Distribution and conservation status of the Manapany day gecko, *Phelsuma inexpectata* Mertens, 1966, an endemic threatened reptile from Réunion Island (Squamata: Gekkonidae)

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Abstract: The Manapany day gecko *Phelsuma inexpectata* Mertens, 1966 endemic to the south of Réunion Island, is a threatened species currently closely associated with the coastal habitat, one of the most endangered ecosystem on the island. We investigated the extent and the evolution of its distribution and its population size and density. We found that the species is extremely restricted, with an extent of occurrence (EOO) and an area of occupancy (AOO) of around 6 km² and 1 km² respectively. Since 1995, several sub-populations have disappeared and the population size has dropped to between 3 000 and 5 000 individuals. We located 15 populations, severely fragmented by urbanisation, agriculture and invasive vegetation. This habitat loss and fragmentation is perceived as the most serious threat, followed by interactions with alien animals (predation/competition) and by environmental pollution. The species qualifies as Critically Endangered according to the IUCN Red-List Criteria. We propose a first conservation strategy to avoid the possible extinction of the Manapany day gecko.

Résumé : Le gecko vert de Manapany *Phelsuma inexpectata* Mertens, 1966 est une espèce menacée, endémique du sud de La Réunion. Ce lézard est aujourd'hui associé aux habitats littoraux, l'un des écosystèmes les plus menacés de l'île. A l'aide d'un échantillonnage des habitats favorables identifiés sur son aire de répartition, nous avons étudié l'étendue et l'évolution de sa distribution, mais aussi la taille et la densité de ses populations. Les résultats de ces travaux montrent que la répartition de l'espèce est extrêmement limitée, avec une aire d'occurrence (EOO) et une aire d'occupation (AOO) (voir méthodologie IUCN, 2001), respectivement d'environ 6 km² et 1 km². Depuis 1995, plusieurs sous-populations ont disparu. De plus, l'effectif total a fortement diminué : estimé entre 5 000 et 10 000 individus par Bour *et al.* (1995), celui-ci est actuellement compris entre 3 000 et 5 000 individus. Nous avons identifié 15 populations, très fragmentées par l'urbanisation, l'agriculture et les surfaces envahies de pestes végétales (principalement *Schinus terebinthifolius* Raddi). La fragmentation et la perte d'habitats naturels représentent les principales menaces qui pèsent sur l'espèce. Celles-ci sont suivies par la prédation et la compétition avec les espèces animales envahissantes, et les pollutions environnementales (traitements chimiques agricoles et lutte anti-vectorielle). La synthèse des résultats de cette étude permet de fournir une justification du statut de conservation UICN du gecko vert de Manapany, listé parmi les « espèces en danger critique d'extinction » (CR). Enfin, une première stratégie de conservation est également proposée pour éviter l'extinction de l'espèce.

Keywords: Manapany day gecko, population size, restricted area, threat, distribution conservation, la Réunion.

Mots clés : Gecko vert de Manapany, taille de population, habitat réduit, menace, distribution, conservation, la Réunion.

INTRODUCTION

The Indian Ocean Islands, especially the oceanic Mascarene archipelago, exhibit a unique fauna and flora with a high endemism rate (Cheke & Hume, 2008). Moreover, the south-west Indian Ocean area which includes the Mascarene Islands, is regarded as a biodiversity hot-spot (Myers *et al.,* 2000; Mittermeier *et al.,* 2005). Human colonisation, resulted in high extinction rates. For instance, la Réunion has lost 30 natives terrestrial vertebrate species since the European colonisation in the 17th century (Cheke, 1987; Probst & Brial, 2002). Numerous terrestrial conservation programs have been conducted in the Mascarene Islands, to try to stop this biodiversity erosion, especially on Mauritius and Rodrigues (Jones, 2008). Comparatively, little effort has been devoted to similar conservation problems in la Réunion. Restoration programs for species and habitat were initiated only very recently, especially for threatened birds (Salamolard & Ghestemme, 2004; Salamolard, 2008) and semi-dry forest (Truong, 2009).

According to Austin & Arnold (2006), the Mascarene Islands had the richest oceanic island reptile fauna in the World. On la Réunion only two species of terrestrial reptiles, among the seven original natives, have survived: the Manapany day gecko *Phelsuma inexpectata* Mertens, 1966 and the Forest day gecko *P. borbonica* Mertens, 1966 (Probst, 2002; Sanchez *et al.,* 2009). An indigenous species once considered locally extinct, the Bouton's Skink, *Cryptoblepharus boutonii* (Desjardins, 1831) has been relocated in 1999 (Honsterette & Probst, 1999; Probst & Deso, 2001). Its current presence on la Réunion is doubtful as it has not been seen since 2001 (Sanchez & Probst, 2009).

