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Conservation of the Seychelles sheath-tailed bat *Coleura seychellensis* on Silhouette Island, Seychelles

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ABSTRACT: The critically endangered Seychelles sheath-tailed bat *Coleura seychellensis* on Silhouette Island has been studied since 1997. The species occupies small caves in boulder fields in lowland woodland. Lepidoptera and Coleoptera dominate the diet, with a strong preference for the latter before and during the breeding season (November to April). Foraging areas change seasonally according to wind direction, and foraging occurs in gaps in the woodland. Mature native woodland is favoured due to the abundance of Coleoptera in this habitat. Habitat management on Silhouette has removed alien plants from around the roosts and improved foraging conditions for the bat. This has been accompanied by increases in foraging activity in managed areas and an increase in breeding activity. The population at La Passe on Silhouette has increased from 14 to 25 ind. in the 1990s to 32 in 2008. The management approach is to be extended to another area of Silhouette where bats have been located and should also be used on Mahé. Increases in human development activity on Mahé and Silhouette may threaten population recovery of this bat, and legal controls on development in appropriate habitat are urgently needed. With effective legal controls and intensive habitat management recovery of this species is possible.

KEY WORDS: Conservation · Emballonuridae · Habitat · Population · Restoration

INTRODUCTION

Recent assessments of the status of mammals have concluded that bats face particularly high levels of threat (Mickleburg et al. 2002). Levels of extinction are low compared to those of many other taxa, but this may reflect limited research on most bat species. The bats of the Seychelles Islands are characteristic of the group in this regard, comprising 1 abundant and relatively well-known endemic species (*Pteropus seychellensis*), 1 'vulnerable', largely unstudied, but regularly recorded endemic species (*Pteropus aldabrensis*), 1 widespread, but under-recorded species (*Taphozous mauritianus*), 2 very poorly known endemics (*Chaerephon pusilla* and *Triaenops* sp.) and the 'critically endangered' Seychelles sheath-tailed bat *Coleura seychellensis*. The conservation status assessments 'vulnerable' and 'critically endangered' are those used by the International Union for the Conservation of Nature (IUCN 2007). No bat species are protected under Seychelles law, although the Aldabran endemics (*P. aldabrensis*, *C. pusilla* and *Triaenops* sp.) are all protected by virtue of being restricted to a special reserve. The Seychelles sheath-tailed bat was described in 1868 (Peters 1868), but no ecological research on the species was published until 1982 (Nicoll & Suttie 1982). Since 2004 there has been a substantial increase in research activity on the species (Burgess & Lee 2004, Gerlach 2004, in press a,b, Joubert 2004, Rocamora & Joubert 2004, Bambini et al. 2006, Gerlach & Taylor 2006).

The Seychelles sheath-tailed bat has been recorded from 5 islands (Mahé, Silhouette, Praslin, La Digue and Marianne, with isolated records from the Amirantes and Zanzibar; Goodman et al. 2008), but is now restricted to 4 sites on 2 islands. The species was first recorded on Mahé Island, where it is now restricted to 3 roosts, 2 in the Port Launay–Baie Ternay area with some 27 ind. (Bambini 2008) and 1 at Anse Major of only 1 or 2 ind. (P. Senior pers. comm.). The larger of

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the roosts is adjacent to a recently approved hotel development, which is expected to have a large impact on the population. On Silhouette Island, 2 separate populations are known, one may be restricted to a few individuals, the other numbers 32 ind. as of March 2008. This population has been the focus of intensive research and conservation management efforts since 1997, which are described here.

MATERIALS AND METHODS

Population size. The La Passe roost of *Coleura seychellensis* on Silhouette Island has been monitored since 1997. Installation of roost CCTV in 2006 has allowed frequent and accurate counts. All other identified roost sites on this island have been visited at least once a year since 2005 (Grande Barbe in March/April and December every year and Pointe Etienne in March/April) and searched for signs of recent occupancy — the presence of bats or of recent guano. Guano was categorized as fresh (not completely dry), recent (deposited since the previous visit), or old. No bats have been found in these roosts although occasional small quantities of fresh guano have been located; consequently, population estimation is only possible for the La Passe roost.

Distribution and characteristics of roosts and foraging habitat. Searches of boulder fields have been made in all coastal areas. There are historical records of roosts at La Passe, Anse Lascars, Anse Mondon, Grande Barbe and Pointe Etienne (Fig. 1). All these were investigated.

Foraging habitat was investigated using automated bat detectors (Anabat II system); these were placed in clearings in woodland or on rocks overlooking the canopy or potential flyways. The bat detectors were set to record between the hours of 18:00 and 06:00. In the feeding area identified at La Passe, 7 regular monitoring points were established in 2007, 3 of these had been surveyed in 2006, providing between 1 and 2 yr of monitoring data. An additional 6 sites were used occasionally.

The main foraging areas identified by this study were mapped using global positioning system (GPS) data and topographical features. Food availability was investigated by maintaining a malaise trap in the foraging habitat. This was emptied every 2 wk for a 12 mo period.

