potassium salt in the form of a gel, was sought from a horticultural research lab in New Zealand in 2003. Vigilant is an herbicide gel for direct application on freshly cut stems of weeds. A comprehensive field trial was laid out to test the effectiveness of the herbicide (Kueffer & Schumacher 2005) with resulting suggestions as follows:
- Application of the herbicide (from Kueffer & Schumacher 2005)
    - Stems should be cut at 10cm above the ground.
    - Treat both parts of the cut stem by applying 3-5mm of gel. The product should kill the root system and the aerial parts, preventing the shooting of aerial roots.
    - For those plants high up in the trees (previously cut and now shooting aerial roots), send tree loppers to apply Vigilant on the main stem remaining on the trunk.
    - If aerial shoots are close to the ground, treat them as well.
    - It is worthwhile to try to avoid rainfall within 12 hours of treatment. In order to avoid leakage of product to the ground, treated stems should be covered with plastic bags.
- Although the preliminary results were very good, the Forestry section was provided with only 480g of the product for the trial so they could not ascertain the long-term effectiveness of the herbicide (B. Esther

pers. comm.).

- Cousin Island (2000s): The herbicide Vigilant was being used to control another semi-climbing creeper *Quisqualis indica* (Rangoon creeper) quite successfully and it seemed to be more cost-effective (e.g. 10 man hrs was reduced to 50 man minutes) but this needed to be evaluated against the real cost of buying and transporting the chemical, applicators and training plus the biodiversity impact of using the herbicide (Dunlop et al. 2005).

Conclusion

Physical control by cutting and removing all parts of the plant can work in small infested areas, given sufficient labour and time but would be difficult on a larger scale. Where Filodendron grows over tall trees, some sort of chemical treatment could be considered as preferable, such as the method described above (Kueffer & Schumacher), in order to prevent regrowth of the plant in places where it cannot be reached.

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8. AQUATIC WEEDS

There are not very many aquatic weed species so far in Seychelles and only 2-5 are regarded as major problem species. Most are controlled by mechanical means although this is not apparently cost effective, even considering the small size of freshwater wetlands in the granitic Seychelles. Several of these species were almost certainly introduced into aquaria and then released into local wetlands, e.g. Water hyacinth, Water lettuce, *Vallisneria sp*., the latter being a more recent introduction which is now a problem in several rivers in Victoria. Water lilies (*Nymphaea spp.*) are present but only a problem in certain wetlands and hand cleared if necessary. Likewise, *Ipomoea aquatica* (Bred lanmar), which is edible, can become a problem when it is not being adequately harvested for food. A further species which may become more of a problem is *Lemna sp*., which has very tiny floating leaves and can form a thin mat over the water surface, cutting off oxygen and light from anything living beneath.

Water lettuce *(Pistia stratiotes)* / Leti lanmar

<u>Biology and Ecology</u>

- Leti lanmar *(Pistia stratiotes)* is a free-floating aquatic plant with a rosette of dark green to pale yellow-green leaves depending upon nutrient availability in the water. Roots are feathery
- Individual plants can range in size from 2cm up to 30cm in diameter and can often be found floating as large mats on open water in ponds, rivers and marshes.
- The mats can become thick and extensive and block both sunlight and air from reaching the water surface, thereby impacting on aquatic biodiversity and fisheries.
- Normally, it is spread along water systems by flow and wind but sometimes can be assisted by humans or aquatic animals (water birds).

<u>Native Range and Occurrence in Seychelles</u>

- This is a widespread aquatic plant in the tropics and sub-tropics that may have originated in East Africa and was well known even in the 1st century AD.
- In Seychelles the species could have been introduced as an ornamental plant and it is found mainly on the inhabited granitic islands of Mahé, Praslin and La Digue. It first became a problem in the 1990s.
- There is an unconfirmed report that the species could have been eradicated on Praslin.

<u>Control/Management Options</u>

Physical Control

- According to P. Murugaiyan (2009 pers. comm.) there is an ongoing management programme funded by the Government of Seychelles to control and eventually eradicate the species in most of the important wetland areas on all the islands.
- The main control programme of invasive alien freshwater aquatic species, using manual removal of plants, was carried out between 2000 and 2004 on Mahé: at North East Point once per week and at Anse Royale once per month, with a workforce of 6 man hours per week.
- On Praslin, it was carried out twice per week with a workforce of 5 staff at 4 to 5 sites on rotation, with each site being visited once or twice a month.
- On La Digue, each site was visited twice per month with a workforce of 4 staff on a daily basis.
- Murugaiyan considered the government scheme (initial budget of SR 1 million for the first year and a gradual reduction to SR 250 000 in the final year) was not cost effective as it only kept the plants under control but did not eradicate them. The programme therefore has to be continually funded. This budget did not include staff personal salaries which were estimated to be costing the government about SR 4 million per year.
- In conclusion, he proposed the use of either chemical or biological control as a long term solution towards complete eradication of the weed.
- <u>2009</u>: This species is a problem in the marsh at Banyan Tree Hotel and Resort, Takamaka, where according to C. Thomas (2009 pers. comm.) there is an active management programme to eradicate it manually.
- In other areas of the main granitic islands, the control programme is in the process of being handed over to private contractors.

Chemical Control

There is no record of the use of herbicide in Seychelles to specifically control Water lettuce. Howard & Matindi (2003) reported that the herbicide 2-4 D is quite effective in controlling this freshwater aquatic weed;

however they did warn against the obvious negative impacts on non-targeted freshwater aquatic organisms in wetlands and water bodies.

Biological Control
There is no documented record of any biological control in Seychelles to specifically control Water lettuce. Howard & Matindi (2003) reported that bio-control agents such as beetles, particularly the weevil *Neohydronomous affinis,* have been effective in tropical situations.

Management Options
Howard & Matindi (2003) proposed that the most effective method of controlling this freshwater aquatic weed is by reducing nutrient input into wetlands and water bodies, although this can be expensive and is not always possible.

Conclusion
Manual physical control has significant limitations, given the rapidity of growth of Water Lettuce and the difficulty of removing all propagules. Although no chemical control has been attempted, there are obvious negative consequences for the environment and human health. There is potential for investigating the possibilities of biological control.

References

- Howard, G.W. & S.W. Matindi (2003) *Alien Invasive Species in Africa's Wetlands: Some threats and solutions.* IUCN Eastern Africa Regional Programme, Nairobi, Kenya.

Water hyacinth *(Eichhornia crassipes)*

Biology and Ecology
- Water hyacinth *(Eichhornia crassipes)* is a free-floating aquatic plant with shiny dark green leaves and a striking pale blue-purple flower with yellow markings.
- The leaves have extended, hollow stems which can extend to 2m above the water level and the submerged roots are long, extending as much as 1m below the water.
- It reproduces through seeds which can remain viable for up to 15years and by vegetative propagation from its stolons.
- When in its optimum temperature (25^{o}C) and high relative humidity (90%) and given ample supplies of dissolved salts it grows fast and can form extensive mats on previously open water.
- However, the species only tends to become invasive when there is alteration in the waterways such as introduction of nutrients or modification of flows.

Native Range and Occurrence in Seychelles
- This noxious weed originally comes from the Amazon River Basin of South America but is now widespread in the tropics and sub-tropics.
- In Seychelles the species could have been introduced as an ornamental plant.
- It is now found on Mahé and particularly on La Digue. There it has become a problematic weed in the waterways where it blocks the drainage canals resulting in inundation of the coastal plateau and agricultural lands.
- This species could have been eradicated on Fregate Island where it used to occur.

Control/Management Options

Physical Control
- According to P. Murugaiyan (2009 pers. comm.) the ongoing management programme, started in 2000 and funded by the Government of Seychelles, to control and eventually eradicate the species on the two islands has not been successful.
- The control programme using manual removal of plants was carried out between 2000 and 2004 on Mahé: at North East Point once per week and at Anse Royale once per month, with a workforce of 6 man hours per week.
- On La Digue, each site was visited twice per month with a workforce of 4 staff on a daily basis.
- The government scheme for control of Water hyacinth and Water lettuce had an initial budget of SR 1 million for the first year, with a gradual reduction to SR 250 000 in the final years. However the programme was not considered cost effective as it only kept the plants under control but did not eradicate, so it had to be a continuing process. This budget did not include staff personal salaries which Murugaiyan estimated to be costing the government about SR 4 million per year. In conclusion, he

proposed the use of either chemical or biological control as a long term solution towards complete eradication of the weed.

Chemical Control

There is no record of the use of herbicide in Seychelles to specifically control Water hyacinth. Howard & Matindi (2003) reported that various herbicides (possibly 2-4-D, Gylphosphate and Diquat) are effective in controlling the freshwater aquatic weed; however they did warn against the obvious negative impacts on non-targeted freshwater aquatic organisms in wetlands and water bodies.

Biological Control

There is no documented record of the introduction of any biological control agent in Seychelles to specifically control Water hyacinth. G.W. Howard and S.W. Matindi (2003) reported that the most successful and self-sustaining control measure is by using two small beetles (the weevils *Neochetina eichhorniae* and *Neochetina bruchi*) and other species such as a moth, a mite and pathogenic fungi. However, they proposed an integrated control involving physical or mechanical and chemical control as well, because biological control alone may not always be effective.

Alternative uses

Although Water hyacinth populations are not large in Seychelles, in other countries this weed is used to produce paper and baskets, as well as biogas.

Conclusion

Manual control of the relatively limited populations of Water hyacinth in Seychelles is currently sufficient. Alternative uses for the cut material could be considered.

References

- Howard, G.W. and S.W. Matindi (2003) *Alien Invasive Species in Africa's Wetlands: Some threats and solutions.* IUCN Eastern Africa Regional Programme, Nairobi, Kenya.

CONCLUSIONS AND RECOMMENDATIONS

Good practice for IAS management requires that certain basic strategies are followed:

- If a new invasion, then there should be early reaction.
- Preliminary studies are required to determine IAS population size and distribution in the area of infestation.
- A full feasibility study is essential for a potential containment, eradication or control programme. This should include the following to be more certain of success:
  - Studies of the characteristics and ecology of the species and of control techniques; checking legislation regarding methods (e.g. Pesticides Control Act 1996); and testing of alternative methods if possible in situ, including the best timing for the control programme.
  - Assessment of the risks of control techniques to non-target species (plus procedures and costs of mitigation if required).
  - Systematic methods for implementation of the control programme should be built in.
  - Systematic monitoring should be built in and carried out throughout the programme (which helps to ascertain where adaptation may be necessary or where mistakes were made).
  - Cost-benefit analysis for the control techniques and the whole programme.
  - Full identification of project partners, capacity needs and sources of funding for the complete programme (including follow-up measures if required).
  - Whether stakeholders and the public are supportive of the project, and whether or not awareness programmes are required.
  - Whether or not it is necessary to have procedures and protocols in place after the control programme to prevent reinvasion and if so, how this will work.
- Once the containment / eradication / control of the IAS is assessed as feasible, then all procedures should be followed as outlined above.

What made for a successful programme in Seychelles?

- The programmes which have been most successful have mostly had a strategy in place, similar to that outlined above, including not only quantitative assessment of populations, testing of techniques on both target and non-target species and full monitoring during and after the programme, but also systematic application of the technique(s). Such strategies have frequently (but with notable exceptions) been linked with the import of international consultants, due to the lack of suitably qualified local people in this small country. These international consultants were hired on long-term contracts or short term consultancies specifically for a particular IAS problem. However, even in these cases, appropriate monitoring and recording after the programme was often not in place, which is one reason why it has been difficult to evaluate the effectiveness of some programmes.
- Another factor which has been very important for success is ensuring that funding is sufficient for both the management programme and any required follow up. In the past this often meant assistance from outside Seychelles, e.g. international organisations or governments. More recently, however, several successful projects have involved, for example, local eco-tourism ventures (albeit often owned by overseas companies) in joint ventures between a hotel resort island, an NGO, a private enterprise and Seychelles government.
- As well as adequate funds, successful programmes have included prior planning with respect to logistical arrangements (including backup plans), e.g. they have obtained all necessary permits and authorisations, made procurement and storage arrangements for equipment and chemicals (for example), and allowed for emergency changes to plans (e.g. in the case of poor weather conditions or logistical delays).
- However, in some cases earlier management programmes for a single species were very successful on small islands when carried out consistently, even if not designed in a sophisticated way, e.g. cats on small islands of less than 25ha. Similarly, removal of alien plant species in small areas can be effective if followed up with replacement by native species and continuous removal of any invading alien species. Likewise, quite simple methods of control tried out by local farmers and landowners have sometimes been remarkably efficient in keeping pest numbers down. Therefore sophistication has not always been a prerequisite for success!
- Finally, occasionally, for example with the early attempts at biological control of agricultural pests, the positive result was probably more a question of luck in the choice of species than due to proper strategic planning, studies and follow-up!

Why have some programmes been less successful in the Seychelles context?

