Habitat use by a population of the Seychelles kestrel (*Falco araea*)

Justin Gerlach

PO Box 207, Victoria, Mahe, SEYCHELLES
133 Cherry Hinton Road, Cambridge CB1 7BX, UK
[jstgerlach@aol.com]

Abstract: The Seychelles kestrel *Falco araea* is classified as a Vulnerable species with main breeding populations restricted to two islands of the Seychelles group (Mahé and Silhouette). An attempted reintroduction to Praslin in 1977 has had poor results. It is the worlds smallest kestrel species and is adapted to preying on small lizards in forest habitats. The habitat preferences, territory size and distribution on Silhouette island was studied confirming previous reports of a preference for lowland habitats. The Silhouette population is estimated at 48 pairs, showing no significant change from the previous (1981) estimate. Exceptionally small territories (as small as 9.0ha) were found in habitat mosaics of lowland forest on bare rock, associated with abundant cliff nesting sites and high lizard population densities. The larger island of Praslin supports very few kestrels and as the size distribution of lizards on that island is skewed towards large individuals, this may result in food scarcity. Combined with nest site scarcity the paucity of small prey may cause the lack of significant population recovery on Praslin.

Key words: conservation, *Phelsuma*, population, Praslin, Silhouette

Introduction

The Seychelles kestrel *Falco araea* Oberholser, 1917 is endemic to the granitic Seychelles islands. It is the world's smallest kestrel (Cade 1982), a characteristic that may be an adaptation to small isolated islands. The species has a short wingspan comparable to that of the New Zealand Falcon (*Falco novaeseelandiae*) (Cade 1982), although not as short as the Mauritius kestrel (*Falco punctatus*) (Jones 1987; Groombridge 2000) and is adapted to hunting in forest habitats. Other more subtle adaptations may also exist but have not been detected to date.

Historically the Seychelles kestrel was recorded as a resident species from the islands of Mahé, St. Anne, Cerf, Long, Thérèse, Silhouette, North, Praslin, Curieuse, La Digue, Felicité and Marianne (Newton 1867, Oustalet 1878; Hartlaub 1877; Vesey-Fitzgerald 1940) (Fig. 1). Following human colonisation of the islands in 1772 it was heavily persecuted directly and was brought close to extinction in the mid-1900s; an estimate in 1969 put the population at fewer than 30 birds (Gaymer *et al*. 1969). Further population reductions were suggested to be caused by barn owl nest site competition (Fisher *et al*. 1969) resulting in the extinction of the population on La Digue island (Penny 1968). In 1974 breeding was believed to be restricted to Mahé and Silhouette islands and an estimated 100 pairs were present on Mahé (and an unknown number on Silhouette). Protection under the Wild Animals and Bird Protection Act has allowed the population to recover and in 1975-7, 370 pairs were estimated to be present on Mahé (Watson 1981) and single pairs reported on St. Anne and Cerf (Feare *et al*. 1974; Temple 1977). The Silhouette population was only evaluated during a short visit and an estimate of 36 pairs made (Watson 1981). On Praslin the kestrel was reported to be extinct by the mid 1970s although 1-2 had been observed in 1970-3 (Feare *et* *al*. 1974) and reports of kestrels on Praslin and La Digue in 1975-7 were suggested to be juveniles moving from Mahe (Watson 1981, 1989) although these did not form a viable population. Approximately 10 territories were present in 1980-7 (Watson 1981, 1989; Skerrett *et al*. 2001), possibly rising to 20 pairs (reported from unknown sources - Collar *et al*. 1994) and subsequent declines suspected (Rocamora 1997). In recent years small numbers have been seen on Cerf, La Digue and North islands, although it is not known if any of these represent permanent breeding populations. It is currently categorised as Vulnerable by IUCN (Hilton-Taylor 2000).