Behaviour within the roost. Behaviour in the roost was recorded by examination of recorded footage from the La Passe CCTV system. The number of bats in the roost and the number engaged in defined behaviours was noted every 15 min for 4 d (24 h periods) each month. Behaviours were defined as:

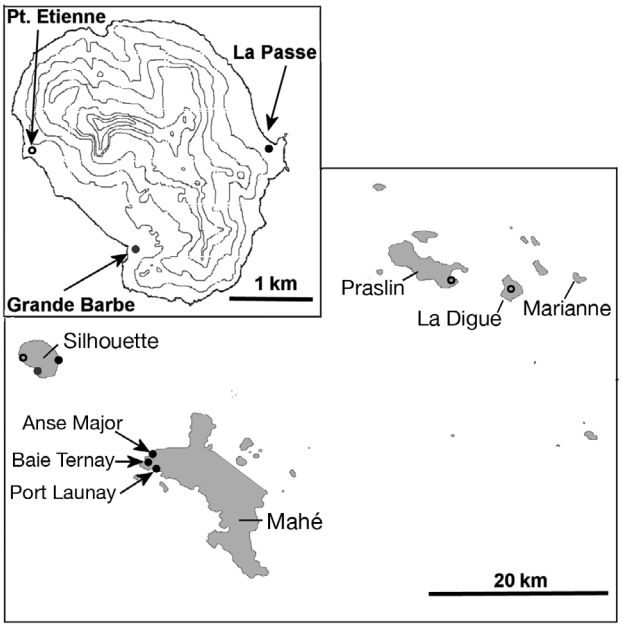

Fig. 1. *Coleura seychellensis.* Granitic islands of the Seychelles showing localities mentioned in the text. ●: occupied roosts; ○: historical roosts; ◉: occasional roosts. Inset: Silhouette Island with 100 m contours shown

1. Rest: hanging by hind limbs only, not moving
2. Groom: scratching and licking of body and/or wings
3. Stretch: wings expanded whilst remaining on the roost ceiling
4. Alert: all 4 limbs in contact with roost ceiling, a distinctive posture
5. Argue: agonistic interaction between 2 or more bats
6. Move: walking over the roost ceiling
7. Fly: visible flight in the roost

Recordings of vocalizations in the roost were made quarterly using the automated bat detector. This provided data on individual calls (Gerlach in press b).

Reproductive biology. ***Breeding cycle:*** The breeding cycle was inferred from the numbers of females breeding in each season and the levels of male 'song' recorded. Male 'songs' are stereotyped calls in the form of complex short FM-tones that are variable in the degree of development of the initial upsweep of each call, the characteristic frequency and duration (Gerlach in press b). By synchronising call recordings and the CCTV footage (Gerlach in press b), it has been possible to demonstrate that distinct calls are produced by different individuals, allowing different males to be discriminated, as has been reported for other emballonurid bats (Davidson & Wilkinson 2004).

Juvenile growth: Still images showing juveniles next to adults were recorded from the CCTV weekly. Measurements were made of still images taken from

footage of both adults and juveniles, providing a weekly range of relative sizes. This provides an approximate growth pattern for the time between small juveniles being left in the roost and their becoming indistinguishable from adult bats. Inevitably these measurements are approximate, but may provide a reliable indication of growth patterns as they were all taken from a visual area corresponding to a 15 × 15 cm area of roost ceiling and all measurements were made when bats were hanging at rest vertically. It was impossible to identify individual bats visually, and these measurements represent the growth of a cohort of juveniles rather than individual growth.

Conservation. Conservation action comprised 2 main aspects: roost protection and habitat management. Threats to the roost have been addressed when they arise; these have included smoke from the La Passe settlement, rubbish dumping, increases in alien mammal populations and insecticide use.

Early research on roost characterization indicated that the major problem facing the bats was habitat deterioration. Accordingly, habitat management was carried out around the roost and in the foraging area. Around the roost, alien plants are removed by uprooting (invasive creepers) or by selective removal (alien trees). The trees are removed by pruning or by ring-barking so as to cause slow habitat improvement and avoid rapid changes to the microclimate or appearance of the roost areas. To a distance of 10 m around the abandoned roosts, small invasive *Cinnamomum verum* trees are felled, larger *C. verum* and *Tabebuia pallida* are ring-barked to enable as rapid habitat recovery as possible. Coconut seedlings are removed regularly, and coconut leaves obscuring potential flyways are removed.