- Some control programmes, especially for a newly arrived IAS, have been delayed due to, for example, slowness of the appropriate authorities to respond to initial alerts, problems with finding and assessing suitable management methods, lack of capacity, and problems with acquiring funding. All control programmes require funding and certain expertise, and this is often not immediately available.
- Although it is important to have guiding principles and strategies, such as those laid out above, in practice it may have been difficult to follow these. For example, if an IAS was perceived to require control, then a land manager may have preferred to carry out some sort of ad hoc management programme rather than do nothing at all. Also, even if a programme appeared to be showing signs of success, it may have been terminated simply because there was little or no capacity for systematic follow up. The result was likely to be reduced efficacy of managing the IAS.
- Many control and eradication programmes in earlier years were more like experimental or field trials, particularly for biological control, and lacked proper feasibility studies, as judged from the absence of these in reports. However, it seems likely that there must have been at least an attempt to get some idea of the extent of the population of a species and its impacts, otherwise control attempts wouldn't have been carried out in the first place.
- What seems to have been missing from many early programmes, however, is the lack of sufficient consideration of the effects of the control programme on non-target species or other aspects of the environment, e.g. a biological control organism or insecticides on other local species. However this is not something specific to Seychelles as such issues were ignored in much of the world at the time.
- Quite a number of early mammal eradication attempts resulted in only partial control or in reintroduction of the pest species. In some cases this was the result of an inadequate or unsuccessful methodology. In others, although apparently systematic methods were used, it was only later realised that faulty design may have lead to failure of the programme. In other cases it was the result of lack of funds, logistical problems, or lack of follow up protocols to prevent re-entry of the pest species. If an island is uninhabited or difficult to 'police', it is more likely to receive unwanted visitors in boats bringing unwanted species back!
- While it may not be possible to fully eradicate some species and have to be satisfied with reduction in population numbers, in many cases if the first control effort was not followed up by a regular control and maintenance programme (i.e. IAS management) populations simply built up again to high levels which were even more difficult to control. For example, even in the recent past, many IAS management activities on the main islands (e.g. for invasive creepers) have been carried out on a rather ad hoc basis, e.g. by a voluntary group on a special environment day with limited financial input, and with little consideration of the sustainability of the programme. Thus, control has been temporary at best.
- In past programmes, such lack of follow up was not only the result of inadequate funds allocated for this, but due to lack (or loss) of sufficiently aware and trained personnel, i.e. lack of resources and capacity. For example, for post-programme monitoring of IAS populations, or for stringent supervision of reinvasion prevention protocols. Finance and well-trained personnel for strategic IAS control programmes have been a continuous problem in this small country, and remain so.
- Even after successful eradication or control, the subsequent management of the environment is very important, e.g. there is no point in removing large alien trees or large masses of creepers and then allowing natural regeneration if the regenerating species are likely to be IAS. In such cases, subsequent rehabilitation should have been built into the control programme.
- Following an eradication programme, the ecosystem has to readjust to the absence of the IAS. In some cases this results in changes in populations of other organisms, sometimes beneficial (e.g. increase in threatened bird species after eradication of a predator) and sometimes not (e.g. regeneration of alien plants that were kept partially under control by a herbivore). Such changes have been reported and also need to be taken into consideration but cannot always be predicted in advance.
- One further point is that Seychelles' Biodiversity laws are in a very prolonged process of being revised, and until they are, certain plant species which are now considered to be invasive remain on the Protected Species list because of their previous value as economic resources, viz. Coconut, Albizia, Bwa zonn (*Alstonia*), Kalis dipap (*Tabebuia*), Agati (*Adenanthera*), and Casuarina (in the areas where it is invasive). This means that permission has to be sought from public authorities to remove unwanted trees.

Recommendations

- It is necessary to carry out management, control and eradication programmes according to a protocol (such as that devised by the Global Invasive Species Programme (GISP) - see Wittenberg & Cock (2001) in order to better plan the programme and be more likely of achieving success. All programmes in the future should therefore follow a suitable management strategy, as outlined above.

- A system needs to be devised for prioritising which invasive species to tackle, in which order and where, whether this is done at a national level (with an agreed list of priority species to be controlled, if this can be achieved) or, perhaps more usefully, at an organisational/management level. Devising such a system is proposed as a possible activity for further funding.
- Biological control for certain agricultural species (e.g. the spiralling whitefly) should be reconsidered on a national basis, as methodologies and protocols are now very much more advanced (and internationally recognised) compared with early attempts in the mid 1900s which made government officials very wary of this method.
- Integrated Pest Management (IPM) is recommended wherever several management methods can be used in combination, and should be encouraged, rather than relying on one method alone.
- Public / private cooperation for IAS management seems to have worked well and could be encouraged as a way forward in the future, particularly including the involvement of local business companies and voluntary public or NGO participation.
- However, different stakeholders may have very different perceptions of for example the need for monitoring and for very strict protocols (both of which are often expensive to operate and maintain at sufficiently strict levels), particularly on hotel/tourism islands. Hopefully the current GEF projects, which are aimed at mainstreaming the main environmental issues into the major economic sectors of Seychelles, are helping to bring together concerned stakeholders and raise awareness.
- Another activity under this GEF project will produce revised policies for prevention of new introductions. Many of the species in this report were inadvertently introduced or reintroduced (after they had been eradicated) on boats to islands. Strict biosecurity protocols need to be in place. There is still insufficient public awareness of the dangers that new introductions can bring and while the managers of some smaller islands are now very aware of the need for measures to prevent invasions, others remain lax and further effort is required to convince and train staff.
- As there is a great deal of uncertainty about how species react to changes in the atmosphere brought about by climate change, non-invasive alien species already present in Seychelles may become invasive. It is also possible that new species may be introduced in spite of new biosecurity regulations, so it may well be necessary to update the IAS-control priority lists from time to time.

<u>The next step</u>

The next activity for this consultancy, according to the Terms of Reference, is the production of a Field Guide to best practices for IAS management in Seychelles. The questionnaire prepared as part of this report (see Annex 1) already identified species considered a problem by stakeholders. Discussions during the follow-up workshop helped to determine what information is essential for the guide and what format it could best take. However, it became increasingly obvious during these discussions that such a field guide to best practices requires considerable further research because best practices cannot currently be given for many of the IAS in Seychelles due to lack of information on the efficacy of techniques and methodologies. Additionally, management practices used elsewhere would require testing and adapting to the specific conditions and situations within Seychelles before being included in a field guide, whether in printed or database format. It was therefore proposed by PCA that a smaller, more general, guide to overall best practices for IAS management would be more appropriate at this time, intended particularly for land managers rather than the public in general.

Finally, within the GEF project, funds are available to develop a national database on IAS which should include the most effective control practices for the Seychelles. By doing this the results of this review will not be static and new information can be uploaded when it becomes available.

<u>References</u>

- Wittenberg R. & M.J.W. Cock (Eds) (2001) *Invasive Alien Species: a toolkit of best prevention and management practices.* (GISP) CAB International, Wallingford, Oxon, UK

MAINSTREAMING PREVENTION AND CONTROL MEASURES FOR INVASIVE ALIEN SPECIES INTO TRADE, TRANSPORT AND TRAVEL ACROSS THE PRODUCTION LANDSCAPE

REVIEW AND EVALUATION OF INVASIVE ALIEN SPECIES (IAS) CONTROL AND ERADICATION ACTIVITIES IN SEYCHELLES
AND DEVELOPMENT OF A FIELD GUIDE ON IAS MANAGEMENT

REVIEW OF IAS CONTROL AND ERADICATION PROGRAMMES IN SEYCHELLES

ooooooo ANNEXES oooooooo

Prepared by the Plant Conservation Action group

Editors: Katy Beaver and James Mougal

December 2009

ANNEX 1 I.A.S. QUESTIONNAIRE RESPONSES AND ANALYSIS

The Questionnaire

A questionnaire was devised by PCA and circulated to around 45 stakeholder organisations (often several individuals within the organisation to be more likely of getting a response - some 70 people in all). Organisations included different sections of the Department of Environment DoE; parastatal organisations (Seychelles Agricultural Agency SAA, Seychelles National Parks Authority SNPA); environmental NGOs; island managers; eco-tourism hotels and resorts (some on small islands, others on the main islands); other protected area managers; and individuals who might have experience of dealing with IAS in their work or as landowners.

Question 1 was designed to find out:

a) which Invasive Alien Species (IAS) are the most problematic for these stakeholders,
b) which of these IAS they are currently controlling,
c) which IAS have been a problem in the past and have been eradicated, or controlled but rebounded.

A Table of possible IAS was presented so that it was easy for respondents to check and to add extra species if necessary (see Results Table on p 7)

Questions 2 to 6 were designed to find out:

a) whether there might be unpublished reports available that PCA had not seen,
b) whether the stakeholder would be willing to share information and experience, and if so, how freely,
c) for which invasive species stakeholders require more management information,
d) whether it would be useful to have a system for prioritising IAS control.

Responses

Around 25 responses were obtained, with 21 being in the form of returned Questionnaires by organisations (an almost 50% return). There was a general tendency for stakeholders to focus on IAS that are more problematic to their respective organisations, therefore some of the questionnaires were only partially completed.

<u>The IAS which are important for stakeholders</u>

The Table of results for Question 1 is given on pages 7-10). A summary table ranking all named IAS, from most often reported to least often reported, is given on page 3. Similar group summaries (e.g. Birds, Trees) are given on pages 4-6. An overall verbal summary is given below:

- The biggest current problem species appears to be Spiralling whitefly (14 respondents).
- Next most reported are Black rat and Mealy bugs (Lipou blan) (9 and 8 respondents respectively).
- Several species were reported by 7 respondents - Indian myna, Giant African snail, Scale insects, Albizia, Lantana (Vyeyfiy), Leucena (Kassi) and Takamaka Wilt disease.
- Also important (5-6 respondents) are Feral cat and Yellow crazy ant (as animals), with the remainder being plant species - Cocoplum (Prindfrans), *Stachytarpheta* (Zepible), *Alstonia* (Bwa zonn), Coconut, *Clidemia* (Fo watouk), Water lettuce and Philodendron creepers.
- Some species were only a problem on specific outer islands, e.g. Feral goat on Aldabra, several ornamental plants (Oleander, Oyster plant, Lys-bordmer) on Alphonse).
- Interestingly the *Merremia* creeper which is so prevalent on Mahé does not yet appear to be a problem on other islands.
- In certain cases invasive species have been controlled but have returned in greater numbers or remain a problem, e.g. Black rat, Indian myna, Mealy bugs, Takamaka Wilt disease.
- Overall, respondents are managing or controlling about 58% of the species they recorded as being a problem.
- There was a disagreement on the invasive status of a few species, e.g. Papaya, among stakeholders.

Responses to Questions 2 to 6

2. Might you have additional unpublished reports about IAS control that we may not have found during our research? Yes: **5** **No: 14**

3. If any species (IAS) is currently being managed by your organisation, would you be willing to share your experience with other stakeholders, for the benefit of all?
   Yes (unconditional): 10 **Yes, with certain limitations: 9** No: **0**

4. Do you have other important lessons/experience with IAS that you are willing to share with others? (We would be particularly grateful for information on IAS control/maintenance costs and effectiveness)
   Yes: 9 **No: 8**

6. Would it be useful to you to have a system for prioritising control of problem species (e.g. a chart with specific criteria) in order to decide which species to tackle first?
   Yes: 14 No: **3**

Note that Question 5 required specific IAS to be named in order to acquire further information. These species will be followed up in the Field Guide to best IAS management practices.

Comments

- Question 2: It seems that a few unpublished reports from five sources may still be extant but as some respondents are reluctant to share unconditionally, these may remain unavailable.
- Question 3: Some information relating to control of invasive alien species may still require documenting or validating, although again, certain respondents are reluctant to share their information unconditionally so it may remain unavailable.
- Question 4: Likewise for sharing of important lessons learned - some information can be followed up but there remains a reluctance to share without specific conditions attached.
- Question 6: The majority of respondents would find it useful to have a mechanism for prioritising problem species that require control.

The general reticence of certain managers, NGOs and staff in sharing useful information is a well known phenomenon in Seychelles. While it is understood that there are certain reasons for this, it is regrettable to see that people are reluctant to share their experience and knowledge with each other for fear that someone else will take the information and use it in some way that benefits himself or herself, their island or their organisation alone. But that is life, and a way around this problem would be useful to find! However, we would like to sincerely thank all the respondents who have agreed to share their information unconditionally or with limited conditions for the benefit of others.