We investigate the distribution of *P. inexpectata*, a Critically Endangered species according to the Red List of threatened species in France (IUCN France & MNHN, 2010). There are few scientific studies about this gekkonid: Bour *et al.* (1995) defined its distribution on a 10 km long littoral fringe at an elevation lower than 250 m. The extent of the occupation was estimated to 5 km² and the greatest part of the observed population was situated around Manapany-les-Bains. Bour *et al.* (*loc.cit.*) described 31 sub-populations and estimated the whole population at between 5 000 and 10 000 individuals. In 2001, an introduced population was discovered at an elevation of 600 m in the district of le Tampon, some 25 km from its known natural range (Deso, 2001). In 2008, another sub-population was found on the Grand-Bois beach (district of Saint-Pierre) some 2 km from the past occidental limits of the species' range (Sanchez *et al.,* 2010). The species is currently confined to an 11 km long littoral fringe. However, we do not know the former distribution of the species: it could be possible that this distribution was larger, throughout the west coast (in coastal habitats, lowland savanna and lowland dry forest) and in an altitudinal limit at around 400 m (Sanchez *et al.* 2009).

Various authors have documented a population decline (Probst & Turpin, 1997) and a local extinction (Duguet, 2006; Sanchez *et al.,* 2009) since the last decade or so. The current gecko population appears to be very small and critically fragmented. Faced with that situation, it is now essential to evaluate the conservation situation of *P. inexpectata*. This study intends to accurately document the species' distribution and to estimate the population size based on data acquired since 2008. We discuss the possible explanation behind the gecko's restricted distribution, propose a first conservation strategy and provide evidence in support of the species` classification as Critically Endangered for both the Red List of threatened species in France, and the IUCN World Red List.

STUDY AREA

La Réunion (area: 2 512 km²) is a relatively young volcanic oceanic island (2–3 million years BP), located at about 700 km east of Madagascar and 200 km from Mauritius. Its steep relief

reaches 3 069 m in the centre (Piton des Neiges) and 2 631 m in the south-east (Piton de la Fournaise, the only currently active volcano of the island). The eastern (windward) side is exposed to abundant rainfall, from 1 500 mm on the coast to more than 8 000 mm in the mountains and locally up to 12 000 mm at an altitude between 1 300 and 1 900 m (Barcelo, 1996). On the more xeric western part (leeward side) rainfall is markedly lower, less than 1 000 mm along the south-western coast (Robert, 1986). The population of the island stands at about 800 000 inhabitants (Insee, 2009), with 80% of people living in the coastal lowlands (750 000 in 2003).

According to Lagabrielle (2007), 73% of the original native vegetation cover has been transformed by agriculture, urbanisation or other land uses and invasive species. The original intact vegetation is found at higher elevations (> 1000 m) and scarcely in lowland natural habitats (coastal habitats, lowland savanna, lowland dry forest, and lowland rainforest) (Strasberg *et al.,* 2005).

The potential area occupied by *P. inexpectata*, i.e. low-altitude habitats from Saint-Pierre to Saint-Joseph, between 50 and 250 m, (*Fig. 1*) has been much transformed by agriculture and urbanisation. The few natural coastal habitats (< 50 m) mainly located on the cliffs, are invaded by alien plants (mostly *Schinus terebinthifolius* Raddi and *Furcraea foetida* L.).

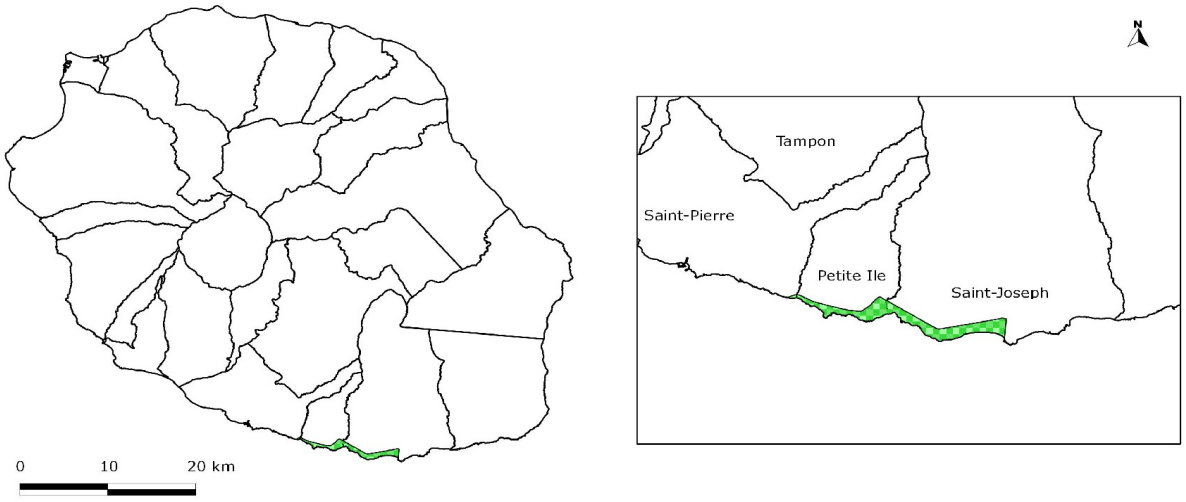

Figure 1. – Location of the study area (in green) on the south of la Réunion and with the district limits (black line) (extracted from Sanchez & Caceres (2011), with DEAL`s permission).