In foraging areas habitat management has created clearings by removing *Cinnamomum verum* trees since 1997. In these clearings existing native plants have been encouraged to grow (by removal of shading vegetation) or have been planted. In some areas a closed canopy of introduced trees has been maintained while native trees were planted, the canopy has been progressively thinned as these plants have become established. This creates a mosaic of habitat management regimes — un-managed areas, cleared and planted areas of varying ages and closed canopy management areas, again of varying ages. Trees planted include fast-growing, indigenous species (*Ficus reflexa*, *Morinda citrifolia* and *Ochrosia oppositifolia*), indigenous lowland forest trees (*Heritiera littoralis* and *Intsia bijuga*) and threatened endemics (*Carissa edulis* var. *seychellarum*, *Grisollea thomasseti*, *Mimusops sechellana*, *Northea hornei*, *Rothmannia annae* and *Tarrena seychellensis*) and scarce endemics (*Vershaffeltia splendida*). Endemic herbaceous plants have also been established (*Allophyllus seychellensis* and *Gynura seychellensis*). This habitat restoration has been carried out by the Nature Protection Trust of Seychelles (NPTS), with occasional assistance from volunteers and visiting field courses. Since January 2008, labour has been provided by the Labriz Hotel, Silhouette.

RESULTS

Population size

The La Passe population of *Coleura seychellensis* has grown since 2001, reaching 32 ind. by the end of 2003. There was a decline from 2005 to 2007, but numbers increased again towards the end of 2007 (Fig. 2). Monitoring data indicate a semi-regular pattern of population decline in the second quarter of the year (80% of years) and increase in the fourth quarter (75%). The first quarter shows little change (changes in only 20% of years), and the third quarter is equally balanced between increases and decreases. The fourth quarter includes the start of the breeding season, and increases would be expected in that season. Declines in the second quarter may coincide with weaning and dispersal of juveniles or of non-breeding adults. No other populations were located, although at least 1 bat was present in the Grande Barbe area between 2006 and 2008.

Basic population biology data were extrapolated from the numbers of bats in the La Passe roost and their behaviour. In the 2007/2008 breeding season 7 different male songs were recorded and 6 females produced young. In addition, 4 adult-sized bats can be assumed to be the juveniles from the previous year, indicating that the 24 adult bats represent 7 males, 6 females and 11 unsexed adults (of which 4 would

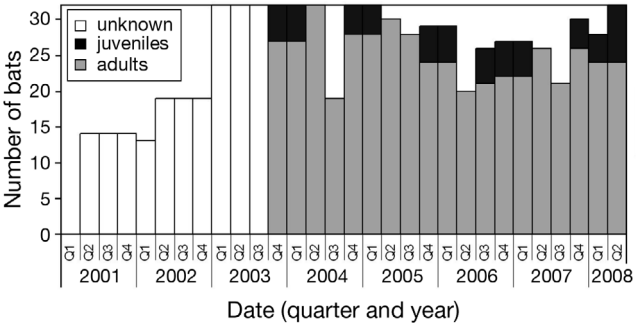

Fig. 2. *Coleura seychellensis.* Population change in the La Passe roost. The low figure for mid-2004 is thought to be due to a number of bats using an alternative roost site temporarily. Other changes may represent genuine population changes. Data are grouped into quarters

have been born in the 2006/2007 season and may be immature). Losses in the population were interpreted as mortality, although they could also represent emigration. As only one population has been located in the La Passe area, it was assumed that emigrating bats did not survive or new roost sites remain to be located. From the population changes it can be estimated that adult survivorship in most years was close to 100%, with the lowest estimate being in 2006/2007 (57 to 73%). For juveniles, 80% survived in 2006/2007, and all in 2007/2008 have survived at least 6 mo to date.

Distribution and characteristics of roosts and foraging habitat

The only permanently active roost found on Silhouette was the La Passe roost (Roost System A and B). Evidence of occasional use (small quantities of fresh guano but no bats) was found at one site at La Passe (Roost D) and at Grande Barbe. In addition, an abandoned roost was found at La Passe and at Pointe Etienne. No roosts could be found at Anse Lascars and Anse Mondon.

Foraging habitat mapping showed a southwards movement of the feeding area between July 2007 and December 2007; in April 2008 the range extended northwards, encompassing all feeding areas and then contracted again in June 2008 (Fig. 3), showing that this is a seasonal pattern. There was also evidence of an increase in foraging in one area (the 'forest rehabilitation site') (Fig. 3) correlated with beetle numbers collected in malaise traps ($F = 0.52$, $p_{(4)} = 0.023$). No significant correlations were found with any other insect group ($p < 0.5$ in all cases). Foraging was only recorded in open areas, in forest clearings, or over exposed rocky slopes.