Conclusions

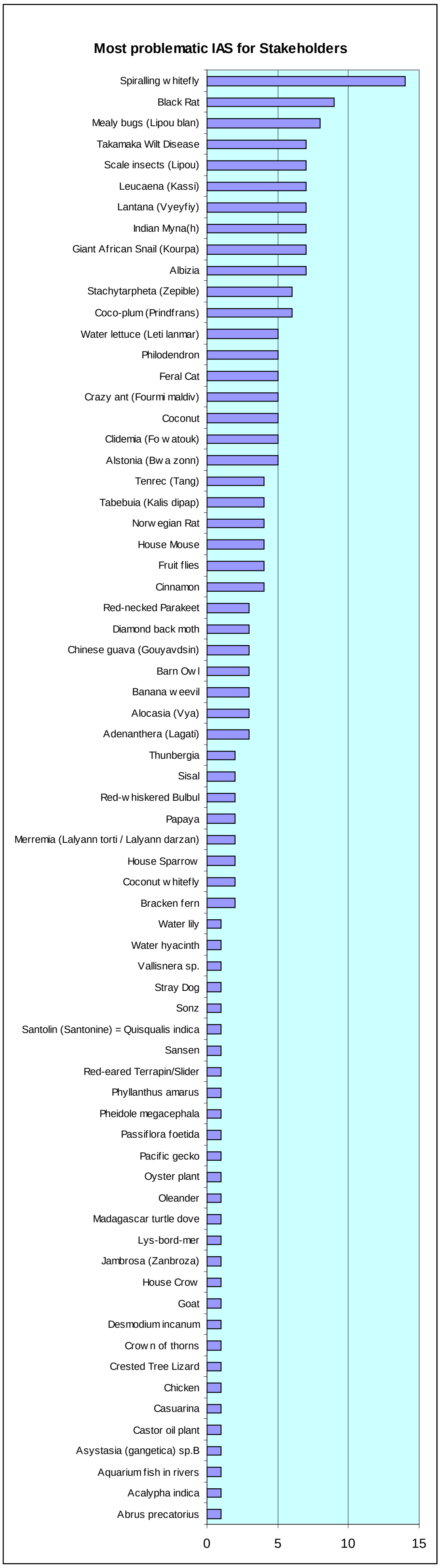
Overall the responses to the Questionnaire have helped to identify that:

- Spiralling whitefly is the most serious pest, and Black rats and Mealy bugs remain a problem in spite of control programmes;
- that there are many IAS which are a problem for stakeholders and for which no reports are available regarding their management, even though the species are undergoing some sort of control;
- several common problem species remain difficult for stakeholders to control.

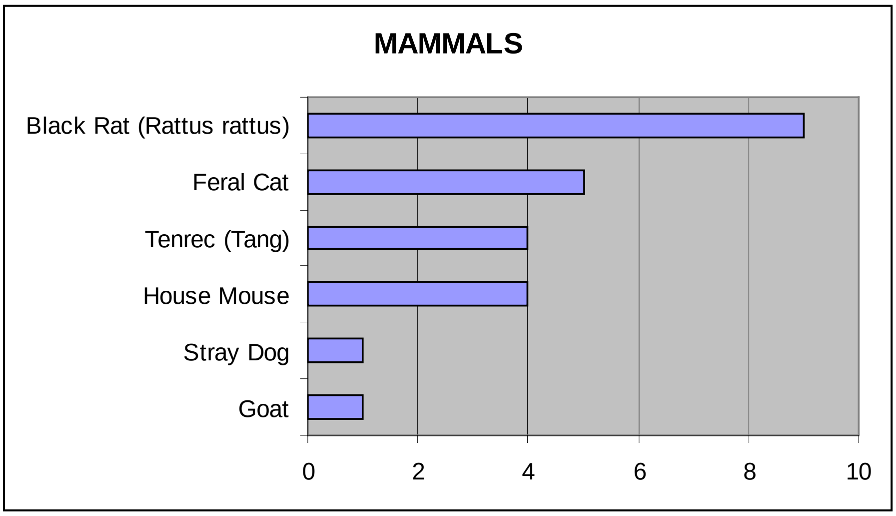
Recommendations

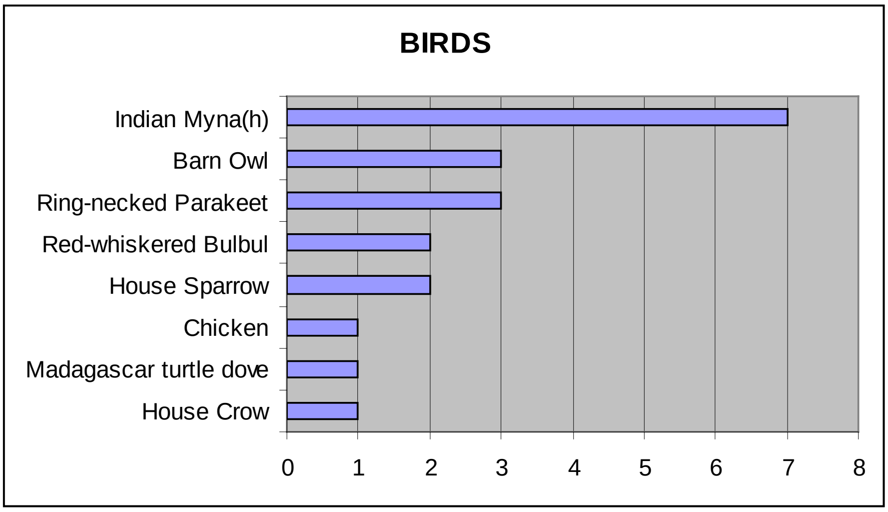
1. A suitable mechanism for prioritising the control of IAS requires development. This should be a future project or activity as it does not fall within the remit of this project. Some countries or areas have already developed such systems (e.g. Galapagos) which could be adapted for use in Seychelles.

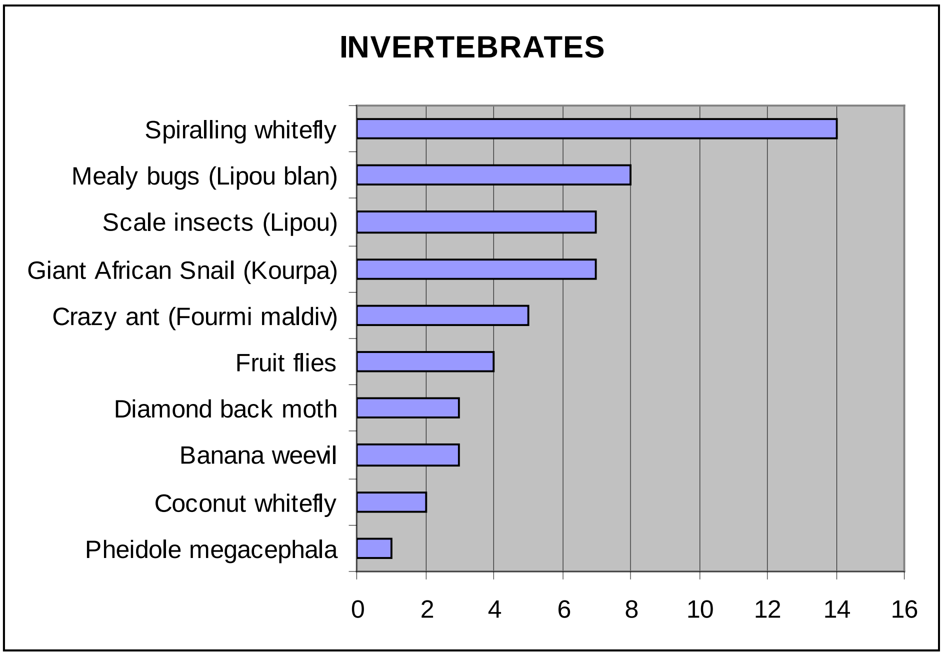
2. Certain of the IAS mentioned by stakeholders probably require a national response rather than a response from individual stakeholders, e.g. Spiralling whitefly.

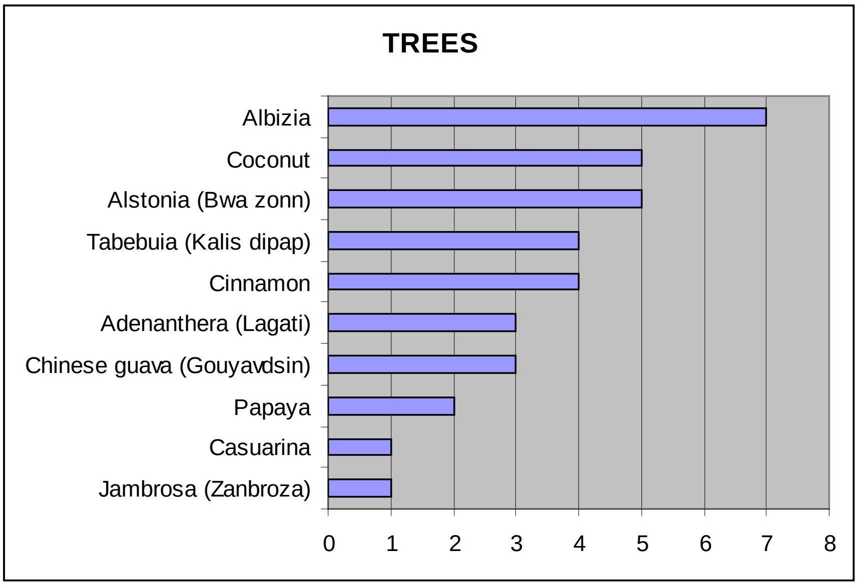

Most problematic IAS for Stakeholders
Spiralling whitefly
Black Rat
Mealy bugs (Lipou blan)
Takamaka Wilt Disease
Scale insects (Lipou)
Leucaena (Kassi)
Lantana (Vyeyfiy)
Indian Myna(h)
Giant African Snail (Kourpa)
Albizia
Stachytarpheta (Zepible)
Coco-plum (Prindfrans)
Water lettuce (Leti lanmar)
Philodendron
Feral Cat
Crazy ant (Fourmi maldiv)
Coconut
Clidemia (Fo watouk)
Alstonia (Bwa zonn)
Tenrec (Tang)
Tabebuia (Kalis dipap)
Norwegian Rat
House Mouse
Fruit flies
Cinnamon
Red-necked Parakeet
Diamond back moth
Chinese guava (Gouyavdsin)
Barn Owl
Banana weevil
Alocasia (Vya)
Adenanthera (Lagati)
Thunbergia
Sisal
Red-whiskered Bulbul
Papaya
Merremia (Lalyann torti / Lalyann darzan)
House Sparrow
Coconut whitefly
Bracken fern
Water lily
Water hyacinth
Vallisnera sp.
Stray Dog
Sonz
Santolin (Santonine) = Quisqualis indica
Sansen
Red-eared Terrapin/Slider
Phyllanthus amarus
Pheidole megacephala
Passiflora foetida
Pacific gecko
Oyster plant
Oleander
Madagascar turtle dove
Lys-bord-mer
Jambrosa (Zanbroza)
House Crow
Goat
Desmodium incanum
Crown of thorns
Crested Tree Lizard
Chicken
Casuarina
Castor oil plant
Asystasia (gangetica) sp.B
Aquarium fish in rivers
Acalypha indica
Abrus precatorius
0
5
10
15