Research into this species has provided population estimates of varying reliability, and basic data on reproduction and diet (Feare *et al*. 1974; Watson 1981). There have been few in depth studies of raptors on small islands and the diminutive Seychelles kestrel makes a good model of small island adaptations. The Silhouette population is isolated from the main population on Mahé by 19km, a distance that is likely to prevent inter-island dispersal in a short-winged kestrel (C. Jones & D. Birch pers. comm.). The island retains most of its original forest cover and provides a relatively small (1992ha) discrete area to study the natural ecology of the Seychelles kestrel in the absence of modern anthropogenic disturbances.

The only studies of the kestrel on Silhouette island comprised of 4 short visits in which Watson (1981) provided a population estimate of 36 pairs based on only two imprecisely defined areas totalling 630ha. Greig-Smith (1979) published notes on its distribution and in 1996 brief visits to Silhouette by two expeditions estimated the population to be "less than 20 pairs" (Rocamora *et al*. 1996) or "at least 15 pairs, and certainly no more than 20 pairs" (Mellamby *et al*. 1996). Recent observation suggest that these population estimates are inaccurate with local population densities being higher than published estimates. Local reproductive success appears to be high with observations being made of nests rearing 2 chicks. The territories are also exceptionally small (some being smaller than 20 hectares, in contrast to published home range estimates on Mahé of 49.8-103.2ha).

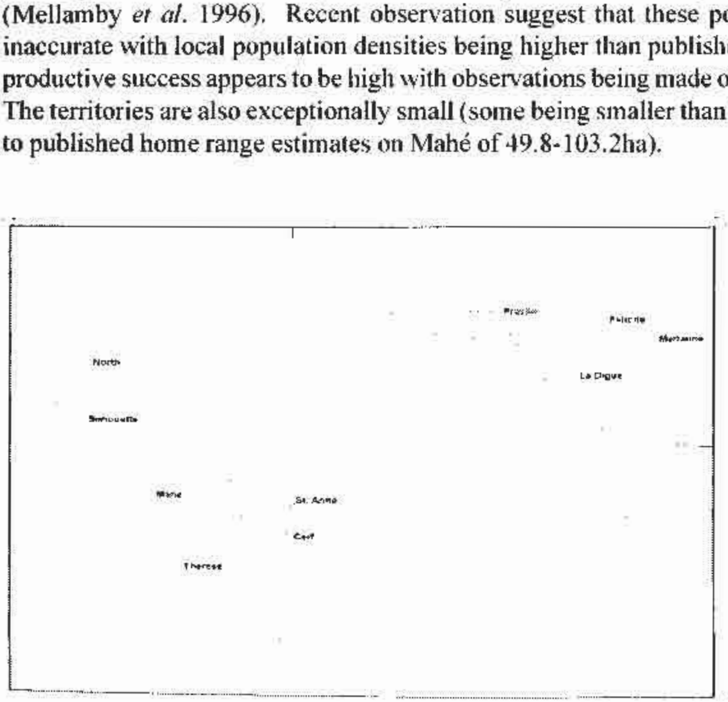

Fig. 1. The range of the Seychelles kestrel, islands with recorded historical populations.

Methods

The present study compiled data on kestrel distribution and location of territories on Silhouette island in 1990-2001 covering almost all the island (530 hectares intensively) and in all habitat types. The locations of visible or audible kestrels were recorded and where possible the birds were watched in order to identify nest sites and territory boundaries. In lowland areas with good vantage points this could be determined with accuracy, at higher altitudes fewer vantage points were available and few territory boundaries could be determined accurately. The data were combined with habitat maps (Gerlach 1993) to produce habitat structured population density estimates.

