

Population and conservation status of the reptiles of the Seychelles islands

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Abstract: The population sizes of most Seychelles reptiles was assessed through transects and focal counts for squamates and literature reviews for chelonians. Population density estimation tested several different sampling methods: transects, focal counts, leaf-litter quadrats and drift fences. Transects were suitable for estimating populations of skinks and snakes. Focal counts were more effective for geckos. Population assessments are made for all species except the cryptic *Urocytyledon inexpectata*. The data presented here allow the first attempt to assign IUCN Red List categories to all Seychelles reptiles; nine taxa are considered to be Vulnerable (*Ailuroonyx tachyscopaeus*, *Ailuroonyx trachygaster*, *Dipsochelys dussumieri*, *Janetaescincus veseysfitzgeraldi*, *Phelsuma a. abbotti*, *P. abbotti sumptio*, *Phelsuma sundbergi ladiguensis*, *Trachylepis wrightii* and *Zonosaurus madagascariensis insularis*), four Endangered (*Chelonia mydas*, *J. braueri*, *Lamprophis geometricus* and *Lycognathophis seychellensis*) and three Critically Endangered (*Eretmochelys imbricata*, *Pelusios subniger parietalis* and *P. castanoides intergularis*). The major threats to these species are intrinsically small ranges, habitat deterioration and, for some species, predation by introduced tenrecs.

Island faunas are widely recognised to be both of great conservation significance as biodiversity hotspots and as being highly threatened (Whittaker 1998). Major threats include development pressures and invasive species. These have had a significant impact on island reptile faunas with 26% of threatened reptiles being restricted to islands (overall 61% of all evaluated reptiles are categorised as threatened compared to 85% of evaluated island reptiles) (data from IUCN 2004).

The Seychelles islands support a notable diversity of reptile species divided into two major biogeographical groupings: the granitic and coralline islands. The granitic islands support 30 reptile species and subspecies (24 endemic) of 20 genera (6 endemic) and 14 amphibian species (13 endemic) of 7 genera (6 endemic, including two placed within an endemic family). The coralline islands support a less diverse and more cosmopolitan fauna of 10 reptiles (1 endemic) of 8 genera and no amphibians.

The herpetofauna of the Seychelles islands is well known taxonomically and basic ecological data exist for most species. The native species play an important role in the ecology of the islands, being common insect predators and flower pollinators (Cheke 1984; Gardner 1986). They are also the main prey items of the endemic vertebrates, such as the Vulnerable Seychelles kestrel (*Falco araea*) and the Endangered Seychelles bare-legged scops owl (*Otus insularis*) (Watson 1981; Gerlach 2002a). Monitoring procedures and data on population sizes and distributions exist for all the species of chelonians but little is known of the population sizes of the other reptiles. During preparation of the Seychelles entries for the Global Reptile Assessment it has become apparent that the accuracy of assessment for several species is limited by the lack of reliable population

data. The need to provide such data and to develop a population monitoring programme initiated research into population sizes. The results of this research are discussed here.

Methods

Population assessments for Seychelles Chelonia are well developed (Bourn *et al.* 1999; Marine Conservation Society of Seychelles 2005; Gerlach 2008) and no new assessments were made for the present study. New assessments were made for all squamate species. Transect data from 46 islands were collected in 2000-2005 and these were combined with results from tests of other methods in April and July 2005 on the large, diverse islands of Mahé, Silhouette and Praslin. Data were collected from 36 of the granitic islands (no data were collected from Moyenne, Long, Round island [Mahé], Round island [Praslin] and Chauve Souris [Praslin]), four coral cays, two raised coral islands and four coral atolls. Four census techniques were used:

1. Quadrats – in each habitat area 10 randomly placed 1m² quadrats were studied, for each of these a 20cm wide band of leaf litter was removed from around the quadrat and then leaf litter removed progressively from the quadrat. The 20cm band enabled any escaping reptiles to be detected. Within the quadrat all moveable rocks and logs were overturned. This was carried out on all islands. Quadrats provide direct density estimates for each habitat type. Habitats were identified a priori using the classification of Gerlach (1998).
2. Transects – over 10 years (1995-2005) 9 regular transects were walked on Mahé, 12 on Silhouette, 3 on Praslin, one on Curieuse and one on La Digue. These transects were walked in March-April, June-July, September-October and December-January. 9 occasional transects (walked on 1-2 occasions) were used on Mahé, 4 on Silhouette and 3 on Praslin. A further 32 transects were used on single occasions on the other islands in 2000-2005. Transects were 2m wide and of varying length. Geckos usually remained immobile when encountered and were easily recorded by a single observer. Skinks rapidly hid from observers and were only recorded in a 1m width of the path as individuals to the side of the path could not all be identified to species. Along each transect the number of reptiles observed in 100m stretches was recorded. Along one transect (Jardin Marron, Silhouette) the position of each reptile observed was recorded in metres along the path and centimetres from the mid-line in July 2005. The data obtained were used in population estimation.
3. Drift-fences – a study of the efficacy of drift fences was carried out on Silhouette island in April 2005. 5 drift fences 10m long were constructed at different altitudes (0, 50, 100, 380 and 390m). The drift fence was 50cm high and at every 2m a 25cm diameter, 30cm deep pot was sunk into the soil. Each pot was emptied twice per day, any captured reptiles were marked on the back of the neck with paint.
4. Focal counts - 100 trees were randomly selected in each main habitat and examined carefully for the presence of geckos using binoculars. At each focal point 10 quadrats of 5x5m was used to record the number of each tree species present in the area, this allows reptile numbers per tree of each species to be converted to a population density estimate.