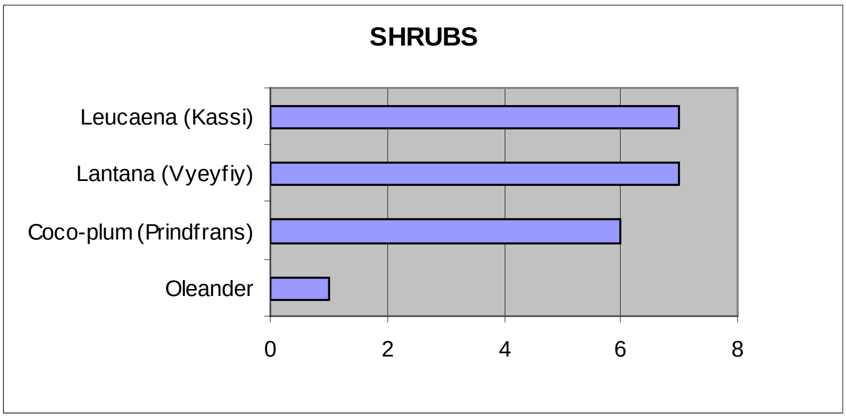
Group summaries

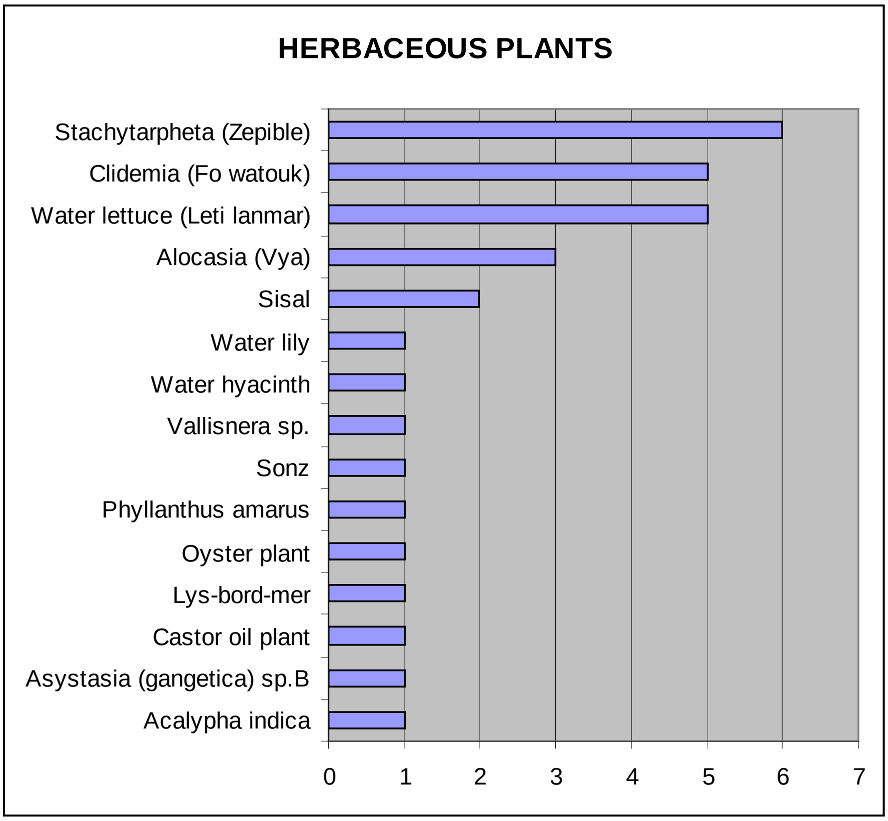


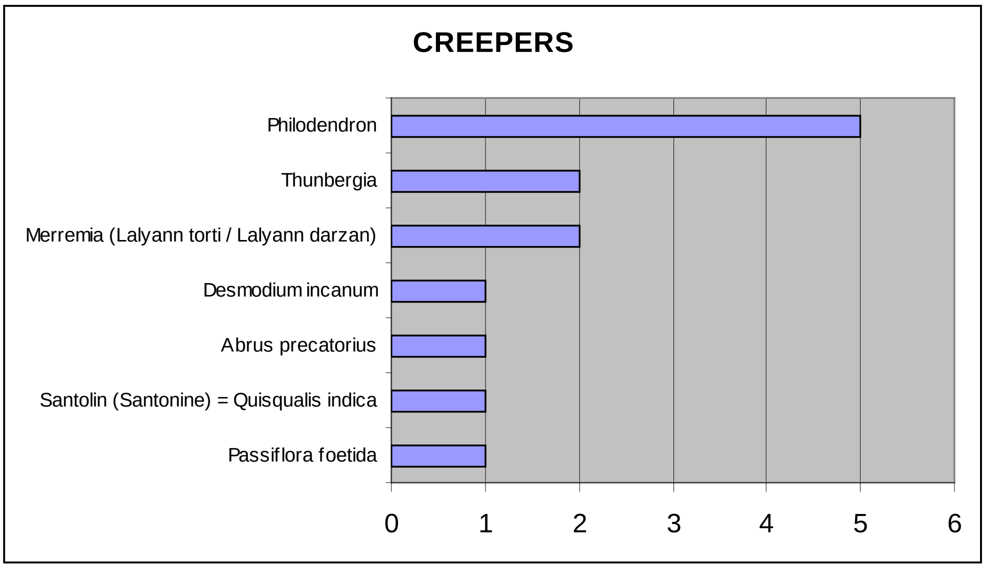


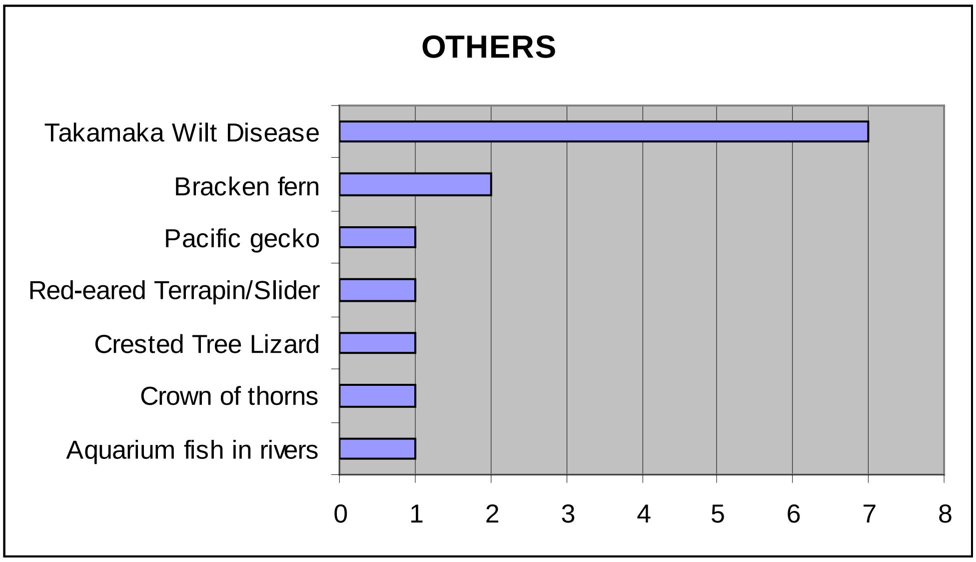



TREES
Albizia
Coconut
Alstonia (Bwa zonn)
Tabebuia (Kalis dipap)
Cinnamon
Adenanthera (Lagati)
Chinese guava (Gouyavdsin)
Papaya
Casuarina
Jambrosa (Zanbroza)
0 1 2 3 4 5 6 7 8


SHRUBS
Leucaena (Kassi)
Lantana (Vyeyfiy)
Coco-plum (Prindfrans)
Oleander
0 2 4 6 8


HERBACEOUS PLANTS
Stachytarpheta (Zepible)
Clidemia (Fo watouk)
Water lettuce (Leti lanmar)
Alocasia (Vya)
Sisal
Water lily
Water hyacinth
Vallisnera sp.
Sonz
Phyllanthus amarus
Oyster plant
Lys-bord-mer
Castor oil plant
Asystasia (gangetica) sp.B
Acalypha indica
0 1 2 3 4 5 6 7


CREEPERS
Philodendron
Thunbergia
Merremia (Lalyann torti / Lalyann darzan)
Desmodium incanum
Abrus precatorius
Santolin (Santonine) = Quisqualis indica
Passiflora foetida
0
1
2
3
4
5
6


OTHERS
Takamaka Wilt Disease
Bracken fern
Pacific gecko
Red-eared Terrapin/Slider
Crested Tree Lizard
Crown of thorns
Aquarium fish in rivers
0
1
2
3
4
5
6
7
8

Results Table for Question 1

Invasive Alien Species	Is this species a major problem for your organisation?	Is this species currently being managed / controlled by your organisation?	Was this species once controlled but has increased in numbers again?	Was this species a problem in the past but is now eradicated?
MAMMALS				
Feral Cat	5	5	0	5
Black Rat (*Rattus rattus)*	9	6	2	3
Norwegian Rat (*Rattus norvegicus*)	4	1	1	2
Feral Rabbit	0	0	0	0
House Mouse	4	1	0	0
Goat	1	1	0	1
Tenrec (Tang)	4	1	0	0
Stray Dog	1	0	0	0
BIRDS				
House Crow	1	1	0	0
Ring-necked Parakeet	3	1	1	0
House Sparrow	2	1	0	0
Barn Owl	3	2	0	1
Indian Myna(h)	7	3	2	0
Red-whiskered Bulbul	2	0	1	0
Chicken	1	1	0	0
Madagascar turtle dove	1	0	0	0
REPTILES				
Crested Tree Lizard	1	1	0	0
Red-eared Terrapin/Slider	1	1	0	0
Pacific gecko	1	0	0	0

Invasive Alien Species	Is this species a major problem for your organisation?	Is this species currently being managed / controlled by your organisation?	Was this species once controlled but has increased in numbers again?	Was this species a problem in the past but is now eradicated?
FISH				
Tilapia	0	0	0	0
Aquarium fish in rivers	1	0	0	0
Crown of thorns	1	1	1	0
INVERTEBRATES				
Crazy ant (Fourmi maldiv)	5	0	1	0
Giant African Snail (Kourpa)	7	4	1	1
Mealy bugs (Lipou blan)	8	3	2	0
Scale insects (Lipou)	7	3	1	0
Fruit flies	4	1	1	0
Spiralling whitefly	14	2	1	0
Banana weevil	3	1	1	0
Diamond back moth	3	1	1	0
Pheidole megacephala (Ant species)	1	1	1	0
Coconut whitefly	2	0	0	0
TREES				
Cinnamon	4	3	0	0
Chinese guava (Gouyavdsin)	3	2	0	1
Albizia	7	5	0	1
Alstonia (Bwa zonn)	5	5	0	0
Tabebuia (Kalis dipap)	4	4	0	0
Adenanthera (Lagati)	3	2	0	0
Coconut	5	5	0	0
Jambrosa (Zanbroza)	1	0	0	0
Papaya	2	1	0	1

Invasive Alien Species	Is this species a major problem for your organisation?	Is this species currently being managed / controlled by your organisation?	Was this species once controlled but has increased in numbers again?	Was this species a problem in the past but is now eradicated?
Casuarina	1	1	0	0
SHRUBS				
Coco-plum (Prindfrans)	6	3	0	0
Lantana (Vyeyfiy)	7	6	0	1
Leucaena (Kassi)	7	4	0	1
Oleander	1	1	0	0
HERBACEOUS				
Clidemia (Fo watouk)	5	4	1	0
Water lettuce (Leti lanmar)	5	2	0	0
Stachytarpheta (Zepible)	6	5	0	0
Alocasia (Vya)	3	1	0	0
Asystasia (*gangetica*) sp.B	1	1	0	0
Acalypha indica	1	1	0	0
Phyllanthus amarus	1	1	0	0
Sisal	2	1	1	0
Castor oil plant	1	1	0	0
Lys-bordmer	1	1	0	0
Oyster plant	1	1	0	0
Sonz	1	0	0	0
Water hyacinth	1	1	0	0
Water lily	1	1	0	0
Vallisnera sp.	1	1	0	0
CREEPERS				
Merremia (Lalyann torti / Lalyann darzan)	2	1	0	0

Invasive Alien Species	Is this species a major problem for your organisation?	Is this species currently being managed / controlled by your organisation?	Was this species once controlled but has increased in numbers again?	Was this species a problem in the past but is now eradicated?
Philodendron	5	3	0	0
Thunbergia	2	2	0	1
Passiflora foetida	1	2	0	0
Passiflora suberosa	0	1	0	0
Santolin (Santonine) = *Quisqualis indica*	1	1	0	1
Sansen?	1	1	0	1
Syngonum sp.	0	1	0	0
Abrus precatorius	1	1	0	0
Desmodium incanum	1	1	0	0
FERNS				
Bracken fern	2	2	0	0
FUNGI				
Takamaka Wilt Disease	7	3	1	0
Sandragon wilt				

ANNEX 2 List of stakeholder questionnaire respondents

Name of Organisation	Contact Person	Post Title	Contact Details
Cousine Island	Kevin Jolliffe	Conservation Officer	cousine2@seychelles.net Tel. 322961/713421
Fregate Island Private	Madel Wilkens Brent Whittington	Conservation Manager Ecology Manager	ecology@fregate.com Tel. 727421/727436
The Ecotourism Society of Seychelles (TESS)	Joseph Rath Marc Marengo	Programs Development Chairman	josephrath@hotmail.com Tel. 225914/526794
Nature Seychelles Denis/Cousin Islands	Terence Vel	Education & Advocacy Coordinator	wcs@natureseychelles.org Tel. 719047
Seychelles Agricultural Agency (SAA) Plant & Animal Health Service	Will Dogley	Manager	seypro@seychelles.net Tel. 611479/722607
Island Conservation Society (ICS) Aride/Alphonse Islands	Riaz Aumeeruddy	Science & Project Manger	icsscience@seychelles.sc Tel. 375354/71268
Seychelles Islands Foundation (SIF) Vallee de Mai/Aldabra Island	Nancy Bunbury Naomi Doak	Projects Programme Coordinator Aldabra Research Officer	nancy@sif.sc Tel. 321735/565621
Department of Environment (DoE) Conservation Section	Elvina Henriette Payet	Senior Project Officer	Tel. 670500
Island Conservation Society (ICS) Alphonse Islands	Pierre-Andre Adam	Scientific Officer	pierreandreadam@yahoo.co.uk Tel. 229040
Eden Island Development Horticultural Department	Steve Vinda Lucille Monty		lucille@edenisland.sc Tel. 346000
Department of Environment (DoE) Forestry Section	Basil Esther	Senior Project Officer	b.esther@env.gov.sc Tel. 670500
North Island	Linda Vanherck	Environment Officer	lindav@north-island.com Tel. 293186/576111
Seychelles National Park Authority (SNPA) Curieuse Island	Barbara Kilindo Michelle Etienne	Research Officers	b.hoareau@scmrt-mpa.sc Tel. 323494/522930
Banyan Tree Resort Seychelles	Cedrick Thomas	Chief Gardner	Tel. 522281
Barbarons Biodiversity Centre	Damien Doudee	Horticulturist	damien@cwci.blackberry.com Tel. 722170
Fond Ferdinand Nature Reserve	Nigel Colin Valmont	Manager	collinvO@gmail.com Tel. 722881
Marine Conservation Society of Seychelles (MCSS)	Elke Talma David Rowat	Project Officer Chairman	elke@mcss.sc Tel. 261511/713500
Moyenne Island Nature Reserve	Brendon Grimshaw	Owner / manager	Tel. 552828
Department of Environment (DoE)	Murugaiyan Pugazhendui		Tel. 722415
Nature Protection Trust of Seychelles (NPTS) Silhouette Island	Justin Gerlach	Scientific Coordinator	jstgerlach@aol.com

ANNEX 3 Report of the IAS workshop held on 29 September 2009

REVIEW & EVALUATION OF INVASIVE ALIEN SPECIES CONTROL (IAS) AND ERADICATION ACTIVITIES IN SEYCHELLES and DEVELOPMENT OF A FIELD GUIDE ON IAS MANAGEMENT

REPORT OF THE WORKSHOP HELD ON

TUESDAY 29 SEPTEMBER 2009 08.30 - 12.00
CARE House conference and training room

The workshop had the following objectives:

1. To briefly review the results of Objective 1 (see below - Review of IAS management field activities in the Seychelles), including the results of the Questionnaire previously sent out to most of the stakeholders.