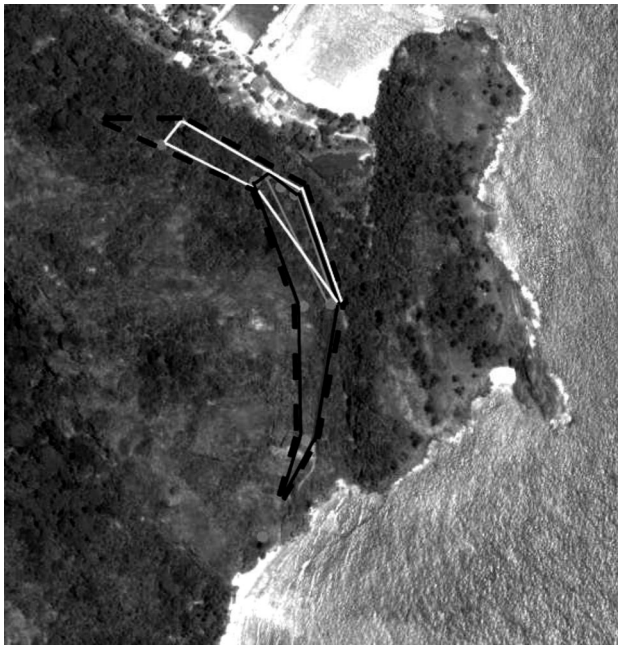

Fig. 3. *Coleura seychellensis.* Map of foraging areas at La Passe, Silhouette. White line: area used in July; solid black line: December; dashed black line: April

Behaviour in roost

Seasonal trends in behaviour include an increase in daytime activity in the cooler months of the year (July to November), and low levels of activity from December to April (Fig. 4). In July to November frequent incidences of grooming, stretching, arguing and movement were recorded, whereas in December to April almost all bats spent the day resting, with occasional grooming. Bats were present in the roost at all hours of day and night, with low numbers present at night (or with long periods with no bats present). From November until the end of March at least one bat was present in the roost at all times. In December to January and in April juvenile bats remained in the roost, accompanied by 1 to 2 adults. No significant interactions were noted between the juveniles and the accompanying adults at night.

Reproductive biology

Mating has not been observed, but, based on the timing of male 'song', was inferred to occur from December to March. Birth also occurs in the December to March period. The smallest independent juveniles seen were 75% of adult size; from the relative growth rates (Fig. 5) this was approximately 9 d old. Before this stage small juveniles were carried by the females and could not be measured accurately from the CCTV images. The first time the roost was empty at night (i.e. all juveniles were flying), the smallest bat was 89% of adult size and estimated to be 17 d old. This coincided with all juveniles being independent and no longer being carried by adults. Full size was reached within 29 d, and weaning appeared to be complete by 4 mo. Once the young were large enough to be left on their own, they grouped with other bats (varying in age and sex), associating specifically with the mother mainly for feeding. At night these large, non-flying juveniles remained in the roost, accompanied by 1 or 2 adults for 2 mo. Sometimes the juveniles and the adults clustered together, but usually they remained spread out for most of the night. From the age of 1 mo, juveniles also left the roost at night for <30 min, with the roost unoccupied for more than an hour once the juveniles were 2 to 3 mo old and presumably feeding themselves.

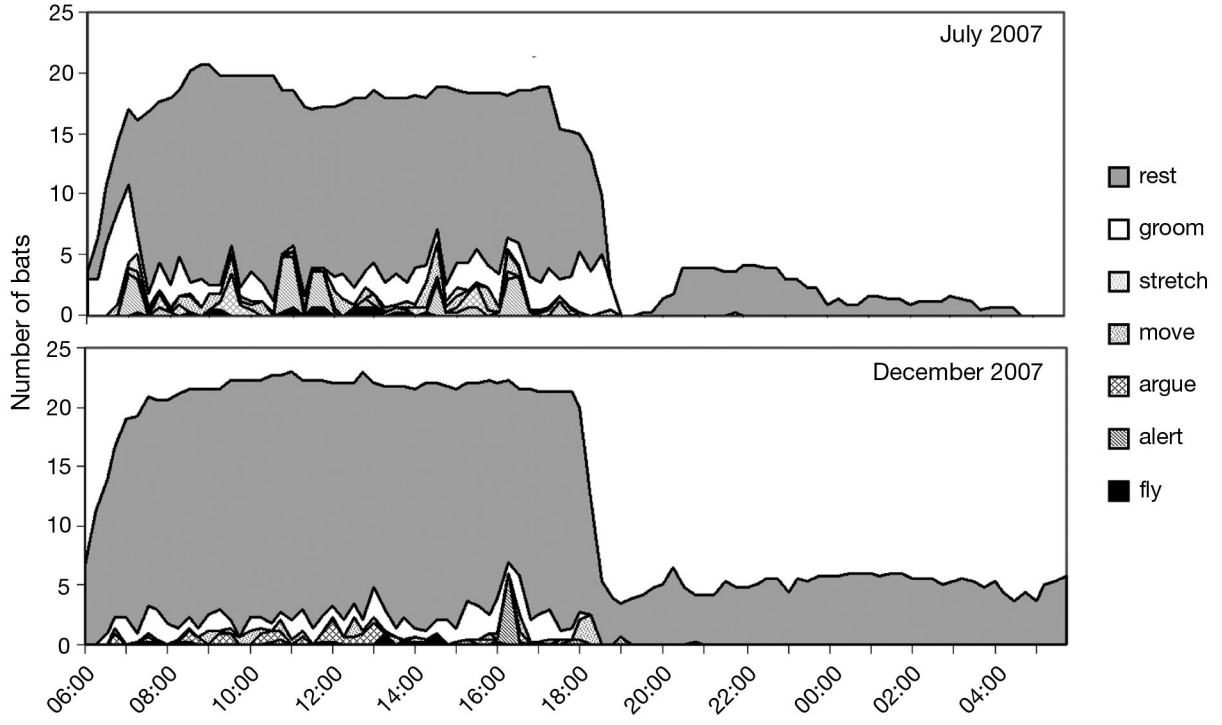

Fig. 4. *Coleura seychellensis.* Monthly behaviour patterns in the La Passe roost showing 2 extremes: July (high activity, low night-time occupancy) and December (low activity, high night-time occupancy). Time (h) is on the horizontal axis