Table 1. Transects used in the Seychelles islands. Transect numbers show in Fig. 1

Island	Transect	Length (m)	day	No. surveys		Altitude (m)	Habitat	
				night	total			
North	1	900	1	-	1	0-10	coconuts	
Silhouette	2	900	2	-	2	10-150	lowland - degraded	
	3	1400	7	-	7	0-550	lowland - high forest	
	4	500	16	-	16	200-250	mid forest	
	5	100	40	-	40	550-600	high forest	
	6	3400	16	-	16	0-250	lowland	
	7	1300	159	-	159	550-650	high forest	
	8	800	17	-	17	0-500	lowland - high forest	
	9	1800	24	-	24	100-500	mid - high forest	
	10a	400	4	-	4	10-200	lowland	
	10b	50	12	8	20	200	lowland	
	11	500	4	6	10	10-20	lowland	
	12	700	2	-	2	0-300	mid forest	
	13	600	2	-	2	400-600	high forest	
	14	500	1	-	1	0-150	lowland	
	15	2000	10	-	10	0-350	bracken	
	16	400	4	-	4	650-770	moss forest	
Mahé	17	1750	4	-	4	500-550	high forest	
	18	4000	2	-	2	500-600	high forest	
	19	2000	1	-	1	0-30	lowland	
	20	3000	10	-	10	250-500	high forest	
	21	200	2	-	2	0-50	lowland	
	22	200	4	-	4	300-320	degraded	
	23	500	3	-	3	300-350	degraded	
	24	200	3	-	3	350-400	high forest	
	25	1500	1	-	1	350-600	high - moss forest	
	26	600	2	-	2	250-350	degraded	
	27	800	5	-	5	300-350	high forest	
	28	1300	16	-	16	250-450	palm forest	
	29	3000	1	-	1	50-250	mid forest	
	30	3000	1	-	1	0-400	mid forest	
	31	900	1	-	1	350-400	high forest	
	32	600	8	-	8	350-400	mid forest	
Therese	33	500	1	-	1	0-20	coastal	
Conception	34	500	1	-	1	0-50	coastal	
St. Anne	35	300	1	-	1	0-50	coastal	
Seche	36	50	1	-	1	0	Sea-bird	
Cerf	37	800	4	-	4	0-20	coastal	
Anonyme	38	400	1	-	1	0-20	coastal	
Praslin	39	4900	16	4	16	10-250	palm forest - mixed	
	40	2000	12	-	12	0-10	coastal	
	41	3000	1	-	1	50-150	degraded	
	42	2000	10	4	10	0-10	coastal	
St Pierre	43	50	2	-	2	0	Sea-bird	
Curieuse	44	2000	8	-	8	0-100		
Aride	45	400	12	-	12	0-100	Sea-bird	
Cousine	46	200	2	-	2	0-100	Sea-bird	
La Digue	47	3000	2	-	2	0-350	degraded	
Marianne	48	300	1	-	1	0-20	Coconuts	
Felicite	49	300	1	-	1	0-200	Coastal	
G. Soeur	50	400	1	-	1	0-10	Coconuts	

Table 1.	(cont).						
P. Soeur	51	200	1	-	1	0-10	Coconuts
Recifs	52	100	1	-	1	10-20	Sea-bird
Ilot Freg.	53	50	1	-	1	10	Sea-bird
Fregate	54	3000	2	-	2	10-200	Coastal
Booby	55	50	1	-	1	10	Sea-bird
Bird		400	4	-	4	0	Sea-bird
Dennis		400	4	-	4	0	Coastal
Assumption		400	1	-	1	0	mixed scrub
Aldabra	Picard	750	1	-	1	0	mixed scrub
	Polymnie	500	1	-	1	0	mixed scrub
	Esprit	50	1	-	1	0	mixed scrub
	Malabar	625	2	-	2	0	mixed scrub
	G. Terre	500	1	-	1	0	woodland
Astove	wood	3450	1	-	1	0	woodland
	scrub	500	1	-	1	0	mixed scrub
Cosmoledo	Menai	200	1	-	1	0	mixed scrub
	North	100	1	-	1	0	Sea-bird
	Grand Ile	1500	1	-	1	0	Coastal
	North-East	300	1	-	1	0	Sea-bird
D'Arros		500	2	-	2	0	Coastal
St. Joseph		400	1	-	1	0	Coconuts
Alphonse		400	2	-	2	0	Coconuts
St. Pierre		140	1	-	1	0	Casuarina

Following recent taxonomic revisions (Gerlach & Canning 1996; Gerlach 2002b, 2005a) all species of Seychelles reptile are easily identifiable. A possible exception to this is the burrowing skink genus *Janetaescincus*. This is widespread on Mahé, Silhouette, Fregate, Felicite, La Digue and Curieuse. Two species have been described in this genus: *J. braueri* sensu stricto is apparently restricted to high forest on Mahé and Silhouette whilst *J. vesityfitzgeraldi* is found below 500m on several islands (pers. obs.). The validity of the latter species has been questioned (Cheke 1984) and their taxonomy is currently being revised; they are not distinguishable without capture and at present the distribution of the two species has not been clearly elucidated. In data collection no attempt was made to distinguish the two species, but following capture of 20 individuals all *Janetaescincus* collected below 250m were found to be *J. vesityfitzgeraldi* and all over 500m *J. braueri*. Between these altitudes both species were encountered. The analysis considered lowland skinks (under 250m) were to be mainly *J. vesityfitzgeraldi*, whilst high forest (over 500m) skinks were assigned to *J. braueri*.

For the tiger chameleon *Calumma tigris* environmental variables were recorded in each section of each transect: altitude (metres above sea level), aspect (flat ground, slope or valley), canopy cover (estimated percentage cover in 25% bands), estimated canopy height (metres) and vegetation composition. The latter variable was recorded using a 5x5m quadrat, in which all trees over 2m tall were identified and recorded. All chameleons observed within 2m either side of the transect line during daylight (all surveys 08:30-14:00 hrs) were sexed, measured and their location on the transect was noted. This method only provided information on chameleons visible from the