2. To discuss what form of "field guide" (see Objective 2 below) would be most useful for stakeholders, and/or whether this is indeed the most valuable 'next step' in the consultancy as there are other options.

3. To make recommendations for this 'next step'.

The overall objectives of this consultancy are:

1. To review IAS management field activities in the Seychelles, with particular reference to mitigation, control and eradication measures, including an evaluation of their effectiveness and efficiency.

2. To develop a "field guide on IAS control and eradication measures".

Workshop participation

There were fewer participants at the workshop than the expected number of c.25 or more. Around 20 participants from government, environmental NGOs and parastatals were present, with no representatives from the private sector, which was disappointing as they could be one beneficiary of the expected output(s) from the following up activities. The participant list forms Annex 1 of this report.

Workshop programme

The Workshop programme forms Annex 2 of this report. The programme went more or less according to plan. Several additional small activities were included as part of the main programme, e.g. participants were asked to name the six IAS they assessed as being the priority species for the country; there was a small demonstration activity to reveal the complexity of dealing with IAS management.

Outcomes of Objective 1 (Review of IAS management report):

There were few comments on the review of the IAS field management activities in Seychelles, except for the possible need to standardise the definition of an Invasive Alien Species for the overall strategy for dealing with these species.

The main question regarding the review of the Questionnaire responses was how representative these were of the stakeholders who had been sent the questionnaire. It was explained that there was a broad range of responses, with around a 50% return from organisations, including NGOs, parastatals, protected areas, private islands, private enterprise, but no response from local community (districts).

Outcomes of Objective 2 (Group work to discuss the possible next steps)

Participants were divided randomly into 3 groups of c.6 people and asked to discuss the possible next steps for the project, using the guidelines given in Annex 3. In summary:

1. Field guide - if so what kind and what format?
2. Field trials of management methods - What? When? Where? Who?
3. Action plan? - e.g. guidelines based on where we are at now.
4. System for prioritizing IAS problems / management? - At national level? At individual management level?

<u>Group 1</u>

- This group eliminated '<u>Field trails</u>' as an immediate next step - as they can be done in the future (this was also agreed by other participants), and incorporated the <u>Action plan</u> guidelines into the other possibilities.
- The <u>Field guide</u> could be better conceived as a <u>Toolkit</u> for how to manage IAS, which could be a technical document but aimed at the general public to help with decision-making. One person in the group felt strongly that it should be technical, as general education and awareness about IAS were not the point of this project.
- The toolkit would deal with the main problem species (including photos and other identification information) but also include brief information to help with identifying other species.
- It could include a decision-making "tree" with good and bad practice case studies for the problem species, together with resources (references and contacts) for management.
- <u>Prioritising</u> - this could be done for species at a national level, e.g. through a stakeholder workshop.
- A prioritisation framework with criteria for IAS management could be at both a national level and a local level adapted for land owners and organisations. The framework would be roughly similar for both situations but with slightly different issues addressed.

<u>Group 2</u>

- This group concentrated on two possibilities for the next step.
- The <u>Field guide</u> could be in the form of an <u>on-line database</u> (perhaps with a CD-Rom), as this can be a more flexible tool than a printed book.
- Already-used management practices could be included and if there are none, this would be indicated. It might also be possible to use community-based information for management practices.
- The database would be updated as information becomes available.
- <u>Prioritising system</u> - this would not be easy as different sectors have different priorities e.g. agriculture and conservation, so the criteria would have to be chosen carefully (see also the Additional Suggestion on page 3 with respect to identifying the 'top ten').
- It could lay out international standards for IAS management practices where they already exist (e.g. for many agricultural IAS), so that managers would follow a protocol.
- It could help build awareness of IAS and also provide practical solutions for management.

<u>Group 3</u>

- This group looked at all four 'next step' suggestions.
- The <u>Field guide</u> could be:
  - A small simple guide for general use to maximise IAS awareness about the main problem species (c.100 species), with identification pictures and practical management actions (+ references + internet links for more information);
  - A more technical guide which has best detailed management practices/options for the most problematic species, together with actions to take against re-invasion, and a section on the potential risks of new introductions, with examples of the most dangerous.
- <u>Field trials</u> are useful to advance knowledge on species about which little is known (e.g. non-native ants), or where the specific reactions of an IAS are not well understood. Possible field trials: rat eradication in mangrove areas, whitefly, invasive ants, etc
- Information gained during trials carried out at the Agricultural training centre could be disseminated for household use.
- Funding for trials could be from owners/managers, overseas funding agencies or possibly government.
- The <u>Action plan</u> should be part of the Biosecurity Policy/Strategy.
- Action plans should be prepared for, say, the top ten most problematic species (see also the Additional Suggestion on page 3 with respect to identifying the 'top ten').

- Prioritisation needs to be in the form of a dynamic national system and updated (e.g. every 5 years), with the rationale driven by stakeholders (at least one person in the group felt that this should include government, private or NGO institutions, or any individuals who have an interest and can contribute).

Outcome of the assessment of the most problematic IAS at a national level

Participants were asked to name the six most problematic species for the Seychelles by placing six coloured stickers on charts containing all the names of Invasive Alien problem species previously identified through the stakeholder questionnaire. Species in red are species which were added by workshop participants.

ANIMAL species	No. of stickers	PLANT species	No. of stickers
Mammals		Trees	
Black rat	15	Cinnamon	6
Feral cat	2	Chinese guava	4
Norwegian rat	1	Albizia	3
Feral goat	1	*Alstonia* (Bwa zonn)	4
Birds		Jambrosa	1
Indian myna	7	*Chrysophyllum* (star apple)	1
Red-whiskered bulbul	2	Shrubs	
Madagascar turtle dove	2	Cocoplum	4
Invertebrates		Lantana	1
Yellow crazy ant	5	*Ardisia spp.*	2
Spiralling whitefly	6	Creepers	
Fruit flies	5	"Philodendron"	6
Diamond-back moth	1	*Merremia* (lalyann darzan)	1
Other ant species	1	*Macfadyena unguis-cati*	1
Other animals		*Lonicera spp.*	1
Pacific gecko	1	*Lygodium japonicum* (a fern)	1
Crested tree lizard	1	Herbaceous species	
Man	1	*Clidemia* (fo watouk)	7
		Water lettuce	1
		Water hyacinth	1

The top six are: Black rat (15) / Clidemia (7) / Indian myna (7) / Cinnamon (6) / "Philodendron" (6) / Spiralling whitefly (6).

It was pointed out that the choices of the participants were most probably influenced by their field of work and experience. It was noticeable for example that one participant added 5 new plant species to the list, which are all incipient invasive species. If this exercise was to be carried out further to get a national assessment, it would require defined criteria, and a more scientific assessment. Nevertheless, it was an interesting exercise to have carried out and would have given further food for thought if there had been a greater number of participants.

Additional suggestion

There was a suggestion that it might be necessary to produce separate 'Top Ten' IAS priority lists for e.g. the Conservation, Agriculture, Health and Community sectors. These lists should be reviewed every 5-10 years.

An interesting additional outcome arising from other activities in the workshop

Although we are not professional psychologists or human behaviourists, it was interesting to note the reluctance of a very small minority to participate fully in the additional creative activities that were included in the workshop and/or the production of logical rather than creative outputs, which to our minds suggests the difficulty which some people have with the use of the 'right side of the brain' in their work. Current problems with IAS require creative thinking for their solution as well as more rigorous scientific work and there is much need for creative thought processes.

CONCLUSIONS AND RECOMMENDATIONS

PCA's conclusions and suggestions based on the outcomes of the workshop:

- In general, the participants agreed that the PCA's review on IAS management activities in Seychelles was comprehensive and they did not have additional information to contribute.
- There is insufficient information available at the moment to produce a detailed field guide to best IAS management practices.
- Of the suggestions from stakeholders such as <u>an 'identification' field guide</u> with <u>practical management actions</u> for c.100 species, <u>a field guide</u> in the form of <u>an online database</u>, or <u>a detailed technical manual, guide or toolkit</u>, all would require considerable time <u>(6-8 months)</u> and effort to accomplish. At present, PCA does not have the time to produce such an output due to other prior commitments.
- However, based on the PCA review of IAS management programmes in Seychelles, it might be possible to produce a simple overall guide (e.g. 10 pages) to IAS management strategies. This would help stakeholders to understand what best practice involves (with a few local case studies of good and bad management) and an example of a decision-making tree that would assist stakeholders to decide whether or not management of a particular IAS is likely to be possible.

ANNEX 1 of the IAS Workshop Report: Workshop participant list

UNDP-GEF Biosecurity Project:

REVIEW & EVALUATION OF INVASIVE ALIEN SPECIES (IAS) CONTROL & ERADICATION ACTIVITIES IN SEYCHELLES and DEVELOPMENT OF A FIELD GUIDE ON IAS MANAGEMENT

29 September 2009 from 08.30am - 12.00 noon
at CARE House Meeting Room, Freedom Square

No.	Name	Organisation	Contact/ E-mail address
1.	Sylvanna Antha	SNPA + PCA	s.antat@scmrt-mpa.sc
2.	James Mougal	SNPA + PCA	j.mougal@env.gov.sc
3.	Bruno Senterre	UNDP + PCA	bsenterre@gmail.com
4.	David Derand	Nature Seychelles	david@natureseychelles.org
5.	John Nevill	GIF	office@gif.sc
6.	Naomi Doak	SIF	research@sif.sc
7.	Anna Gray	SIF	anna@sif.sc
8.	Herve Barois	S4S	hbarois@yahoo.com
9.	Frauke F. Dogley	SIF + PCA	ceo@sif.sc
10.	Brad Auer	UNDP-GEF	Brad.auer@undp.org
11.	Lindsay Chong-Seng	SIF + PCA	l.chongseng@sif.sc
12.	Gerard Rocamora	ICS	whiteye@seychelles.net
13.	Randy Stravens	NPPO SAA	rs25goal@hotmail.com
14.	Danielle Dugasse	NPPO SAA	desparon@hotmail.com
15.	Andrew Jean-Louis	PCU	a.jeanlouis@pcusey.sc
16.	Elvina Henriette	DoE	elvinahenr@gmail.com
17.	Will Dogley	SAA	seypro@seychelles.net
18.	Jan Rijpma	UNDP-GEF	rijpma@intelvision.net
19.	Marc Jean-Baptiste	SIF	marc@sif.sc
20.	Katy Beaver	PCA	kbeaver@seychelles.net
21.	Joseph Rath	PCU + TESS	j.rath@pcusey.sc

ANNEX 2 of the IAS Workshop Report: Workshop programme

GOS- UNDP-GEF PROGRAMME COORDINATION UNIT

MEETING TO REVIEW FINDINGS AND DISCUSS NEXT STEPS OF THE CONSULTANCY UNDER THE BIOSECURITY PROJECT:

REVIEW & EVALUATION OF INVASIVE ALIEN SPECIES CONTROL (IAS) AND ERADICATION ACTIVITIES IN SEYCHELLES and DEVELOPMENT OF A FIELD GUIDE ON IAS MANAGEMENT

TUESDAY 29 SEPTEMBER 2009 08.30 - 12.00
CARE House conference and training room

Introduction:
This short-term consultancy is currently being undertaken by the local NGO, Plant Conservation Action group (PCA), with advice and input from an international consultant Dr Charlotte Causton. There are two main objectives (according to the ToR):

3. To review IAS management field activities in the Seychelles, with particular reference to mitigation, control and eradication measures, including an evaluation of their effectiveness and efficiency.
4. To develop a “field guide on IAS control and eradication measures”.

Workshop Objectives:

4. To briefly review the results of Objective 1 (Review of IAS management field activities in the Seychelles), including the results of the Questionnaire previously sent out to most of the stakeholders.
5. To discuss what form of “field guide” (see Objective 2 above) would be most useful for stakeholders, and/or whether this is indeed the most valuable ‘next step’ in the consultancy as there are other options.
6. To make recommendations for this ‘next step’.