Conservation

Roost protection

At present there is no legal protection of the bats or of the roost sites they occupy. Direct human disturbance to the roosts is not a significant threat at present (although there are anecdotal reports of deliberate disturbance in the past of some of the abandoned roosts by people knocking bats off the roost ceilings with sticks; Matyot 1995). Human disturbance is an issue through fires and rubbish disposal. Until 1998 a copra dryer was in operation 300 m from the roost; during the season of south-east trade winds smoke from the dryer was blown directly into the roost throughout the hours of daylight for 5 to 6 d of the week. In 1998 an agreement was reached with the Islands Development Company, the government parastatal company managing the island, that no fires would be lit in the vicinity of the roost; since then a population increase has been recorded in the roost. The creation of a construction worker's camp at the site of the old copra dryer in 2005 (still present) means that a wood cooking fire produces smoke which reaches the roost at times. This is generally low level, and significant disturbance has not been observed. A more significant issue is the dumping of rubbish in the foraging area of the bats. This has been ongoing since 2005, initially with food waste, subsequently with garden waste and household rubbish. This has led to an increase in rat and cat numbers in the area. In 2006 the CCTV camera showed high levels of agitation in the roost. No direct cause could be identified, but investigation found rat foot-prints in the roost. In October 2006 the roost was completely abandoned, but the bats returned in the following month. Rats in the roost may have been a source of direct disturbance or, more significantly, may have attracted cats. From January 2007 3 poison bait stations were positioned in the entrance to the roost. These were main-