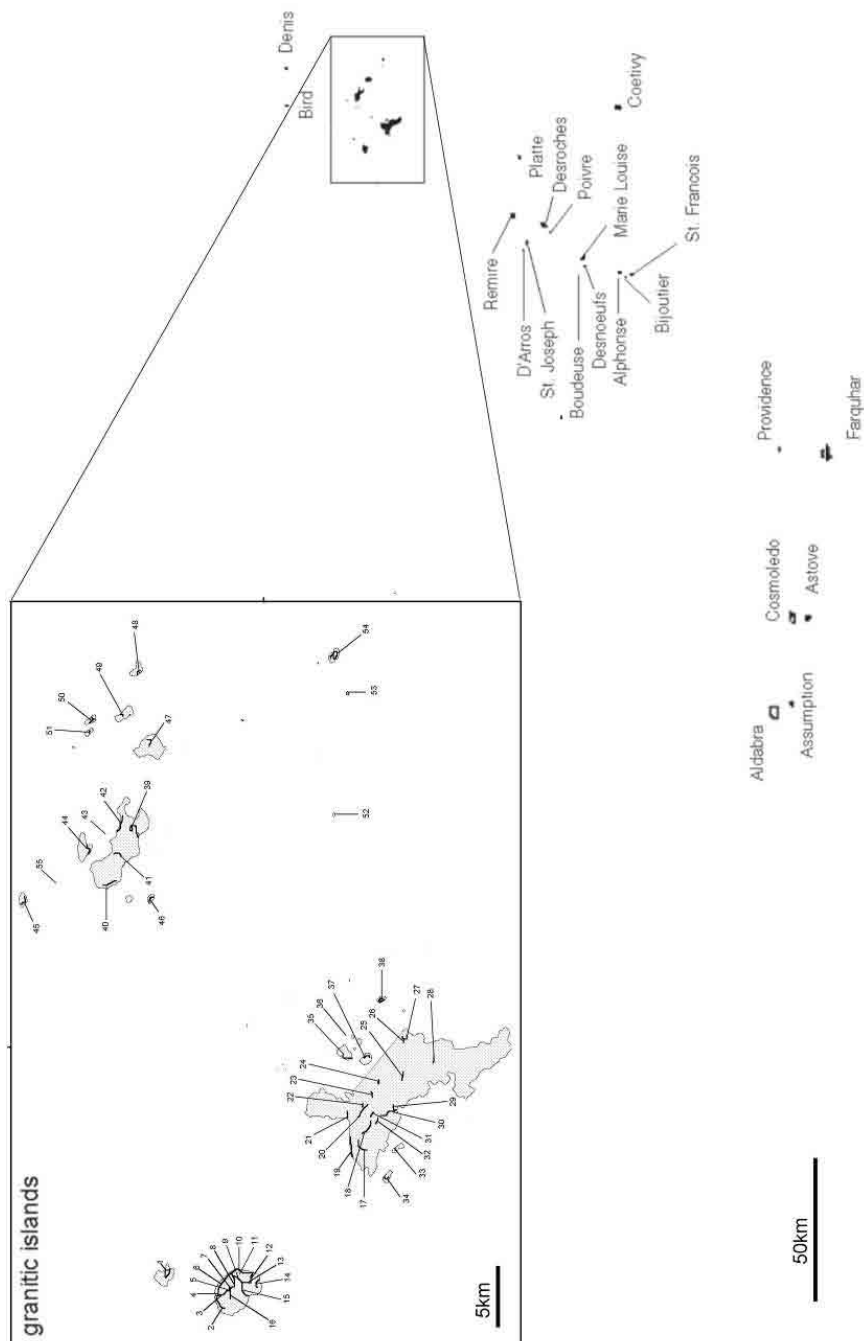


Fig. 1. Transects used on the Seychelles islands (transects numbered as Table 1)

path, excluding those on the far side of trees, more than 2m from the path and more than 2m above the ground. Chameleons (including other *Calumma* species) have been located in Madagascar by using nocturnal transects. It has been reported that as roosting chameleons become pale they are relatively easy to detect by torch light (Raxworthy 1988, 1991; Jenkins *et al.* 1999; Brady & Griffiths 1999). However, four nocturnal transects (Vallée de Mai, Praslin; 20:00-22:00 hrs) surveys have failed to locate *C. tigris*. The nocturnal lightening effect is minor in this species (pers. obs.) and this means that they are not easier to locate at night than by day. Although nocturnal searches are well established in chameleon research and are considered to be the most reliable survey method they did not prove effective with *C. tigris*; consequently only the diurnal transects are reported on here.

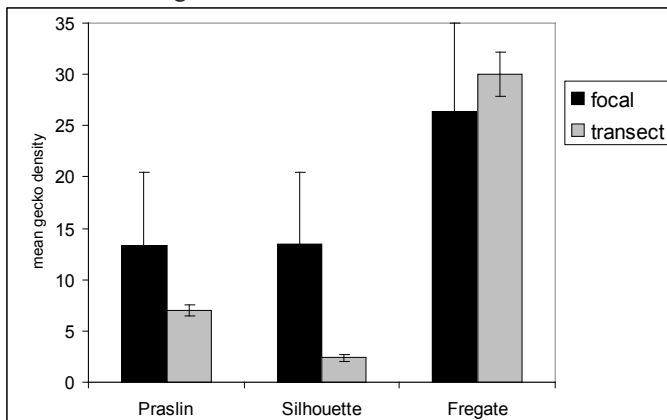
Results

Sampling methods

Only two reptile species were recorded in quadrats. The burrowing skink *Janetaescincus braueri* was collected in a single quadrat at Mon Plaisir, Silhouette (1000±3000ha⁻¹). On Fregate island *J. veseytitzgeraldi* and *Pamelaescincus gardineri* were recorded under rocks, with densities of 190.0±101.2 and 126.5±75.5ha⁻¹ respectively. They were not located in such sites on other islands and this appears to be a locally high density.

Snakes, skinks, chameleons and most gecko species were located using the transect method. The house snake *Lamprophis geometricus* was only recorded during the night transects, other reptiles recorded at this time were small numbers of the geckos *Ailuronyx seychellensis* and *A. trachygaster*. Distance based methods and classical line transects did not produce significantly different population estimates for the Jardin Marron transect. All estimates were within 95% of the estimates for classical linear transect methods.

Fig. 2. Comparison of transect data and focal counts for geckos on Praslin, Silhouette and Fregate islands.



Drift-fences recorded only one reptile species: the burrowing skink *Pamelaescincus gardineri*. Three individuals were captured in 25 trap days, the limited species range and low capture rate lead to this method not being pursued beyond an initial trial. Focal counts recorded only geckos but they produced higher counts of all geckos than the transects (Fig. 2).

Seasonality

Only one species showed significant seasonality: the snake *Lycognathophis seychellensis* was more likely to be encountered in November-December than in other months. The proportion of transects where snakes were encountered was not significantly different for these months but the numbers of snakes encountered were raised (from 1-2 to 8-12), this was largely due to local aggregations of snakes, probably associated with mating. No other significant seasonal effects were found for any other species.

Method evaluation

Of the methods used in this study, transects proved to be the most useful in terms of generating data and repeatability. Distance based methods did not affect the population density estimates. This method is preferable to classical transect studies when not all animals in the sample area are likely to be encountered (Buckland *et al.* 1993), in this case the narrow transects and the active nature of most of the reptiles concerned mean that the distance methods are not significant improvements. Although drift-fences were expected to provide effective collection of the skinks, only one species was trapped. Too few quadrats were used to provide sufficient data points for reliable analysis, and only recorded one reptile species. Focal counts were highly labour intensive but produced quantified counts of gecko abundance with greater precision than transects. However, they have high standard errors; sample sizes will need to be expanded considerably to produce reliable population estimation with this method.