Workshop Facilitators:

- Jan Rijpma (GOS-UNDP-GEF Biodiversity Programme Manager)
- Katy Beaver and James Mougal (on behalf of PCA)

Proposed Programme:

TIME	TOPIC	FACILITATOR
08.30 - 08.40	Welcome + Background of the assignment	Jan Rijpma
08.40 - 08.45	IAS? (creative exercise)	Katy
08.45 - 09.30	Management of IAS: The review process / results / missing information + Questionnaire responses and analysis	James
09:30 - 10:00	Introduction to the ‘Next Step’: a. Field guide (if so what format?); b. Field testing; c. Action Plan; d. Prioritisation system	Katy
10:00 - 10:20	Tea / Coffee	
10.20 - 11.20	Small group discussions about the ‘Next Step’	Katy
11:20 - 12:00	Plenary - Feedback from groups - Discussion and recommendations	James / Katy / Jan
12:00	LUNCH	

Participants will include representatives from:
Dept of Environment, Dept of Natural Resources, Seychelles National Parks Authority, Seychelles Agricultural Agency, Island Development Co., NGOs, Private Islands, Resorts, Environmental Education, Landscape personnel, Community leaders, etc.

ANNEX 3 of the IAS Workshop Report: Small group discussion points

Field Guide?

- All 60 or so species identified? (with minimum info)
- Fewer species for which there is enough info?
- A few selected important problem species only?
- Awareness raising guide rather than only management?
- What content / format is required?

Field trails?

- For which species?
- Where? Will stakeholders provide land areas?
- Who should do the trials? Are stakeholders willing?
- Who will fund?

Action plan?

Less detailed than a field guide.

i. For each species, suggest whether eradication, control, containment or mitigation is best.

ii. Identify species that have been successfully controlled: Give brief overview of methods but no details, only relevant references and contacts.

iii. Identify species where efficacy of control methods not proven: Give basic appropriate methods based on what has been done here and elsewhere with refs and contacts. Recommend experiments/trials or other research.

iv. Species where no successful control methods known: ?

System for prioritising IAS management?

This was considered a useful tool by 75% stakeholders.

It would require more time than is available to formulate but could be recommended as a next step.

- Devise criteria for use in decision making
- Give a weighting to each criterion

- Does this require a national priority list for IAS?
- Should it be prepared on a national basis?
- OR for individual management situations?

ANNEX 4 Summary table of Invasive Alien Species (IAS) management activities carried out in the Seychelles

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
MAMMALS						
Feral Cat	Aride	1930s	Dogs + boys	Eradication	✓	Physical method possible on small island with few cats.
	Fregate	1960-1982	Poison / traps	Control and Eradication	✓	Few details, first attempts (1960s/1970s) were control only. Eradication in the early 1980s more systematic but again few details; eradication confirmed only by lack of cats seen.
	Cousine	1983-1985	Traps	Eradication	✓	Physical method (baited traps) possible on small island; eradication confirmed only by lack of cats seen.
	Curieuse	2000	Poison (0.1%1080) / traps	Eradication	✓	Feasibility study done; systematic programme of poisoning, followed by baited traps; but not followed up by systematic monitoring.
	Denis	2000	Poison (0.1%1080) / traps	Eradication	✓	Feasibility study done; systematic programme of poisoning, followed by baited traps; but not followed up by systematic monitoring.
	North	2003	Poison (0.1%1080) / traps	Eradication	✓	Population estimate prior to systematic pre-baiting, followed by poisoning and trapping; follow-up monitoring carried out.
	D'Arros	2003	No details	Eradication	✓	Suitable two years wait period before confirmation of eradication.
	Cosmoledo	2007-2008	Incidental poisoning during rat control programme + lack of food	Control	(✓)	After rat poisoning (Brodifacoum), cat numbers had decreased through incidental poisoning + subse-quent lack of food; proper eradication attempt with cat poison abandoned due to logistical problems.
	Aldabra	ongoing	Shooting	Control	(✓)	Trapping difficult because of non-target species; opportunistic shooting.
Black Rat (*Rattus rattus*)	Granitics / outer islands	Pre-1950s	Traps / poison (Zinc phosphide) + bounty	Control	(✓)	In the early 20th century, traditional 'lasonmwar' traps were often used, later replaced with metal traps of various types & rat glue. Bounty was increased over time. Campaigns helped to keep populations down in coconut plantations
		1950s-1980s	Traps / poison (anticoagulants) + bounty	Control	(✓)	
		1980s onwards	Traps / poison / public awareness campaigns	Control	(✓)	As before, with poison often in block bait form. Campaigns mostly carried out by Heath Ministry.
	Mahé	1949-1952	BC (Barn owl)	Control	X	No feasibility study done. Introduction proved a mistake as although Barn owls ate rats, they also ate indigenous fairy terms in considerable numbers and spread to other islands; a bounty was introduced for the owls in 1969.
	Mahé (La Misere	2006-2009	Poison bait / traps	Control	✓	Grid system developed with regular trapping and follow-

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
	& Haut Barbarons					up monitoring.
	Anonyme	2003	Poison (Brodifacoum 20ppm bait blocks) - land based application + traps	Eradication	X	Grid system and regular monitoring. Post-eradication monitoring interrupted by sale of island, so rats were able to recolonises part of the island.
		2006	Poison (Brodifacoum 20ppm bait blocks) - land based application + traps	Eradication / Control	✓	Same system used as in 2003, with continuing follow-up monitoring. Occasional reinvading rats from Mahé are eliminated through the post-eradication protocol.
	Ile aux Rats (near Anonyme)	2005	Poison (Brodifacoum 20ppm bait pellets) - land based application x 1 + traps	Eradication / Containment	✓	Small islet only. Systematic method with follow-up monitoring. Partly carried out to prevent reinvasion of nearby Anonyme Island.
	Bird	1996	Poison (Brodifacoum 20ppm bait blocks and bait pellets) - land based application x2 + follow-up system	Eradication	✓	Feasibility study done. Grid system and regular monitoring. Post-eradication monitoring. Protocols in place for some non-target species, but some ground-feeding birds affected. Post-eradication protocols.
	Curieuse	2000	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 2 + follow-up with some bait blocks	Eradication	X	Feasibility study done. Helicopter flew along transect system. Regular monitoring. Protocols in place for some non-target species, but some ground-feeding birds affected. Failure possibly due to rats remaining in mangrove or to lack of post-eradication protocols.
	Denis	2000	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 2 + follow-up with some bait blocks	Eradication	X	Feasibility study done. Helicopter flew along transect system. Regular monitoring. Protocols in place for some non-target species, but some ground-feeding birds affected. Failure probably due to lack of post-eradication protocols.
		2002	Poison - land-based application	Eradication	✓	No details made available.
	North	2003	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 3 + follow-up system	Eradication	X	Feasibility study done + systematic methodology and regular monitoring. Helicopter flew along transects. Protocols in place for some non-target species, but some ground-feeding birds affected. Failure probably due to failure to follow post-eradication protocols well enough.
		2005	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 4 + follow-up system	Eradication	✓	Pre-programme preparation for follow-up protocols. Systematic methodology and regular monitoring. Helicopter mostly flew along transects. Protocols in place for some non-target species, but some ground-feeding birds affected. Post-eradication protocols strictly followed.
	Cosmoledo (Grande Ile, Grand Polyte, Petit Polyte)	2007	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 2 + follow-up system	Eradication	✓	Systematic methodology and regular monitoring. Helicopter flew according to ground markers. Effects on non-target species monitored - no mortality. Systematic trapping 1 year later confirmed success.
Norwegian Rat (*Rattus*	Mahé	1900s onwards	Traps / poison	Control	(✓)	The same methods used for Black rats are used for Norwegian rats, with limited success at reducing

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
norvegicus)						populations.
	Fregate	1995	Poison (Flocoumafen) - ground-based + traps	Control	(✓)	Only semi-systematic following this first invasion but protocols in place for avoiding non-target species.
		1995-1996	Poison (Difenacoum) - ground-based + traps	Eradication	X	Semi-systematic methods with partial grid system. Poisoning was not continuous. Traps sometimes caught non-target species.
		1996	Poison (Brodifacoum bait blocks + bait pellets) - ground-based	Eradication	X	More systematic using grid system. Protocols in place for non-target species but programme stopped after 1 Magpie robin died probably from secondary poisoning.
		2000	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 3 + follow-up system	Eradication	✓	Feasibility study done. Helicopter flew along transect system. Regular monitoring. Protocols in place for all important non-target species, but some ground-feeding birds affected. Post-eradication monitoring and protocols in place.
	D'Arros	2004	Poison	Eradication	✓	No details made available.
	Conception	2007	Poison (Brodifacoum 20ppm bait pellets) - aerial application x 2 + follow-up system	Eradication	✓	Feasibility study done. Helicopter use visual transect system. Regular monitoring. Protocols + monitoring in place for important non-target species, no losses. Follow-up monitoring.
Feral Rabbit	Bird	1995-1996	Poison (20ppm Brodifacoum) : Land-based application	Eradication	✓	Visual population assessment only; carried out as part of rat eradication programme - rabbits killed by same poison; systematic land-based methodology but no follow-up monitoring of rabbits.
House Mouse	Bird	1995-1996	Poison (20ppm Brodifacoum) : Land-based application	Eradication	X	Visual population assessment only; carried out as part of rat eradication programme - mice killed by same poison; systematic land-based methodology but no follow-up monitoring; mice either survived or reinvaded.
	Fregate	2000	Poison (20ppm Brodifacoum) : Aerial application	Eradication	✓assumed	Carried out as part of rat eradication programme - mice killed by same poison; systematic aerial poisoning; no details about follow up monitoring.
Feral goat	Aldabra	1987-1988 1993-1997 2007-2009 onwards	Shooting. Judas goats + shooting. Neutered Judas goats + shooting	Control Eradication Eradication	✓ X ?	2 systematic shooting trips, followed by opportunistic shooting 1989-1992. Eradication successful on 2 islands, but only control achieved on the largest. Opportunistic shooting 2000-2006 kept numbers fairly low. Sterilized Judas goats more successful but difficult terrain means longer time necessary to achieve success (radio batteries to be replaced).
BIRDS						
Indian House Crow	Mahé	1977-1994	Mainly shooting + trial with poison + bounty + awareness	Eradication	(✓)	Occasional invading birds can be shot, but if allowed to multiply, crows cannot be shot in large groups as they

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
			programme			become gun-shy. Chemical (alphachloralose) in bait attracted non-target species so could not be used. Eventually all individual birds were shot.
		1998 onwards	Shooting of individual birds + awareness programme	Containment / Eradication	✓	All the occasional re-invading crows have been individually shot and killed to prevent spread.
Ring-necked Parakeet	Mahé	2000s	Shooting	Control	X	Shooting effort has been minimal and small or large flocks are now seen in some parts of Mahé.
House Sparrow	Mahé	2002-2003	Shooting + a variety of trapping methods	Containment / Eradication	(✓)	Occasional invading birds must be eliminated at once. If allowed to breed, systematic trapping at nest sites seemed most effective.
Barn Owl	Central Granitics	1969 onwards	Bounty system	Control	X	Relatively ineffective at keeping numbers down.
	Aride	1996 onwards	A variety of trapping methods + shooting	Eradication / Control	✓	Trapping is often more effective if a decoy bird and / or recorded calls are used. Shooting only possible if licensed gun + shooter available. New invasions require immediate action.
	North Island	2003-2009	Incidental poisoning during rat eradication + starvation	Eradication	✓	Rat eradication left little for barn owls to eat and the island currently has few seabirds; but reinvasions possible.
	Cousin / Cousine	1999 onwards	Shooting	Eradication	✓	Occasional invading birds (attracted by seabird populations) apparently shot
Indian Myna(h)	Fregate	1992	Various trapping methods + poison (alphachloralose)	Experimental Control	X	Trapping not very effective; Mynas developed aversion to food containing the poison. Non-target endemic birds would be affected by poisons.
		1993-1997	Shooting	Control	(✓)	Many birds shot, but not systematic enough to really impact the population.
		1998-2002	Shooting + nest trapping	Control + Experimental	(✓)	Nest trapping had some success. More systematic shooting considerably reduced the Myna population but post-2002 this stopped and the population increased again.
	Aride	1993-1994	Shooting	Eradication	✓	16 of 17 birds shot; the last apparently disappeared.
		2001	Shooting	Eradication	✓	2 newly invading birds shot.
	Cousin	2000-2002	Nest trapping + shooting	Eradication	✓	Small population eradicated.
	Cousine	<1996	Trapping + shooting + bounty	Control	(✓)	Small population apparently controlled.
		2002 onwards	Shooting	Control / Eradication	✓	Apparently eliminated by shooting and occasional reinvading birds also shot.
	Denis	2001	Poison (DRC1339) + shooting	Experimental / Control	(✓)	Pre-baiting, followed by poisoning reduced Myna population in several areas; follow-up shooting was terminated due to reappearance of rats (precluding introduction of rat-sensitive threatened birds).
	North	2005	Incidental poisoning during rat eradication (Brodifacoum)	Control	(✓)	Myna population considerably reduced (c50%) but subsequently increased again.