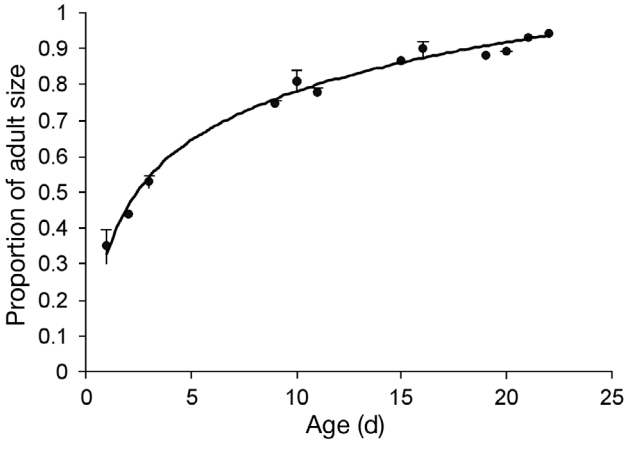

Fig. 5. *Coleura seychellensis.* Relative juvenile growth rates

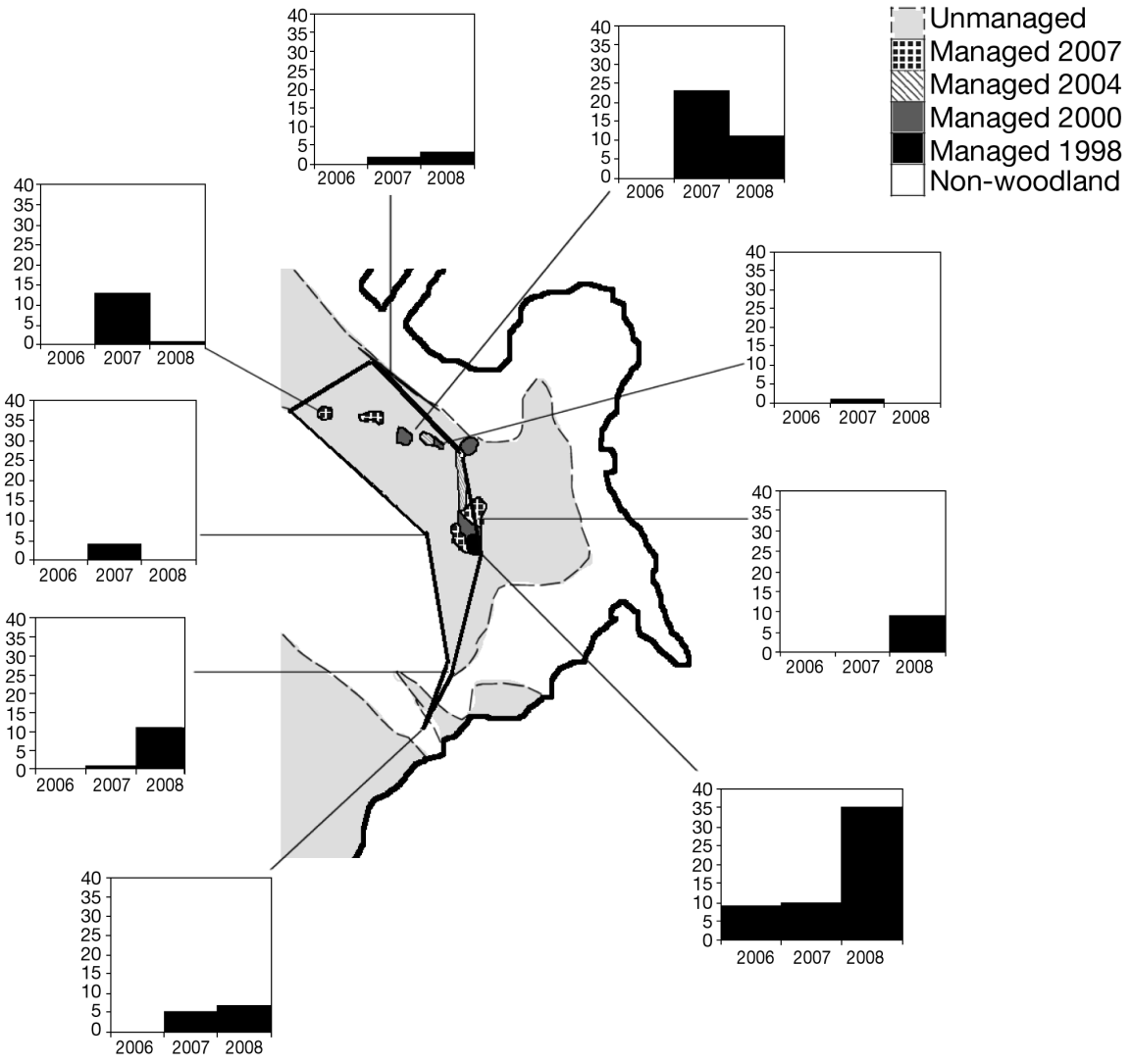

Fig. 6. *Coleura seychellensis.* Habitat management areas at La Passe showing the woodland areas and the dates of the start of management. Graphs show bat activity levels in different years (measured as mean number of seconds of recorded activity per night)

tained until March 2008 when it was concluded that the continued high rate of bait consumption could be attributed to snails rather than by rats. The bait stations will be re-employed if there is any further indication of rat or cat disturbance. Dog hair was found in Roost D in 2006, and a stray dog was heard in the vicinity throughout that year. Stray dogs were removed from the island, and all domestic dogs were neutered in 2007; this appears to have been effective as no stray dogs were located subsequently.

It is generally assumed that, historically, insecticide impacts have been low. Use of DDT in the mid-20th century may have had some impact, but there is no evidence to allow evaluation. In recent years there has been an increase in the application of insecticides applied by fogging around human habitations. On Silhouette this has occurred within 200 m of the La Passe roost, and insecticide fog was observed drifting up to the roost site in February 2007. Such fogging practices have occurred in 3 to 6 mo intervals since early 2006 to provide short-term control of mosquitoes. In March 2007 it was agreed that insecticide use would be restricted to buildings in the main settlement area, at least 300 m from the roost and outside foraging areas.

Legal protection for the roost site is under discussion as a large part of the island is to be designated as a national park. The boundaries of this protected area are currently being discussed, and should include the important sites for the bats.

Habitat management

Management areas are shown in Fig. 6. The data on foraging were compared to the management regime of each of these areas (Table 1), foraging was only recorded in the cleared areas. A positive correlation was found between the age of the cleared area and the levels of foraging recorded (Fig. 7).

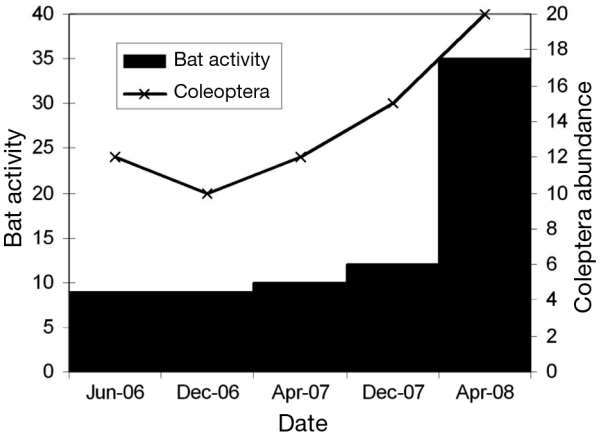

Fig. 7. *Coleura seychellensis.* Relationship between the age of the cleared area and foraging activity and beetle (Coleoptera) numbers, as indicated by changes in the oldest management area. Bat activity in number of seconds of recorded activity per night