The accuracy of the population estimates depend on the constancy of the detection rate (Schmidt 2004). In observation based studies this will be primarily affected by the visibility of the animals, which will in turn be a consequence of activity and environment. For the wolf snake *Lycognathophis seychellensis* the seasonal component of the transect data suggests an increase in activity associated with seasonal peaks of breeding. This does not appear to be the case for the other species, but vertical distribution has a strong effect on the detection of canopy dwelling species such as *Ailuronyx trachygaster* and *Phelsuma sundbergi* on Praslin. Surveys need to take these limitations into consideration.

Status assessments

Marine turtles Two breeding species of sea turtle are present in the Seychelles islands, the green turtle *Chelonia mydas* and the hawksbill turtle *Eretmochelys imbricata*. The former breeds mainly in the southern atolls, with some 3,400-4,750 females nesting annually, whilst the hawksbill is the main breeding species in the granitic islands, with 1,230-1,740 nesting (estimates from the 1980s - Mortimer *et al.* 1996). Numbers declined throughout the 19th and 20th centuries, but effective protection since 1994

appears to be stabilising populations (Mortimer 2000). Numbers of females nesting on the main nesting beaches are monitored annually, since 2006 this has been in the form of a national monitoring scheme (Marine Conservation Society of Seychelles 2005), no recent analyses of population trends have been published. The species are globally threatened, listed as Endangered for the green turtle and Critically Endangered for the hawksbill (IUCN 2004). Loggerheads *Caretta caretta* and leatherbacks *Dermochelys coriacea* have been recorded in Seychelles waters but do not breed (Frazier 1984).

Tortoises The most recent taxonomic revision recognises four species of *Dipsochelys* giant tortoise from the Seychelles islands (Gerlach & Canning 1998). The most familiar of these is the Aldabra giant tortoise *Dipsochelys dussumieri*. This has been the subject of conservation attention since the 1800s and has been extensively studied over the last 35 years. Populations declined to a low level (approximately 1000 individuals in 1900) (Gerlach 2004) as a result of direct exploitation. Protection of the atoll has enabled populations to recover to an estimated 100,000 in 1997 (Bourn *et al.* 1999). There is evidence of recent declines which are believed to be due to natural processes following over-population in the 1970s. The species is listed (as '*Geochelone gigantea*') as Vulnerable on the basis of restricted range (IUCN 2004). The only natural population is threatened in the long-term by sea level rise (although the well established introduced populations on Curieuse and Fregate islands are secure from this threat). Of the other species, *D. daudinii* is known from only two museum specimens collected prior to 1830 (Bour 1985), this species is presumed to be extinct. A small number of living tortoises have been ascribed to the species *D. hololissa* and *D. arnoldi* based largely on morphology (Gerlach & Canning 1998), genetic studies have failed to provide clear support for this identification; mitochondrial genes show no variation in the genus (Palkovacs *et al.* 2003), a combination of mitochondrial and nuclear genes have been used to suggest that a single species is present (Le *et al.* 2006) although the data do show some genetic differentiation, microsatellite primers from Galapagos tortoises show no population structuring (Palkovacs *et al.* 2003, although a different analysis was provided by Gerlach 2005) whilst Madagascar tortoise primers show significant separation but continued gene flow (Gerlach & Rioux-Paquette in prep.). The identity of these taxa remains a matter of debate. No wild breeding populations of *D. hololissa* remain (Gerlach & Canning 1998) and this can be categorised as Extinct in the Wild. *D. arnoldi* was reintroduced to Silhouette island in 2006. Both species are included in a successful captive breeding programme (Gerlach 2007).

Terrapins Three taxa of *Pelusios* mud turtle are endemic to Seychelles. Two are endemic subspecies of African species: *P. subniger parietalis* and *P. castanoides intergularis*. The third is an endemic species *P. seychellensis*. The first two are categorised as Critically Endangered on the basis of range restriction, fragmentation and continued declines in range, habitat and population (at least 70% in the last five years for *P. castanoides* and 31% for *P. subniger*; Gerlach & Canning 2001; Gerlach 2008). *P. seychellensis* is known from three specimens collected in 1895, despite extensive searches it has not been relocated and is probably extinct.

Crocodiles Historically crocodiles were present in the Seychelles islands, with *Crocodylus porosus* in the granitic islands until the early 1800s (Gerlach & Canning 1994).

Snakes Snakes have been recorded in all forest habitats, population densities are given in Table 2. The wolf snake *Lycognathophis seychellarum* is locally abundant in forests and transect data show no significant effects of altitude or habitat preference within the forest. It has high population densities on Silhouette and Fregate but comparatively low densities on Mahé and Praslin. This may be due to predation by tenrecs *Tenrec ecaudatus* but there is no direct evidence of this or of any population decline. The house snake *Lamprophis geometricus* was only encountered on the nocturnal transects in the Vallée de Mai, Praslin. An insufficient number of nocturnal transects have been used on Mahé or Silhouette for the abundance of this species to be determined on those islands. Both endemic snakes are considered to be Endangered due to their restricted ranges and the continuing decline in the extent and quality of its forest habitat, especially on Mahé and Praslin islands.

The introduced blind snake *Rhamphotyphlos braminus* was not encountered in any of the population surveys and no methods currently exist for monitoring its populations. It occurs widely, with records from both granitic and coral islands. The sea-snake *Pelamis platura* has been recorded in the islands (Gerlach 1999; Lawrence 2007) but there is no evidence of any breeding populations in Seychelles.

Skinks In the granitic islands skinks have clear altitude preferences as indicated by transect data, with *Trachylepis sechellensis* being a lowland species and the burrowing skinks being more abundant at high altitudes (Fig. 3), although all three occur at all

Fig. 3 Effect of altitude on skink density on Silhouette (individuals per hectare). *Pamelaescincus* $y = -4 \times 10^{-5}x^2 + 0.0216x + 4.6203$ ($R^2 = 0.48$); *Janetaescincus* $y = 0.0201e^{0.0149x}$ ($R^2 = 0.93$); *Trachylepis* $y = 43.61e^{-0.0075x}$ ($R^2 = 0.91$). $P < 0.05$.