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
		2006-2008	Poison (DRC1339) + nest trapping	(Eradication) / Control	X (✓)	Systematic programme of pre-baiting and poisoning reduced Myna population c70%. Planned follow-up shooting impossible due to delays with gun licensing. Subsequent nest trapping not effective; nor further poisoning (many non-target species attracted).
		2008-2009	Shooting	Control	(✓)	Although Myna population increased during 2008, subsequent shooting again brought numbers down.
Red-whiskered Bulbul	Assumption	2005	Bounty system	Control / Containment	X	Not systematic. Partly carried out because of risk to Aldabra endemic bulbul and other endemic species.
Cattle egret (<u>not</u> alien)	Mahé, Praslin (rubbish dumps near airports)	2000s	Poison + shooting	Control	(✓)	Poison not very effective due to too much food choice. Populations somewhat limited by shooting, especially at breeding sites.
REPTILES						
Crested tree lizard	Ste Anne	2004-2006	Mainly pursuit and capture + bounty	Eradication / Control / Containment	X (✓)	Delayed action after 1st detection reduced the likelihood of eradication + lack of capacity hampered control measures + lack of long term follow up means lizards could spread to other islands.
INVERTEBRATES (including agricultural pests)						
Crazy ant	Granitics (Mahé + later other islands)	1969	Insecticide (Dieldrin in fish bait)	Experimental trial / Control	X	Inconclusive and this pesticide now banned.
		1976-1994	Poison (c.20 tested) + bait and poison sprays (Gamma-BHC, Chlorpyrifos, Bendiocarb)	Experimental trials / Control	✓	Very systematic testing methods. Both baits and poisons were tested. Aldrin (now banned) proved most effective in bait. Sprays were effective but could be applied only by professionals. In 1994 most of these chemicals were banned.
		Current	Poison bait (Dursban = Chlorpyrifos) + IPM	Control	✓	Although Dursban is toxic to humans and the environment, it appears to still be used by some. IPM includes destroying the nest and good field sanitation. Other poisons (e.g. Fipronil, Pyriproxifen) may now be more effective with less effect on non-target species.
	Bird	1998-2003	Poison spray (unknown) + poison bait (Hydramethylnon)	Control	✓	Apparently effective in keeping numbers down. Current situation unknown due to lack of information.
Coccids (scale insects & mealy bugs)	Granitics	1911	BC (fungus)	Control	✓	Seems to have been a very specific biocontrol agent - effective against the Coffee green scale
	Mahé, Praslin, La Digue, North Silhouette, Platte	1930-1938	BC (ladybird predator spp.)	Control	✓ ?	Since the 1960s no studies have been conducted to determine the effectiveness of the Coccinellid (ladybird) species.
	Granitics	1980s	Insecticides (Ultracide & Rogor)	Control	✓	Effective but insecticides should be rotated - these pests can develop resistance. Products with systemic rather than contact action should be used. IPM = pruning, change planting regime, reduce fertilisation.
		2000 onwards	Other insecticides + IPM	Control	✓	

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
	Aldabra	1989-1990 onwards	BC (ladybird predator sp.)	Control	✓	Ladybird *Rodolia chermesina* introduced to control Mealy bug *Icerya seychellarum,* using systematic procedures. Failure to follow up systematically but opportunistic monitoring shows apparent successful control, with limited localised flare-ups.
Diamond-back moth (poss. not alien)	Granitics	1960-1980s	Insecticides (Agrocide & Lannate)	Control	✓	The mentioned insecticides are extremely toxic, therefore not recommended anymore.
		1980s onwards	BC (*Bacillus thuringi-ensis* = Thuricide)	Control	✓	Thuricide is a commercial biocontrol agent. Can be effective but depends greatly on the strain of *Bacillus thuringiensis* being used.
		1980s-2004 onwards	Insecticides (Decis, Ambush, Malathion) + IPM	Control	✓	Effective but insecticides should be rotated with the commercially available biological control agent *Bacillus thuringiensis* (Thuricide) - the pest can easily develop resistance. IPM = good field sanitation + netting, inter-cropping, mixed cropping or crop rotation.
	Agric Research Station, Anse Boileau, Mahé	2007	New insecticides (Teflubenzuron & Lufenuron) + BC *Bacillus thuringiensis*	Experimental trial	✓	Teflubenzuron was the most effective insecticide. It seems that *Bacillus thuringiensis* (Thuricide) when used alone is not too effective.
Banana (weevil) root borer	Granitics	1952-1954 1960s on	BC (predatory Hister beetles)	Control	X	They are not specific predators of the Banana weevil, so their effectiveness against the pest is considered minimal.
		1960s	Insecticide (Dieldrin)	Control	✓	Extremely toxic pesticide - no longer recommended.
		1980s onwards	New insecticides (Primicid, Carbofuran, Nemacur) + IPM	Control	✓	The mentioned insecticides are extremely toxic therefore should be used with precautions. IPM = good field sanitation measures. Sex pheromone traps and microbial bio-control are new control methods that could be used in Seychelles.
Citrus black-fly	Granitics	1950s	Chemical	Control	(✓)	Simple use of kerosene/soap mixture or oil emulsions recommended. Although other chemicals can be used, once the biocontrol agent was introduced pesticides were not required.
		1955/1956	BC (parasitic Eulophid wasp)	Control	✓	The introduction was considered a complete success, with occasional outbreaks being quickly controlled by the Eulophid wasp. However, no formal quantitative evaluation was carried out. Biocontrol is used elsewhere in the world with success.
	Poivre & Alphonse	1958	BC (parasitic Eulophid wasp)	Control	✓	No records of results but assumed to be successful.
African Rhinoceros beetle	Granitics	1949-1969	BC (parasitic Scoliid wasp)	Control	(✓)	Good field sanitation seemed to be important for the establishment of a Scoliid wasp colony.

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
(poss. not alien)	North Island	1954-1956	BC (parasitic Scoliid wasp) + good field sanitation measures	Experimental trial / Control	✓	Good field sanitation was presumed to be the reason behind the successful establishment of the Scoliid wasp.
	Mahé, Praslin, La Digue	1954	BC (predatory Elaterid beetle)	Control	X	It is presumed that both beetle species did not survive.
	Curieuse, La Digue, Praslin, Poivre	1960/1961	BC (predatory Carabid beetle)	Control		
	Praslin	1962	Insecticide (Paradichlorobenzene)	Control	(✓)	Not too successful (50% of the treated palms were eventually attacked).
	Granitics	1971-1972	BC (*Rhabdovirus oryctes* virus)	Experimental trial / Control	Unknown	Infection rate was relatively high but the Rhinoceros beetle was able to maintain a breeding population.
	Ste Anne, Mahé, Praslin	1981-1983	BC (Baculovirus oryctes virus)		(✓)	
Melittomma beetle (<u>not</u> alien)	Granitics	1911-1914 onwards 1941	Excision + tar + good sanitation measures Fumigation with insecticide (Paradichlorobenzene)	Control	(✓)	Though the physical treatment was reported to be effective, fumigation was assumed to be more effective.
	Praslin	1953-1958	Fumigation with insecticide (Paradichlorobenzene)	Experimental trial / Control	(✓)	Fumigation was confirmed to be partially effective (<53% of the treated palms remained infected).
	Mahé, Cerf	1955	BC (predatory Monotomid beetle)	Control	X	It is presumed that the predatory beetle did not survive.
	Granitics	1959-1970s onwards	Excision + coal-tar/creosote + good sanitation measures	Control	✓	Creosote/coal-tar treatment must be applied 3 to 5 days after gouging.
	Mahé	1970s	Numerous insecticides	Experimental trials / Control	(✓)	Effective only as a preventative measure - the insecticides used are <u>persistent organic pollutant</u>s - not recommended by SAA.
	Victoria Botanic Garden	2000s	Excision + new insecticide (Confidor) & fungicide (CAC Balsam)	Experimental trial / Control	✓	Seems to have been effective against newly infected palms.
Spiralling whitefly	Granitics	2003 onwards	Numerous insecticides (Malathion, Decis, Vertimec, Confidor...) + improvement of plant hygiene	Control	(✓)	IPM may be the most successful method so far, using either pesticides or simpler soap/kerosene sprays linked with good field sanitation. Elsewhere in the world biocontrol using parasitic wasps has been very successful.
		2004 onwards	Light traps covered with Vaseline coating	Control	unknown	This was suggested but no records of follow-up.
Coconut whitefly	Mahé, Praslin, Silhouette, Ste Anne, La Digue	2007 ?	BC (a new species of parasitoid - being described)	Control	✓	Effective: there seems to be a clear correlation between pest population levels & rate of parasitism, based on observations made on Mahé and La Digue.
Mediterranean fruit fly	Granitics	1980s	Plastic 'sandwich container' trap containing attractant (Trimedlure) + insecticide-impregnated block	Control	(✓)	Mainly introduced to monitor the adult population size. Partially successful in reducing population expansion.
		1980s	Insecticides (Diazinon & Dipterex)	Control	(✓)	Later considered expensive and harmful to natural

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
		onwards			X	enemies of the pest.
		2000s onwards	Pheromone-impregnated blocks with insecticide (Malathion) + IPM	Control	(✓)	IPM = good field sanitation measures + bagging of fruits + use of chemicals.
		2000s onwards	Cover spray or Bait spray (Malathion combined with protein hydrolysate liquid attractants)	Control	(✓)	Best used in combination with good field sanitation measures.
Melon fruit fly	Mahé	2005-2007	Pheromone (Cuelure)-impregnated blocks with insecticide (Malathion) + IPM	Control and Eradication	(✓) X	IPM = good field sanitation measures + bagging of fruits. Programme partially successful but did not eradicate the fruit fly.
		2005-2007	Insecticides (e.g. Malathion, Decis, Spinosad)	Control	✓	Cover sprays used by farmers; Spinosad proved successful but very expensive.
		2007	Insecticides (Karate zone, Decis)	Control	✓	Study showed better control of pupae in cucumber by Karate zone.
Giant African Snail	Granitics	1950s onwards	Collect adult snails + destroy their eggs & hideouts daily + establish physical barriers	Control	✓	Method works well on a very small scale but needs to be systematic and can be very labour intensive.
	Mahé, Praslin, Cerf, Ste Anne	1957/1958	BC (two carnivorous snail spp.)	Control	X	Small population size; restricted to lowland areas. *Euglandina sp*. is only found around Victoria.
	Granitics	1961 onwards	Poison bait (Metaldehyde) + Epsom salt sprinkled on ground	Control	✓	Reasonably successful if used regularly.
MARINE						
Crown of Thorns (<u>not</u> alien)	Mahé	1998	Poison (sodium bisulphite)	Control	(✓?)	Injection of poison. Results could not be evaluated due to coral bleaching event.
		2009	Physical removal from sea	Control	✓	Easy and successful but labour intensive.
Black-spined Urchin (<u>not</u> alien)	Mahé	2000	Destroyed in situ with metal tools	Control	✓	Only to be used when populations are high (200 per 250m^2) and significant coral recruitment taking place.
TREES						
Cinnamon	Congo Rouge, Mahé	1995-1996	Hand removal (uprooting) + Cutting / felling + Ring barking	Experimental trials / Control	(✓)	Physical control is possible on a very small scale but incredibly labour intensive.
			Herbicide trial using Roundup		X	Can be effective at high dose (<15ml concentrate) but can have negative impact on non-targeted plant species.
	Silhouette	1990s onwards	Ring barking of mature trees	Control	✓	Quite effective but should be done thoroughly + weekly removal of shoots. Very labour intensive.
Chinese guava	Congo Rouge, Mahé	1995-1996	Hand removal (uprooting) + Cutting / felling + Ring barking	Experimental trials / Control	(✓)	Physical control is possible on a very small scale but incredibly labour intensive.
			Herbicide trial using Roundup		X	Can be effective at high dose (<15ml concentrate) but can have negative impact on non-targeted plant species.
Albizia	Mahé water catchment areas	1990s	Cutting / felling + Ring barking	Control + Eradication	(✓)	Ring barking is more appropriate but should not be undertaken in public areas - as safety precaution.