DISCUSSION

The last 11 yr of research on the Silhouette population of *Coleura seychellensis* indicates that the species is restricted to a habitat that combines lowland woodland with boulder fields as has been suggested previously (Burgess & Lee 2004, Joubert 2004, Gerlach 2004, Bambini et al. 2006). These provide small caves suitable for roosting (secure roost sites with stable, cool temperatures) and feeding habitat rich in moths and beetles (Gerlach & Taylor 2006). Invasion by introduced plants is high in all woodland areas of the Seychelles, and this has significant impacts on insect populations (Gerlach 2008). The main invasive species in the lowland habitats are *Cinnamomum verum*, *Tabebuia pallida* and *Cocos nucifera*. Habitats dominated by the first 2 species support few insects due to a scarcity of native phytophagous species that are able to feed on them. *C. nucifera* supports abundant insects, but these are predominantly ants which suppress other insects. In contrast lowland forests with low levels of invasion are dominated by endemic palms (*Phoenicophorium borsigianum* and *Nephrosperma vanhouetteana*), *Pandanus balfouri*, *Mimusops sechellarum*, *Intsia bijuga*, *Calophyllum inophyllum* and *Premna serratifolia*. These all support numerous phytophagous insects, principally nocturnal beetles (author's pers. obs.).

Marsh habitat is occasionally used for foraging, but is less important than clearings or gaps within woodland (Gerlach & Taylor 2006). The distribution of foraging areas changes seasonally in accordance with seasonal changes in wind direction. This is probably a seasonal pattern as the northern part of the feeding area would have been exposed to strong winds in the north-west monsoon season of December to February and the southern part exposed to the south-east trade winds of June to August. It is notable that the December movement southwards bring the foraging bats into the vicinity of a roost reported by island residents to have been occupied in the 1970s. This roost has so far not been located. If such a roost can be located, invasive plants removed from its vicinity and foraging habitat restored by alien plant management in these areas it might be possible for reoccupation of abandoned roosts to occur.

The diet of this species has been studied previously (Gerlach 2004, Joubert 2004, Gerlach & Taylor 2006); these studies demonstrated from faecal pellet analysis that the main dietary items were Lepidoptera, Coleoptera and Hymenoptera. The abundance of these insect groups changed seasonally in the foraging area, insect abundance reaching a maximum in September (Gerlach & Taylor 2006), shortly before the breeding season. Diet selectivity changes through the year

Table 1. Habitat management regimes and bat foraging. Foraging levels are number of seconds of recorded activity per night. Trees are designated as endemic (E), introduced (I), or native but planted outside the natural ecological range (N)

Management type	Age of site	Dominant trees	Foraging levels
Unmanaged	–	*Cinnamomum* (I), *Cocos* (N), *Tabebuia* (I)	0
Closed canopy	5 yr	*Cinnamomum* (I)	0
Cleared	10 yr	*Phoenicophorium* (E)	3–35[a]
	3 yr	*Cocos* (N)	0

[a]See Fig. 7

Table 2. Diet selectivity, based on data in Gerlach & Taylor (2006). Only taxa forming at least 5% of the diet or abundance are shown. Values are the proportion of insects in the diet divided by the proportion present in malaise traps. *Z*-values for comparison of 2 proportions are shown in parentheses. *: $p < 0.05$; **: $p < 0.01$

Taxon	Mar	Jun	Sep	Dec
Lepidoptera	2.67 (6.47**)	5.72 (4.03**)	2.14 (11.81**)	0.54 (5.31**)
Coleoptera	9.27 (2.91*)	1.14 (0.70)	0.46 (1.12)	51.65 (3.49*)
Hymenoptera	3.00 (1.98*)	8.59 (0.25)	8.31 (10.81**)	1.92 (2.19*)
Diptera	0.16 (1.19)	0.00 (0.09)	0.46 (0.67)	0.30 (1.41)

(Table 2); Lepidoptera were consumed more frequently than would be expected from their abundance in malaise traps in the period from March to September, and Coleoptera were favoured from December to March. The high levels of consumption of Lepidoptera in March to September may be a result of the ease of capture of these relatively slow flying and large insects. In contrast, most beetles fly low and directly between plants. Non-selective feeding on larger insects will therefore result in moths being the main component of the diet. However, the high proportion of harder to capture Coleoptera in December to March indicates that beetles were highly preferred in this season. By far the strongest preference is for beetles in December (52 times more common in the diet than expected). The limited dietary data from Grande Barbe were dominated by Diptera, specifically Chironomidae from the marsh habitat (Gerlach & Taylor 2006). Given that Diptera make up no more than 9% of the diet at La Passe, this indicates either a different selectivity pattern at Grande Barbe or a scarcity of the preferred prey items. With the degraded woodland at Grande Barbe caused by very high levels of coconut invasion, beetle abundance is low. This may be a contributing factor to the apparent decline in the Grande Barbe population to what is thought to be a critically low level. If a rich supply of beetles is required prior to, and during, breeding, the habitats with the richest beetle populations will be of greatest importance to the bat populations. Beetles were most abundant in lowland woodland, especially in areas with a high proportion of native species (Gerlach 2008 and unpubl. data). Restoration of habitat at La Passe has resulted in an increase in beetle numbers, and this is associated with increased foraging activity by the bats (Fig. 7). An increase in reproductive output in 2007/2008 may be a consequence of this increased food availability. This indicates that habitat restoration is a vital component in improving the conservation prospects of this bat.