The distribution and abundance of the main prey species was studied using the '*Phelsuma* index' (Watson 1991) where 100 trees are studied in each area (coconut crowns below 200m a.s.l. and *Paraserianthes falcataria* of 15-35cm diameter at higher altitudes) by scanning the tree one with binoculars from a distance of 30m and recording the number of day geckos (*Phelsuma* spp.) seen. This provides comparative abundance measures rather than absolute measures and was used to provide a direct comparison with the earlier study. Absolute abundance measures were obtained by observing 20 trees for 30 minutes each, recording all the individual geckos observed. This was combined with existing data on tree density and diversity (Gerlach *et al.*, 1997; Gerlach in prep.) Skink numbers were determined using transects along forest paths. Every 100m along a path the number of *Mabuya seychellensis* skinks which visible 1m either side of the path was recorded. The altitudes of each of these 100m sections were determined from a contour map to give an indication of the relationship between skink abundance and altitude.

Kestrels successfully capturing a gecko on the trunk or branch of a tree was observed on 20 occasions. In each case the approximate position of the gecko on the tree was noted as a proportion of the total tree height.

Regurgitated pellets were collected from accessible roosts on Mahé and Silhouette and dissected to investigate diet. Existing accounts describe the diet of the Mahé population but do not quantify prey size. Accordingly selected bones were measured and compared to skeletal material in the Nature Protection Trust of Seychelle (NPTS) collection on Silhouette to determine which size categories of prey are eaten. This was compared to data on size distribution in the gecko (Gardner 1984; Radtkey 1996) and skink (Gerlach in prep.) populations.

Results

16 territorial pairs were located on Silhouette (Fig. 2) in all habitats except mist forest and *Dicranopteris linearis* scrub (Table 1; Fig. 1). The areas of the territories varied in different habitats (Table 1).

Kestrel territory size was found to be positively correlated with altitude and negatively correlated with the abundance of both reptile prey species (Fig. 3). The values of the *Phelsuma* index were found to be higher on Silhouette than Watson's (1991) data from Mahé (45-210 and 10-60 compared to 44-83 and 20-49 at <200m and >200m respectively).

All successful captures of geckos on trees were in the upper 70% of the tree. Within this 70%, all 20 captures were evenly distributed.

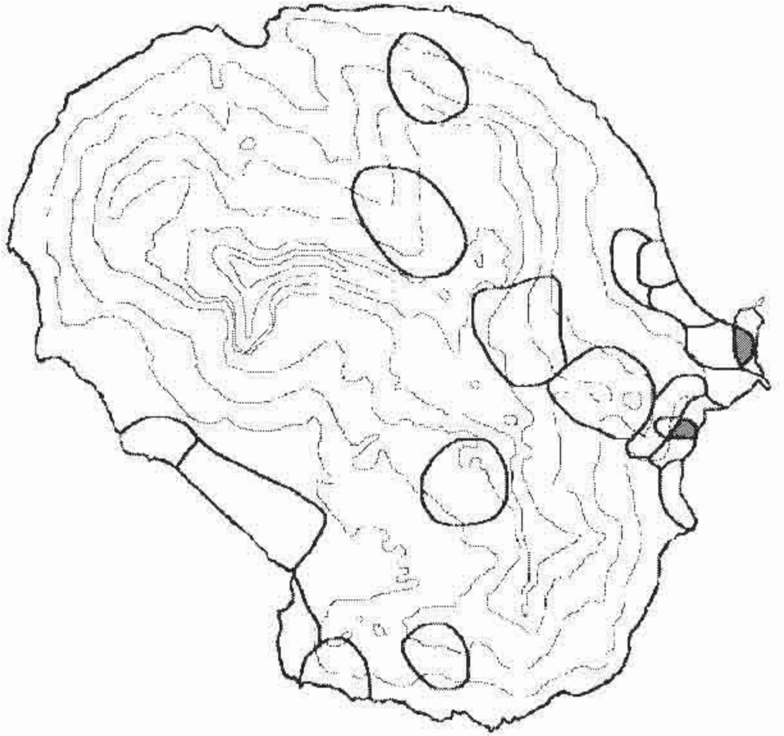

Fig. 2. Location of identified territories on Silhouette island, dark shading shows areas of territory overlap.