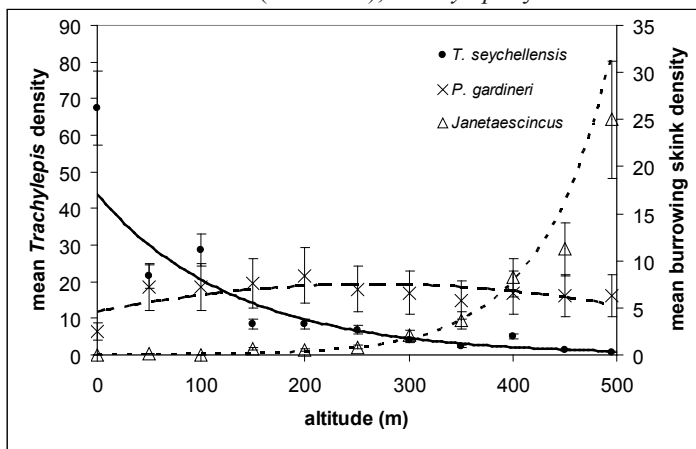


Table 2. Mean (\pm SE) density per hectare from transect data. 2a. snakes & lizards

Island	Habitat	J_{yc}	B_{od}	Ch	Z_m	J_c	J_w	J_b	P_g
Mahe	lowland degraded	0	0	-	-	6.50 ± 0.25 1.20 ± 0.20	-	0	0
	mid forest	0	0	-	-	4.52 ± 0.69	-	0	1.73 ± 0.1
	Palm forest	0	0	-	-	0.92 ± 0.48	-	0	0
	High forest	0.34 ± 0.23	0	-	-	0	-	0	0.42 ± 0.07
	Moss forest	0	0	-	-	0.23 ± 0.19	-	0	0
Praslin	lowland palm forest	0	0	-	-	18.68 ± 5.1 15.1 ± 10.4	-	-	0
	mixed forest	0.08 ± 0.1	0	-	-	5.38 ± 2.33	-	-	0
	scrub	0	0	-	-	5	-	-	0
Curieuse	coastal	0	0	-	-	8.03 ± 2.53	-	0.52 ± 0.02	0.52 ± 0.02
La Digue	Degraded	10	0	-	-	333	-	-	30
Silhouette	Lowland	1.2 ± 0	0	-	-	57.73 ± 16.27	-	0.13 ± 0.01	8.92 ± 0.34
	mid forest	1.78 ± 3.38	0	-	-	2.32 ± 1.13	-	10.76 ± 0.36	26.69 ± 0.33
	high forest	1.01 ± 4.21	0	-	-	0	-	39.47 ± 1.02	36.95 ± 1.01
	moss forest	1.35 ± 1.15	0	-	-	1.3 ± 0.8	-	99.1 ± 0.83	288.76 ± 3.62
	Bracken	0.63 ± 2.1	0	-	-	9.23 ± 2.53	-	5.03 ± 0.25	14.4 ± 0.25
	Degraded	5 ± 2.5	0	-	-	24.18 ± 2.85	-	3.35 ± 0.39	35.89 ± 0.4
North	Coconuts	-	-	-	-	33.33	-	-	-
Cerf	coastal	-	-	-	-	42.19 ± 7.81	-	-	1.56 ± 1.56
St. Anne	Coastal	-	-	-	-	200	-	-	-
Anonyme	Coastal	-	-	-	-	100	-	-	-
Conception	Coastal	-	-	-	-	30	-	-	-
Therese	Coastal	-	-	-	-	50	-	-	-
Arde	Sea-bird	-	-	-	-	286.3 \pm 678.8 4000.1 ± 125.09	301.51 ± 52.6 3250.2 ± 101.1	-	100 ± 200
Cousine	Sea-bird	0	-	-	-	50	-	-	-
P. Soeur	Coconuts	-	-	-	-	100	-	-	-
G. Soeur	Coconuts	-	-	-	-	83.33	-	-	-
Felicitte	Coastal	-	-	-	-	100	-	-	16.67
Marianne	Coconuts	-	-	-	-	100	-	-	-
Fregate	Coastal	0.83 ± 0.83	0	-	-	416.7 ± 101.1	366.7 ± 11 750 ± 5	0.83 ± 0.08	2.5 ± 0.08
St. Pierre	Sea-bird	-	-	-	-	-	-	-	-
Seche	Sea-bird	-	-	-	-	700	-	-	-
Booby	Sea-bird	-	-	-	-	800	-	-	-
Ilot Fregate	Sea-bird	-	-	-	-	300	-	-	-
Bird	Sea-bird	-	-	-	-	10 ± 2.11	-	-	-
Dennis	Coastal	-	-	-	-	-	-	-	-
Assumption	mix scrub	-	-	-	-	-	-	-	-
Picard	coast	-	100	-	-	-	-	-	-
Esprit	mix scrub	-	300	-	-	-	-	-	-
Malabar	mix scrub	-	20	-	-	-	-	-	-
	woodland	-	5	-	-	-	-	-	-
G. Terre	woodland	-	20	-	-	-	-	-	-
Astove	woodland	-	116	-	-	-	-	-	-
	mix scrub	-	50	-	-	-	-	-	-
Menai	mix scrub	-	25	-	-	-	-	-	-
North	Sea-bird	-	5	-	-	-	-	-	-
Grande Ile	Coastal	-	33.33	33.33	-	-	-	-	-
North-East	Sea-bird	-	16.67	-	-	-	-	-	-
St. Pierre	Casuarina	-	46.42	-	-	-	-	-	-