The bats appear to have a low reproductive rate in most years, normally producing 1 young and probably not every year. This low population growth potential may be offset by low mortality rates (<20% for juveniles for the 2 yr of data available) and rapid growth rates. Longevity is not known; the same adult male calls have been recorded in up to 4 successive years (data do not extend beyond this at present), and there are no data of any sort for female survivorship. In contrast, the congeneric African *Coleura afra* is believed to produce 1 to 2 young a year from the age of 1 yr, with 78% of females breeding each year, but with a juvenile mortality of 34% (McWilliam 1987). The report by Nicoll & Suttie (1982) of *C. seychellensis* breeding in November to December and March to April is supported by the present study, but data from Silhouette indicate that this pattern probably represents a breeding season spread over 4 mo rather than 2 distinct breeding seasons. The 2 breeding seasons of *C. afra* correspond to the food peaks of the 2 rainy seasons in east Africa (McWilliam 1987). With only a single rainy season, but a prolonged food peak (December to April) in Seychelles, bats are more likely to have a single breeding season. The available data indicate that most females probably breed every 2 yr rather than annually. With food being at maximum abundance in December to March both sexes would be expected to be in optimal condition for mating. Females with young at this time may not be receptive to mating; those that gave birth in November to December may be receptive before the end of March and may mate, but fertilization or implantation may be delayed for several months as in some other bat species (Sandell 1990). This is largely associated with hibernation, but does occur in a small number of tropical bat species.

Only 1 active roost has been located on Silhouette Island, although a second roost (in the Grande Barbe area) is presumed to exist. The La Passe roost has been the main focus of research and conservation activity. A low population (14 to 25 ind.) at the start of the conservation project has increased over the years, presumably associated with the control of fires in 1998, and reaching a maximum of 32 bats in 2003. Subsequent disturbance caused by infrastructure development and rubbish tipping since 2005 led to a decline to 20 to 25 adults. The reduction of disturbance and successful habitat restoration has allowed population recovery, and, by the end of March 2008, the population had returned to the previous maximum of 32 bats (24 adults, 4 independent young and 4 dependent young). The successful recovery of this small population to its recorded maximum level is associated with the management of threats affecting the roost and habitat restoration. These management approaches are being

extended to the Grande Barbe population and urgently need to be applied to the Mahé populations. This should ensure the survival of these small and isolated populations at least short term. Long-term survival requires significant population and range expansion. As a first step in encouraging such expansion the abandoned roosts need to be restored by removal of invasive plants blocking flyways so that bats dispersing from capacity colonies are able to re-colonise their former range. This is being carried out systematically in the La Passe area of Silhouette, and it is hoped that the combination of a restored population in Roosts A & B and the removal of all alien vegetation around the entrance to Roost E may allow expansion in the near future.

The survival of the Seychelles sheath-tailed bat requires the implementation of the emergency and recovery measures described above and the effective protection of all roosting and foraging areas. Unfortunately the bats frequent lowland woodland and roost in the boulder fields behind the coastal plateaux, which are the main centres of human population. Anecdotal evidence suggests that some roosts have been subject to deliberate disturbance (Matyot 1995), but most roosts have been protected by the difficulty of humans negotiating the boulder fields. Predation by barn owls *Tyto alba* has been suggested to be a contributory factor to their decline (Nicoll & Suttie 1982 and repeated in Bambini et al. 2006). However, this is purely speculative, and no data have been presented in support of the suggestion. No evidence of interaction between the 2 species was found in the present study. This leaves habitat degradation as the most serious threat for which there is evidence. Since 2000 infrastructure development construction has increased dramatically in the Seychelles, particularly in the tourism sector. Of the active roosts, 3 are adjacent to major developments: development at La Passe is nearing completion and the roost is recovering from the past disturbance caused, Grande Barbe is planned for development and Port Launay–Baie Ternay is starting development. The only roost in an existing protected area and not affected by development is Anse Major, which contains only 1 or 2 bats and is of marginal suitability (P. Senior pers. comm.). In the light of these pressures there is an urgent need to implement strict protection of roost sites and foraging areas, as has been noted previously (Rocamora & Joubert 2004, Bambini et al. 2006, Gerlach & Taylor 2006, Bambini 2008). In 2007 the President of Seychelles declared that parts of Silhouette would be declared a protected area. The boundaries of this protected area have not yet been finalised; it will be important for the survival of the sheath-tailed bat that the La Passe and Grande Barbe roosts be included in the national park. Legal protection of roosts by itself will not be enough to save the species; significant habitat management is also necessary. The experience of managing the La Passe population demonstrates that it is possible to pull populations of this species back from the brink of extinction, but this needs intensive management and effective legal support.

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