Species	Location	Date	Methodology (BC = Biological Control; IPM = Integrated Pest Management)	Management strategy	Success confirmed	Additional comments
OTHER PLANTS						
Bracken fern (<u>not</u> alien)	Granitics	1958-1968	Cutting (x2 or x3)	Eradication	(✓)	Method worked well, but needs to be systematic - followed by planting with desirable plant species. Very labour intensive.
Gazontrelle (grass)	Granitics (forestry areas)	1951-1958	Weeding, change planting regime, mulching	Control	(✓)	Method worked well, but needs to be systematic - followed by planting with desirable plant species. Very labour intensive.
		1955	Herbicide trial using Tecane	Experimental trials / Control	X	More expensive than physical control over the long-term.
		1966	Herbicide trial using Gramoxone		✓	No info on whether it was ever tried on a large scale or its cost effectiveness. The herbicide is highly toxic to mammals.
Fo watouk (*Clidemia*)	Mahé	1990s	Hand removal (uprooting) - dept. of environment staff	Control + Containment	(✓) X	Physical control is possible on a very small scale but very labour intensive and needs to be systematic, including post-control monitoring programme. It did not prevent the spread of this invasive.
		2003	Uprooting - community mainly + awareness campaign	Control + Containment	(✓) X	
INVASIVE CREEPERS						
Filodendron (*Epipremnum*)	Vallée de Mai	1997-2002	Cutting (as high as possible all round tree trunk) + hand removal (uprooting)	Experimental Eradication	✓	Method works well for small area but needs to be systematic including regular monitoring programme. Very labour intensive.
	Mahé	2003	Herbicide trial using salt water and Roundup	Experimental trial / Control	X	Not effective.
			Herbicide trial using Vigilant		✓	Preliminary results were good but the long-term effects remain untested.
Merremia (Lalyann darzan)	Intendance, Mahé	1999	Hand removal (uprooting)	Experimental trail / Control	✓	Method works well, needs to be systematic including post-control monitoring programme.
	Mahé (c.26ha in areas of high biodiversity)	1999-2001	Hand removal (uprooting)	Eradication	(✓)	Method works well if systematic + followed by planting with desirable plant species. Very labour intensive and expensive.
Quisqualis indica (Rangoon creeper)	Cousin	2000s	Herbicide (Vigilant)	Control	✓	Quite effective and apparently more cost-effective than physical control, but its impact on non-target species remains untested.
WATER WEEDS						
Water lettuce (*Pistia*)	Mahé (NE Point & Anse Royale), Praslin, La Digue	2000-2004	Hand removal (uprooting)	Control	(✓)	Physical control is possible on a small scale but very labour intensive; needs to be systematic including post-control monitoring. Potential for bio-control.
Water hyacinth (*Eichhornia*)	Mahé (NE Point & Anse Royale), La Digue	2000-2004	Hand removal (uprooting)	Control	(✓)	Physical control is possible on a small scale but very labour intensive; needs to be systematic including post-control monitoring. Bio-control is reported to be more successful and self-sustaining.

ANNEX 5 Table of pesticides and herbicides

(*) Pesticide or herbicide not listed under SCHEDULE 1 of the PESTICIDES CONTROL ACT, 1996, but has been used in Seychelles post-1996.

Pesticides & Herbicides	Other Names	Active Ingredients	Pests & Weeds	Precautions
1080 *	ACTA 1080 Concentrate, Sodium monofluoroacetate	**(mono)fluoroacetate** (with a sodium salt) a naturally-occurring plant toxin	Feral cat and dog	Harmful if swallowed. Highly toxic to birds and mammals. Very low in toxicity to aquatic invertebrates.
Alpha Chloralose	Alpha-D-Glucochloralose, Chloralose	**alphachloralose** (a narcotic drug; acts by anaesthetising rather than killing)	Pest birds (Indian house crow, Indian myna, Turtle dove, House sparrow, Magpie…)	Harmful if swallowed or by inhalation. Highly toxic to birds and mammals.
Ambush	Talcord, Permethrin, Pounce	**permethrin** (a synthetic pyrethroid)	Scale insects, Mealy bugs, Diamond back moth, Caterpillars, Bean pod borer ...	Highly toxic to bees and fish and other aquatic organisms. Low in toxicity to mammals.
Brodifacoum rat bait	Ratak, Volak, WBA 8119	**brodifacoum** (a highly toxic indirect anticoagulant)	Black rat, Norwegian rat, House mouse	Harmful if swallowed in large quantities. Highly toxic to birds and mammals.
Carbaryl	Sevin, Carbafor	**carbaryl** (1-naphthyl methylcarbamate)	Scale insects, Mealy bugs, Diamond back moth, Bean pod borer, Beetles, Mites, Aphids, Moths, Caterpillars, Leaf miners..	Harmful if swallowed, absorbed through the skin, inhaled or if in the eyes. Highly toxic to bees, aquatic and estuarine invertebrates.
Carbofuran *	Faradan, Curater	**carbofuran** (an extremely toxic carbamate)	Banana root borer, Nematodes, Rootworms, Wireworms, Aphids, Thrips...	Poisonous if swallowed, harmful or fatal in prolonged or repeated contact with skin or by inhalation. Extremely toxic to humans, wildlife, fish and other aquatic organisms.
Confidor *	Admire, Gaucho, Imidacloprid	**imidacloprid** (a systemic neonicotinoid)	Scale insects, Mealy bugs, Spiralling whitefly, Mites, Aphids, Leaf miners, Thrips, Termites…	Harmful if swallowed or skin and eye contact. Highly toxic to bees. Low in toxicity to birds, mammals and fish.
Decis	K-orthrine, Deltamethrin	**deltamethrin** (a synthetic pyrethroid)	Scale insects, Mealy bugs, Diamond back moth, Melitoma beetle, Spiralling whitefly, Aphids, Leaf miners, Psyllids, Thrips…	Harmful if swallowed, absorbed through the skin, inhaled or if in the eyes. Highly toxic to bees, aquatic and estuarine invertebrates.
Difenacoum	Difenacoum PW Block Bait, Ratsnip	**difenacoum** (an indirect anticoagulant)	Black rat, Norwegian rat, House mouse	Harmful if swallowed or skin and eye contact. Highly toxic to birds, mammals and aquatic organisms.

Pesticides & Herbicides	Other Names	Active Ingredients	Pests & Weeds	Precautions
DRC 1339 *	Starlicide	**starlicide** (3-chloro-p-toluidine hydrochloride, CPTH)	Pest birds (Indian myna, Turtle dove, House sparrow, Indian house crow, Magpie…)	Highly toxic to birds and aquatic invertebrates. Low in toxicity to mammals.
Dursban	Lorsban, Brodan, Detmol UA, Pyrinex, Chlorpyrifos	**chlorpyrifos** (an extremely toxic crystalline organophosphate)	Crazy ant, other Ants, Borers, Bark beetles, Spider mites, Termites, Cockroaches, Fleas…	Poisonous if swallowed, harmful or fatal in prolonged or repeated contact with skin or by inhalation. Extremely toxic to humans, wildlife, fish and other aquatic organisms.
Epsom salt *	Magnesium sulfate	**magnesium (sulphate) sulfate**	Slug and snail	Harmful if swallowed or inhaled or by prolonged or repeated skin contact.
Fipronil *	Regent, Frontline	**fipronil** (a broad-spectrum phenylpyrazole)	Crazy ant, other Ants, Beetles, Cockroaches, Fleas, Ticks, Termites, Mole crickets, Thrips, Rootworms, Weevils…	Harmful if swallowed. Highly toxic to bees, birds, small mammals, fish and aquatic invertebrates. Very low in toxicity to earthworms, soil micro-organisms and aquatic plants.
Flocoumafen	Storm Secure Wax Block, Stratagem Securable Wax Block	**flocoumafen** (an indirect anticoagulant)	Black rat, Norwegian rat, House mouse	Harmful if swallowed in large quantities. Moderately toxic to birds and mammals. Very low in toxicity to fish and other aquatic organisms.
Gramoxone	Paraquat	**paraquat** (N,N′-dimethyl-4,4′-bipyridinium dichloride)	Broad-leaved trees and shrubs and grasses	Harmful if swallowed or inhaled or skin and eye contact. Highly toxic to mammals. Moderately toxic to birds. Slightly toxic to many aquatic organisms. Low in toxicity to bees.
Hydramethylnon*	Amdro, Maxforce Ant and Insect Bait	**hydramethylnon** (an organic chemical compound)	Crazy ant, other Ants, Cockroaches, Crickets	Harmful if swallowed or after short-term skin contact. Highly toxic to fish and aquatic invertebrates.
Karate *	Warrior, Demand	**lambda-cyhalothrin** (a synthetic pyrethroid)	Melitoma beetle, Melon fruit fly, Caterpillars, Aphids, Thrips, Plant bugs, Bean pod borer, Beetles...	Harmful if swallowed or skin and eye contact. Highly toxic to bees, fish and other aquatic organisms. Low in toxicity to large mammals and birds.
Malathion	Mercaptothion, Cythion, Carbofos, Maldison	**malathion** (an organophosphate parasympathomimetic)	Scale insects, Mealy bugs, Medfly, Melon fruit fly, Diamond back moth, Spiralling whitefly, Aphids, Leaf miners, Housefly…	Harmful if swallowed or inhaled or skin and eye contact. Highly toxic to bees, fish and other aquatic organisms.

Pesticides & Herbicides	Other Names	Active Ingredients	Pests & Weeds	Precautions
Metaldehyde snail pellets	Antimilice, Limatox, Meta, Slug-Tox, Ortho Metaldehyde 4% Bait	**metaldehyde** (a molluscicide)	Slug and snail	Harmful if swallowed or inhaled or skin and eye contact. Moderately toxic to mammals, birds and aquatic organisms.
Nemacur	Fenamiphos, Bay 68138	**fenamiphos** (a systemic organophosphate nematicide)	Banana root borer, Nematodes, Citrus root weevil	Poisonous if swallowed, harmful or fatal in prolonged or repeated contact with skin or by inhalation. Extremely toxic to humans, wildlife, fish and other aquatic organisms.
Nomolt	Teflubenzuron, Dart, Calicide, Nemolt	**teflubenzuron** (a non-systemic insect growth regulator)	Diamond back moth, Caterpillars, Beetles, Flies, Housefly, Mosquito larvae…	Highly toxic to fish and other aquatic organisms and bees. Low in toxicity to mammals.
Orthene *	Acephate	**acephate** (an organophosphate foliar)	Scale insects, Mealy bugs, Spider mites, Thrips, Caterpillars, Aphids, Leaf beetles, Leaf miners, Root weevils, Whiteflies..	Harmful if swallowed or inhaled or skin and eye contact. Highly toxic to bees. Moderately toxic to birds. Low in toxicity to fish.
Primicid	Fernex, Pirimiphos-ethyl	**pirimiphos-ethyl** (an organophosphate)	Banana root borer, other soil pests (dipterous maggots, rootworms and wireworms)	Poisonous if swallowed, harmful or fatal in prolonged or repeated contact with skin or by inhalation. Extremely toxic to humans, wildlife, fish and other aquatic organisms.
Rogor	Cygon, Dimethoate	**dimethoate** (a systemic organophosphate)	Mealy bugs, most Scale insects, Spiralling whitefly, Caterpillars, Aphids, Thrips, Leaf miners, Mites, Psyllids…	Harmful if swallowed or skin and eye contact. Toxic to wildlife, bees, fish and aquatic invertebrates.
Round up	Glyphosate, Accord Herbicide, Rodeo Aquatic Weed and Brush Herbicide	**glyphosate** (an isopropylamine salt)	Broad-leaved trees and shrubs and grasses	May cause slight skin or eye irritation. Slightly toxic to aquatic organisms. Low in toxicity to birds, mammals, bees and fish.
Sorba 050 match*	Lufenuron, Fluphenacur, Match	**lufenuron** (an insect growth regulator)	Diamond back moth, Caterpillars, Mites, Thrips, Beetles, Aphids, Whiteflies…	Harmful if swallowed or inhaled or skin and eye contact. Highly toxic to crustaceans. Slightly toxic to fish and bees. Low in toxicity to mammals.
Spinosad *	GF-120 NF Naturalyte Fruit Fly Bait, Conserve, Comfortis	**spinosad** (a natural fermentation product of a soil bacterium *Saccharopolyspora spinosa*)	Fruit flies, Caterpillars, Thrips, Leaf miners, Spider mites, Fire ants, Leaf beetle larvae…	May cause slight eye irritation. Slightly toxic to aquatic organisms. Low in toxicity to birds, mammals and fish.

Pesticides & Herbicides	Other Names	Active Ingredients	Pests & Weeds	Precautions
Thuricide	*Bacillus thuringiensis,* B.t., DiPel	***Bacillus thuringiensis*** (a naturally occuring soil bacterium)	Diamond back moth, other moths, butterflies, certain beetles and some flies depending on the B.t. subspecies being used	Toxic to bees and earthworms (used according to product labels). Low in toxicity to birds, mammals and fish.
Ultracide	Suprathion, Supracide, Methidathion	**methidathion** (a non-systemic organophosphate)	Scale insects, Mealy bugs, Aphids, Mites, Thrips, Spiralling whitefly…	Harmful if swallowed or inhaled or skin and eye contact. Highly toxic to humans, mammals, birds, bees and aquatic organisms.
Vertimec *	Affirm, Agri-Mek, Zephyr, Abamectin, Avermectin	**abamectin** (a natural fermentation product of a soil bacterium *Streptomyces avermitilis*)	Diamond back moth, Spiralling whitefly, Aphids, Mealy bugs, Mites, Leaf miners, Thrips, Psylla…	Highly toxic to bees and fish and other aquatic invertebrates. Low in toxicity to mammals and birds.
Vigilant *		**picloram** (a potassium salt)	Broad-leaved trees and shrubs and climbing creepers	May cause slight skin or eye irritation. Low in toxicity to birds, mammals, bees and fish and other aquatic organisms.

(*) Pesticide or herbicide not listed under SECHDULE 1 of the PESTICIDES CONTROL ACT, 1996, but has been used in Seychelles post-1996.