2b. geckos

Island	Habitat	A_s	A_{fs}	Atg	P_s	P_{gs}	P_{ab}	H_m
Mahe	lowland degraded	0	0	-	0.50±0.05	0	-	-
	mid forest	0	0	-	1.50±0	0.03±0.02	-	-
	Palm forest	0.36±0.01	0.44±0.02	-	0.15±0.01	0.22±0.05	-	-
	High forest	0	0	-	0.25±0.01	0.07±0.03	-	-
	Moss forest	0	0	-	0.35±0.02	0	-	-
Praslin	lowland	0	0	-	0.24±0.01	0	-	-
	Palm forest	10.42±3.01	27.88±1.62	0	8.03±0.24	6.8±2.55	-	-
	mixed forest	1.5±0.05	0.05±0	4.44±0.26	4.77±0.35	6.54±4.52	-	-
	scrub	0	0	0	2.21±0.01	3.25±0.5	-	-
Curieuse	coastal	0	0	-	0	0	-	-
La Digue	Degraded	6	0	-	1.25±0.06	1.25±0.63	-	-
Silhouette	Lowland	0.56±0.05	2.01±1.11	0	1.67	3.33	-	-
	mid forest	0.31±0.18	0	0.05±0.01	2.75±0.19	7.56±2.04	-	-
	high forest	2.99±0.27	0	0	0.43±0.01	1.67±0.15	-	-
	moss forest	3.5±0.02	0	0	0	0	-	-
	Bracken	0	0	0	1.4±0.08	0	-	-
	Degraded	0	0	0	0.83±0.02	0.23±0.18	-	-
North	Coconuts	0	0	0	3.72±0.1	3.32±1.99	-	-
Cerf	coastal	-	-	-	16.67	-	-	-
St Anne	Coastal	0	-	-	7.81±0.16	3.13±1	-	-
Anonyme	Coastal	0	-	-	50.00	66.67	-	-
Conception	Coastal	0	30	-	0	37.5	-	-
Therese	Coastal	0	-	-	0	40	-	-
Aride	Sea-bird	13.75±1.13	-	-	0	20	-	-
Cousine	Sea-bird	25±2.5	-	-	1±2	-	-	-
P Soeur	Coconuts	0	-	-	-	0.89±0.89	-	-
G Soeur	Coconuts	0	-	-	-	25	-	-
Felicite	Coastal	-	-	-	12.5	37	-	-
Marianne	Coconuts	-	-	-	33.33	50	-	-
Fregate	Coastal	10±0.17	-	-	33.33	66.67	-	-
St Pierre	Coastal	-	-	-	10±0.33	10±1.67	-	-
Seche	Sea-bird	-	-	-	-	200	-	-
Bird	Sea-bird	-	-	-	-	100	-	-
Dennis	Coastal	-	-	-	8±1.33	-	-	-
Assumption	mix scrub	-	-	-	11±2.13	-	-	-
Picard	coast	-	-	-	-	-	2.5	-
	mix scrub	-	-	-	-	-	60	20
Polymnie	mix scrub	-	-	-	-	-	10	10
Malabar	mix scrub	-	-	-	-	-	10	-
	woodland	-	-	-	-	-	20	5
G Terre	woodland	-	-	-	-	-	5	10
Asiove	woodland	-	-	-	-	-	20	10
D Arros	Coastal	-	-	-	-	-	145	-
Alphonse	Coconuts	-	-	-	-	2±0.83	-	-
						625	-	-

altitudes. There is little seasonality in abundance. As with snakes, densities of the burrowing skinks are higher on Silhouette and Fregate than on Mahé or Praslin. Population densities on La Digue are comparable to those on Silhouette but only in a small area with the least degraded habitat. *T. sechellensis* is abundant at low altitudes on all islands, with highest density being recorded in *Pisonia grandis* woodland associated with sea-bird colonies. The sea-bird colonies are also the only places where *T. wrightii* is recorded. The population densities of *Trachylepis* skinks recorded here for sea-bird islands (Table 2, 5) are comparable to those reported by other studies with different methods (Evans & Evans 1980; Brooke & Houston 1983; Castle & Mileto 1991). Densities were comparatively low on small rocks and on Fregate island, the latter was heavily modified throughout the 20th century but now has an expanding tern population, skink densities may still be low due to historically small tern populations. On islands without tern-colonies *T. wrightii* is absent and *T. sechellensis* occurs at low densities.

Pamelaescincus gardineri occurs at relatively low densities on Mahé, Cerf, Praslin and Curieuse. Populations of *P. gardineri* have been suggested to be reduced by predation by rats (Cheke 1984) or tenrecs (Gardner 1986). Diurnal activity on Praslin, Mahé, La Digue and Fregate has been suggested to be due to nocturnal predator (barn owls and rats) avoidance (Cheke 1984), although such predators are not present on Fregate. Alternatively, high densities of *Trachylepis* skinks on the small sea-bird islands may force the smaller *P. gardineri* into a nocturnal niche (Evans & Evans 1980). The present study is the most extensive investigation of reptile populations on the granitic islands of Seychelles and provides a more reliable base for such comparisons. Two particular patterns are notable: for several reptile species population densities are comparatively low on Mahé and Praslin and the nocturnal behaviour of *P. gardineri* is restricted to the sea-bird islands where *Trachylepis* skinks are particularly abundant, and *T. wrightii* is present. This large diurnal skink has been seen eating smaller skinks and may be a major factor restricting *P. gardineri* activity. Reduced population densities on Mahé and Praslin (in comparison to Silhouette and La Digue) are apparent for all ground dwelling lizards except for *T. sechellensis*. However, arboreal geckos have comparatively high densities on Praslin. This comparison indicates that ground-dwelling reptiles on Mahé and Praslin have reduced population densities, which cannot be explained by the distribution of rats or cats (both present on Silhouette and La Digue where reptile densities are high) but does correlate to tenrec presence. These are restricted to Mahé and Praslin and are highly abundant on both islands. Tenrecs are known predators of large invertebrates and small vertebrates, including skinks and snakes (Racey & Nicoll 1984).

The least well known of the Seychelles skinks is the burrowing skink genus *Janetaescincus*. Cheke (1984) noted that its apparent confinement to “the Mahé group of islands and Fregate could well be due to the secretive habits of this species”. The present study extends the known distribution of *J. vesevitzgeraldi* to La Digue, Felicite and Fregate based on captured individuals identified to species. All *J. braueri* specimens have been collected from high altitude forests and the only islands with this habitat are Mahé and Silhouette.

Cryptoblepharus boutonii is only found in the southern atolls where it occurs at high population densities, in all habitats. It is considered Least Concern due to its wide

distribution, although all Seychelles populations are on low-lying islands vulnerable to sea level rise. *Pamelaescincus gardineri* and *Trachylepis sechellensis* are similarly not considered threatened, although *T. wrightii* qualifies for Vulnerable status due to its highly restricted range. *Janestaescincus braueri* is Endangered due to being restricted to two locations, with continuing decline in the extent and quality of its forest habitat on Mahé and Silhouette islands. *J. vesityfzgerald* faces similar threats but has a wider range and is considered to be Vulnerable.