Table 1. territories located in terrestrial habitats on Silhouette. Habitat types modified from Gerlach *et al.*, 1995 and Gerlach, 1998.

Type (area)	Area studied (ha)	Territories	Territory size (ha) range, mean	% overlap	Pairs
Coastal plantation (95.8)	50	3	11.4-(12.0)-12.3	10	6
Coastal forest & glacis (157.9)	60	8	9.0-(12.5)-18.1	15	21
Mid-altitude forest & glacis (369.2)	160	3	20.3-(22.8)-25.0	0	7
Palm rich forest (1087.3)	160	2	45.0-(67.5)-90.0	0	14
Mist forest (216.5)	50	0	-	-	0
Dicranopteris scrub (70.3)	50	0	-	-	0
Total					48

Pellet analysis found a predominance of lizard prey as reported previously (Feare *et al.* 1974; Watson 1981), with both *Phelsuma* spp. and *Mabuya seychellensis* represented. Prey sizes were in the range 19.3-64.6mm snout-vent length (Table 2). These are compared to population size ranges in Fig. 4.

Discussion

The population densities recorded in the present study cover a wide range, including much higher values than previously recorded for the Seychelles kestrel. Feare *et al.* (1974) estimated home ranges to be 49.8-103.2ha (mean = 82.3, n=5) while Watson (1981) estimated population density to be 1 pair per 45ha on Silhouette and 38.8ha on Mahé. The present estimate of territory sizes of 9.0-90.0 (mean = 18.3, n=16) is considerably smaller than previous estimates. Due to considerable territory overlap at low altitudes the population density is 1 pair per 7.8-80/ha depending on habitat. The previous population estimate for Silhouette was given as 36 pairs (Watson 1981) but was based on an incorrect measurement of island area. Once corrected it gives an estimate of 45 pairs. The new estimate allowing for habitat variation is 48 pairs (Table 1). Although these estimates are not directly comparable their similarity suggests that the population has remained stable over the last 25 years.

Table 2. Prey composition and sizes, lizard snout vent lengths (SVL) are given as range with mean in parentheses

Island	**N**	**Insects**			**Lizards**		**Mice**
		Cockroach	**Scarab**	**Earwig**	***Phelsuma***	***Mabuya***	
Mahé	6	20%	10%	10%	30%	20%	10%
Silhouette	10	25%			50%		25%

Size of item	**frontal**	**dentary**	**maxilla**	**ulna**	**humerus**	**ilium**	**femur**	**SVL**
Mabuya - Mahé	3.0	-	-	-	-	-	-	38.7
Phelsuma - Mahé	-	-	5.0	9.0	-	-	9.0	48.3-(50.15)-58.0
Phelsuma - Silhouette	-	6.5	2.0	-	5.8-6	5.5-7.8	8.3-10.0	19.3-(43.9)-64.6

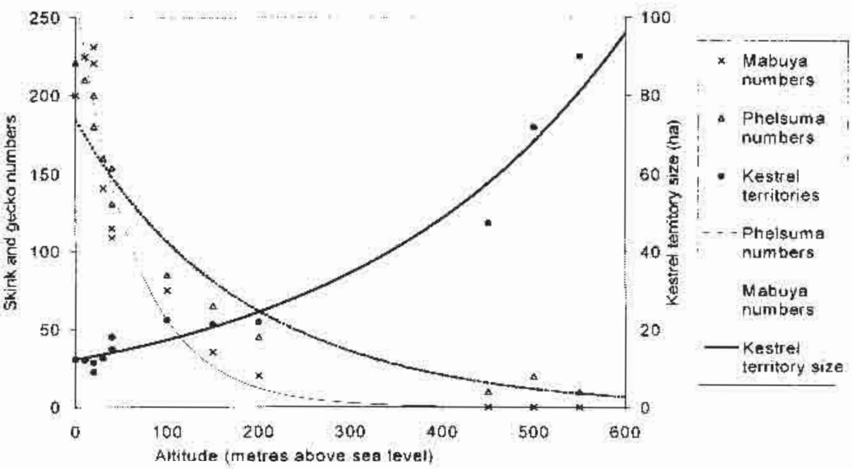

Fig. 3. Relationship between kestrel territory size, prey abundance and altitude.