Other lizards With the exception of some of the geckos and *Cryptoblepharus boutonii*, the only non-endemic native lizard species in the islands is the Madagascar girdled lizard *Zonosaurus madagascariensis insulans*. There is also an introduced population of *Calotes versicolor* on St. Anne island. This may recently have been eradicated (R. Fanchette pers. comm.). The girdled lizard is restricted to Cosmoledo atoll where it has been located on Menai, North island and Grande Ile. The species is widespread in Madagascar but the Cosmoledo subspecies is found only on that atoll and Grande Glorieuse, it therefore qualifies as Vulnerable due to its very restricted range; this subspecies is likely to be threatened by sea-level rise in the long term.

Chameleon The tiger chameleon *Calumma tigris* has a relatively wide range in forest habitats on Mahé, Silhouette and Praslin islands. However, it is not evenly distributed in all habitats and is primarily associated with forested valleys.

Factors influencing chameleon distribution were evaluated by analysis of variance (ANOVA) using each 100m section of transect, comparing observed population densities with the habitat variables recorded in that section (altitude, numbers of each tree species, aspect, canopy cover and canopy height). Significant factors were then used to group similar transect sections. The final analysis used the following groupings: aspect (slope or valley) and habitat (lowland, mid-altitude, garden, palm rich, degraded, high forest, moss forest or scrub). The main influences were found to be aspect, habitat and proportion of native vegetation (Table 3). The proportion of native plants produced had only a weak effect on the ANOVA results, but significant correlation with the density of *Cinnamomum verum* plants was identified. This plant supports very few invertebrates and cinnamon dominated forest is typically very insect poor (pers. obs.), this may reduce the suitability of this habitat for insect predators such as chameleons. Use of aspect and habitat in grouping transects reduce the standard error of density estimates and these have been used in densities and population estimates (Table 4).

Table 3. ANOVA results for chameleon densities and habitat factors. *Cinnamomum verum*, the only significant single species, is treated separately

Factor	SS	Df	MS	F	P
month	407481.2	36	11318.92	1.007	0.472
aspect	1848948	1	1848948	82.360	<0.001
habitat	0.049	1	0.049	0.101	0.752
vegetation	0.351	1	0.351	0.620	0.436
<i>Cinnamomum</i>	92452	1	92452	42.603	<0.01
aspect + vegetation	0.708	2	0.354	0.787	0.459
habitat + aspect	2465664	2	1232832	82.267	<0.001
Error	1214113	108	11241.79		
Total	4394511	147			

Population density is greatest in moist habitats, especially in association with river valleys, this accounts for the significant association between chameleon abundance and the combined habitat and aspect variables, with low density in habits on ridges and higher densities in valleys associated with rivers. The cause of this has not been identified, but may result from this species laying eggs in the axils of plants and in shallow nests (Gerlach & Gerlach 2001; Heygen & Heygen 2004; Nečas 2004) requiring constantly damp habitats to prevent eggs dehydrating. The population densities recorded here are comparable to those recorded for other *Calumma* species on Madagascar with most sites at 2-15 per hectare (Brady & Griffiths 1999) while *C. tigris* occurs at densities of 2.07 ± 5.00 per hectare in optimal (mid-altitude) habitat. The data collected gives an overall population estimate of $2,055 \pm 620$ individuals.

The absence of chameleons from smaller islands has been suggested to be due to low population densities making small island populations unviable (Gardner 1986). Population densities recorded here would indicate that in order to support a viable population of chameleons an island would have have at least 100 hectares of forested river-valley. This does not exist on any of the smaller islands. The species can be considered Endangered due to habitat deterioration (especially on Mahé and Praslin).

Geckos

Two *Phelsuma* species are present in the granitic islands: *P. astriata* and *P. sundbergi*. The coral islands support endemic subspecies of *P. abbotti*, one subspecies of *P. laticauda* and introduced populations of both the granitic island species. *P. abbotti* is restricted to Aldabra and Assumption (with a different subspecies on Madagascar). *P. laticauda* is also present on Madagascar, in Seychelles it is restricted to Farquhar and Providence atolls. This is a widely introduced *Phelsuma* species (Carretero *et al.* 2006; Ota & Ineich, 0006; Rocha *et al.* 2007) and may be introduced to Seychelles, although Farquhar and Providence are the Seychelles islands closest to Madagascar and most likely to be colonised by this species naturally. Gardner (1986) recorded it from St. Pierre but no evidence could be found of its occurrence there in 2005. These are all

Table 4. Population estimate for chameleons in each habitat on the three islands

Aspect	habitat	Area (ha)			Estimate (individuals per ha)		
		Mahé	Praslin	Silhouette	Mahé	Praslin	Silhouette
Slope	low-altitude	210	100	8	0	18±14	0
	mid-altitude	100	0	60	0	0	1±1
	degraded mid-alt.	300	10	50	0	-	0
	high-altitude	250	0	32	70±33	-	0
	moss	50	0	150	0	-	237±80
Valley	scrub	500	500	73	0	0	0
	low-altitude	500	5	12	0	(0)	(+)
	garden	100	0	0	47±13	-	-
	mid-altitude	100	0	32	0	-	16±50
	degraded mid-alt.	700	0	301	0	-	0
	palm rich mid-alt.	100	750	1088	46±19	248±120	457±120
	high-altitude	650	-	96	345±156	-	240±14
Total	moss	50	-	66	0	-	330±10
					508±221	266±134	1,281±265
					2,055±620		

highly adaptable taxa, being found at high densities (Table 2) in all forest types, although with a strong preference for lowland habitats. *P. sundbergi ladiguensis*, *P. a. abbotti* and *P. abbottii sumptio* can be considered to be Vulnerable due to range restriction, the latter two taxa are likely to be threatened by sea-level rise in the long term. There is a record of the Mahé subspecies *P. a. astriata* being introduced to Praslin where at least one individual coexists with the Praslin subspecies *P. astriata semicarinata* (Van Heygen 2004); hybridization may be a threat to the genetic distinctiveness of the subspecies in the future although more extensive genetic sampling is needed to clarify the distinctiveness of these subspecies and the extent of hybridization.

The Seychelles sucker-tailed gecko *Urocotyledon inexpectata* is a small, cryptic species. Consequently its distribution and population sizes remain little known; there has been only one study of its behaviour (Gerlach 1999). It has been recorded under rocks on Aride island, under bark on North island, in leaf litter accumulations on endemic palms on Mahé, in coconut crowns on Silhouette and in buildings on Mahé and Silhouette. Recorded altitudes range from sea level to 700m. These limited data indicate that the species is widespread and adaptable. It is probable not under significant threat, at present no population estimates have been made and it is considered Least Concern.