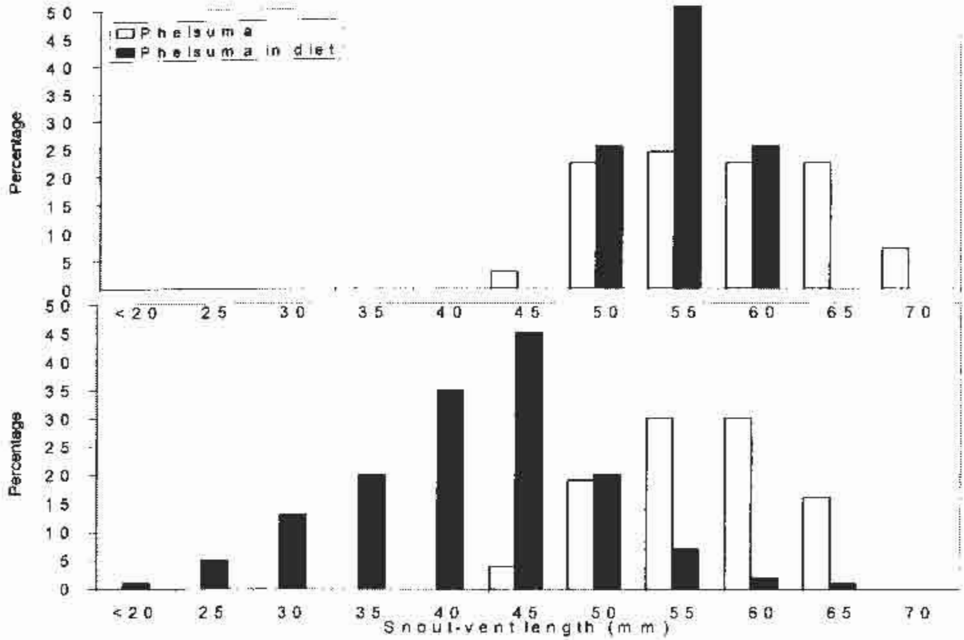

Fig. 4. Size distribution of kestrel prey - **a.** Mahé **b.** Silhouette

The highest population densities and the smallest territories are found in coastal habitats, mid-altitude and palm rich forests. This finding is broadly in agreement with a previous report of a negative correlation between kestrel sightings and altitude (Greig-Smith 1979). Similarly, Feare *et al*. (1974) found the smallest home ranges in coastal plantations and the largest in high altitude primary forest. The high population densities recorded on Silhouette can be related to availability of food and abundant nesting sites (dead trees and rock crevices). Measures of food availability (skinks and geckos) show exceptionally high availability on Silhouette (*Phelsuma* index 1.84 times higher than Watson's 1981 Mahé data). All the diurnal geckos and skinks on Silhouette fall into the size range of items recorded in pellet analysis (Fig. 4). Additional items recorded are insects (including cockroaches and scarab beetles in the present study), rats (only mice were found), birds, frogs and chameleons (Watson 1981). Bird records appear to be rare opportunistic catches of Madagascar fody *Foudia madagascariensis* (Watson 1981), Seychelles sunbird *Nectarinia dussumieri* (R. Gerlach 2001) and Seychelles white-eye *Zosterops modesta* (G. Rocamora pers. comm.).