Table 5. Status evaluations using IUCN Red List criteria (IUCN 2001). Marine turtle data from the 1980s (Mortimer *et al.* 1996). All *Janetaescincus* populations above 500m are assumed to be *J. braueri* and <500m *J. veseftzgeraldi*. ‘Extent’ is total range in Seychelles, ‘Area’ is the occupied ground area.

	Islands	Extent (km ²)	Area (km ²)	Population (individuals)	Status
<i>Chelonia mydas</i>	30	86250	-	3,400-4,750	EN A2abd
<i>Eretmochelys imbricata</i>	30	86250	-	1,230-1,740	CR A1bd+2bcd
<i>Dipsosaurus dussumieri</i>	5	86250	159	100,000	VU B2ab(v)
<i>D. hololissa</i>	2	30	1	3 wild	EW
<i>D. arnoldi</i>	1	0	0	1 wild	EW
<i>D. daudini</i>	0	0	0	0	EX
<i>P. castanoides intergrularis</i>	6	2700	<1	150	CR A2bc; B1&2ab(ii,iii)
<i>P. subniger parietalis</i>	6-7	2700	<1	250	CR B1&2ab(ii,iii)
<i>Pelusios seychellensis</i>	?	-	-	-	EX
<i>Lycognathophis seychellensis</i>	6	2700	133	10,038±2,449	EN B1ab(iii)+2ab(iii)
<i>Lampropholis geometricus</i>	4	2700	132	>780±188	EN B1ab(iii)+2ab(iii)
<i>Trachylepis sechellensis</i>	32	2700	233	357,566±105,010	LC
<i>T. wrightii</i>	7	2500	4	376,205±5,409	VU D2
<i>Pamelaescincus gardineri</i>	12	2700	46	170,895±22,059	LC
<i>Janetaescincus braueri</i>	6	1200	12	5,929±119	EN B1ab(iii)+2ab(iii)
<i>J. veseftzgeraldi</i>	2	2700	16	66,155±2,910	VU B1ab(iii)+2ab(iii)
<i>Cryptoblepharus boutoni</i>	8	40000	200	299,816±86,205	LC
<i>Zonosaurus madagascariensis</i>	3	5	2	6,504	VU D2
<i>Calumma tigris</i>	3	1500	76	3,213	EN B1ab(iii)+2ab(iii)
<i>Ailuroonyx seychellensis</i>	13	2700	74	9,124±670	LC
<i>A. tachyscopaeus</i>	5	2300	57	22,795±1,220	VU D2
<i>A. trachygaster</i>	2	2000	13	3,389±205	VU D2
<i>Hemidactylus mercatorius</i>	5	40000	200	126,900	LC
<i>Phelsuma a. abbotti</i>	4	150	110	269,100	VU D2
<i>P. abbotti sumptio</i>	1	117	117	2,928	VU D2
<i>P. a. astriata</i>	12	1800	190	22,697±1,114	LC
<i>P. astriata semicarinata</i>	16	500	51	26,816±3,862	LC
<i>P. laticauda</i>	3	8	2	?	LC
<i>P. s. sundbergi</i>	9	500	36	3,663±264	VU B1ab(iii)+2ab(iii)
<i>P. sundbergi longinsulae</i>	17	1800	186	19,896±1,703	LC
<i>P. sundbergi ladiguensis</i>	3	100	14	12,751	VU D2
<i>Urocotyledon inexpectatus</i>	11	2300	149	?	LC
<i>Lepidodactylus lugubris</i>	1	2	2	-	?

The house gecko *Hemidactylus mercatoris* is considered to be indigenous to the southern atolls (Cheke 1984) but is introduced in the granitics, currently actively spreading on Mahé (Matyot 2003) and having recently colonised Fregate island (pers. obs.). *H. frenatus* has a scattered distribution on coral islands and *H. brookii* is restricted to Desroches, both probably introduced (Cheke 1984). The identity of '*H. brookii*' needs to be evaluated genetically as African populations have recently been assigned to *H. angulatus* (Carranza & Arnold 2006). *Lepidodactylus lugubris* has only been recorded from Coetivy which has not been surveyed recently and the status and origin of the population are unknown. *Gehyra mutilata* is a widespread introduced species throughout the Seychelles islands, usually found anthropophilically.

It has been suggested that populations or activity patterns of *Ailuronyx* geckos have been reduced by introduced rats (Evans & Evans 1980; Cheke 1984), however Gardner (1986) suggests this is oversimplified and suggests that predation by tenrecs also plays a major role. This was based in part on the erroneous inclusion of Silhouette in a list of islands occupied by tenrecs. The suggestion that arboreal *Ailuronyx* are reduced by terrestrial tenrec predation is not borne out by population density estimates. The populations on Mahé may be more affected by extensive invasion by introduced plants, such as cinnamon *Cinnamomum verum* and guava *Psidium cattleianum*. Forests on Silhouette are stable or recovering (Gerlach 2005b) whilst deterioration continues on Mahé and Praslin.

Future monitoring and conservation

All Seychelles lizards and snakes can be monitored by the methods applied successfully here. Monitoring on Silhouette using transects and focal counts is maintained by the Nature Protection Trust of Seychelles as part of the Silhouette Conservation Project and has been carried out occasionally on other islands; there is a need to establish more regular monitoring. Long term-monitoring and in-depth ecological research will be required to determine conservation needs for individual species but the island comparisons presented above indicate two main aspects that merit further attention: the role of tenrecs on Mahé and Praslin and protection of key sites. These key sites should be protected to ensure the survival of the most important populations, this is already in place for *Trachylepis wrightii* which has substantial populations on several Special Reserves and for the main populations of *Ailuronyx tachyscopaeus*, *A. trachygaster* and *Phelsuma s. sundbergi* which are found within the Praslin National Park, as is the only quantified population of *Lamprophis geometricus*. The main populations of the remaining species are not found within reserve areas; key gaps are Felicite (60% of the *Phelsuma sundbergi ladiguensis* population) and Silhouette islands (43% of *Lycognathophis sechellensis*, 42% of *Janetaescincus veseyfitzgeraldi* and 85% of *J. braueri*). The non-threatened reptile species are all present within existing reserves.

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