The size difference between territories on Mahé and Silhouette may be associated with nesting success as well as food availability. It has been reported that lowland (<200m) territories on Mahé use coconut trees as the main nest sites (46% of pairs) with just over half as many using cliffs (28%) despite cliff nesting pairs having high success rates (76% fledging chicks compared to 19%) (Watson 1991, 1992). At higher altitudes 69% used cliffs (Watson 1992). Such preferred nest sites are largely restricted to the higher pairs of Mahé whilst the more rugged topography of Silhouette results in an abundance of cliff-nesting sites at all altitudes. Correspondingly all nest sites located on Silhouette are on cliffs or in tree cavities (which also have a high fledging success rate – 65%; Watson 1991).

These findings indicate that the Seychelles kestrel is well adapted to the mosaic of rock and forest habitats of the granitic Seychelles islands. It has the potential for a high reproductive output (clutch size of 2-3, mean = 2.63; Watson 1991) and long life-span allowing flexible population dynamics as is found in many other insular species (Gerlach 2001). These characteristics have facilitated recovery from population declines in the mid 1900s on Mahé and (it is assumed) Silhouette. The magnitude of the declines and recoveric can only be guessed at in the absence of early population assessments. A similar recovery did not occur on Praslin, which seems to have retained a population of just a few pairs since the 1970s. There has been no attempt to determine a reason for the lack of recovery despite abundant gecko prey. It is possible that nest sites on Praslin may be limited. The island does not have the extensive cliffs that are found on Mahé and Silhouette and forest cover is limited to 10% (compared to 80 and 95% for Mahé and Silhouette respectively) will provide fewer tree cavities. Kestrels on Praslin may be forced to nest in sub-optimal sites such as palms and buildings, reducing fledging success and population growth rates. However, the birds colonising La Digue might be expected to be more successful due to the cliffs and more extensive forest cover (90%) of that island. The failure of colonisation, despite at least one breeding attempt in 1992 (B. Beckett pers. comm.) indicates that other factors may be involved.

Mahé and Silhouette kestrels feed selectively on small skinks and geckos (20-60mm snout-vent length range: Friedman 2-way ANOVAR by ranks $F = 7.9285$, $P<0.05$). On Praslin and La Digue *Phelsuma* gecko size range is significantly larger (means 63 and 62mm respectively, compared to 54mm - Mahé, 52mm - Silhouette; Gardner 1984; Radtkey 1996). Furthermore a size-related dominance hierarchy among *Phelsuma* results in larger individuals forcing smaller ones into low growing vegetation (Gardner 1984). Only 40% of *Phelsuma* on Praslin are in the kestrel prey size range and 20% of these are found in the band of vegetation used by kestrels in hunting. Thus abundance of suitable prey is 10.5-18.4 per hectare in coastal and lowland habitat, 31.2 in mid-altitude forest and only 7.3 per hectare in open eroded areas (after Evans & Evans 1980; Gardner 1984). This range of 7.3-31.2 is comparable to sites over 350m above sea level on Silhouette where kestrel territories are large (20-90 hectares). This suggests that kestrels will have the smallest territories and be most abundant in mid-altitude forest (20 hectare territories) and lowland habitat (25 hectares), but scarce or absent from eroded land (predicted territory of over 250 hectares). This is in accordance with the known distribution of kestrels on Praslin which are almost entirely restricted to the southern, forested quarter of the island (Watson 1981; Rocamora 1997). 10 pellets of a kestrel on Praslin were examined and found to contain insects only, a diet which may not be suitable for successful reproduction and may be the result of the suggested food scarcity.

Seychelles kestrels are well adapted to the conditions of the granitic islands with adaptive reproductive output and a predation strategy suited to the availabile prey. The selection for a short wingspan to facilitate dynamic flight in forest habitats contributes to its success as a lizard predator but does reduce the potential for inter-island dispersal. This in turn may prevent the Seychelles kestrel from recolonising islands after local extinctions. The successful recovery of the Mahé and Silhouette populations contrasts with the remaining vulnerability of the Praslin population which highlights the ecological differences between these islands.

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