MATERIALS AND METHODS

Study species

Phelsuma inexpectata is a day gecko with a total adult length of 10 to 13 cm (*Fig. 2*). As other *Phelsuma* species (e.g.: *P. antanosy* Raxworthy & Nussbaum, 1993, *P. quadriocellata* (Peters, 1883), *P. lineata* Gray, 1842), it lives on screw pines *Pandanus sp.* (Lehtinen, 2002), represented by *Pandanus utilis* Bory (Pandanaceae) on la Réunion. These screw pines are frequently planted on the coasts areas as windbreaks (Deso *et al.,* 2008).

2a

2b

Figure 2. – The Manapany day gecko, *Phelsuma inexpectata 2a)* male, *2b)* female. Photos by M. Sanchez.

In natural areas, like the littoral cliffs, *P. inexpectata* occurs on the remnants of indigenous coastal vegetation (*Pandanus* thickets and *Scaevola taccada* / *Psiadia retusa* association). When the habitat is fairly open, it also survives on the exotic Agavaceae thickets (*Furcraea foetida*). In urban areas, it lives on planted *Pandanus* thickets / ornamental exotic plants association (Sanchez *et al.,* 2009).

Distribution study

Current distribution

The potential habitats occupied by *P. inexpectata* have been screened in the south of the island in February 2008 to evaluate the species` decline since 1995. We inspected a 12 km long littoral fringe from the Grand-Bois beach on the west, to the Pointe de Langevin on the east (*Fig. 1*). We focussed our research mainly on the population previously defined by Bour *et al.* (1995); other suitable habitats encountered were surveyed. A habitat (spot) was considered as suitable if it was characterized by the presence of Pandanaceae, Arecaceae and Agavaceae plant families. Each spot was prospected twice on two different days during sunny or partially cloudy weather. Each survey lasted between 30 to 60 minutes, depending on the extent of suitable habitat (Harmon *et al.,* 2007). Geckos and clutches were detected on visual cues using binoculars (10x42). A total of 106 spots were surveyed, during more than 100 hours. The introduced population of le Tampon, located in an inaccessible private property, was not sampled.

Population delimitation

We have defined a population as a functional entity that can contain several sub-populations not separated by physical barriers such as a road or large patches of unsuitable vegetation. The dispersion capacity of *P. inexpectata* is estimated at lower than 100 m in an unsuitable habitat. Two

sub-populations isolated by an important physical barrier, natural or artificial, were therefore considered as disconnected. Between April and June 2010, Dubos (2010) surveyed the same littoral fringe. He identified all suitable habitats and defined fix points of research (10 x 10 m) which were sampled during 5 to 15 minutes. Each point was geo-referenced and only gecko presence / absence data was noted. Complementary surveys were conducted in October 2010 by the first author. A total of 799 points were sampled, for 79 hours. Data were mapped with Q-Gis (2010, version 1.5.0.). The cartographic analyses allowed us to evaluate population connexions and to define boundaries.

Extent of occurrence (EOO)

The surveyed populations are mapped on a metric square grid (100 m²)[1]. According to the IUCN Red List methodology (2001), EOO is defined as the area contained in the shortest continuous imaginary boundary which can be drawn to encompass all the known sites of the occurrence of a taxon, excluding cases of vagrancy. EOO is measured by a minimal convex polygon which contains all the sites of occurrence. Here, the convex polygon excludes marine habitats not occupied by the gecko and the introduced vagrancy population of le Tampon.

Area of occupancy (AOO)

This variable is defined as the area in an extent of occurrence which is occupied by a taxon, excluding cases of vagrancy. Here, in accordance with the species biology, AOO is calculated by the sum of 100 m² squares that contain sub-populations.

Population size and density

From March 2008 to October 2010, the gecko's abundance and density were estimated in the occupied spots identified before. Two different methods were used for the population size.

Method 1

The size of *P. inexpectata*' populations located on planted lines of *Pandanus* thickets, was estimated using transects (50 or 100 m long). Geckos were counted along these transects using visual cues with the help of binoculars during 45 minutes for 100 m transect and 22 minutes and 30 seconds for 50 m (Lehtinen *et al.* (2003) adapted method): 29 transects of 100 m and 4 transects of 50 m were sampled during this study, for 23 hours and 15 minutes (1 395 minutes) of transect survey time.

Method 2

When field characteristics rendered the transect method unsuitable (cliffs, high inclines, dangerous fields or low station areas), all suitable supports were surveyed (tree holes and leaf axils of screw pines or other palm species). Each session lasted from 30 to 60 minutes depending on the extent of suitable vegetation surveyed. A total of 18 hours 24 minutes (1 104 minutes) of sampling was realised.

We used samples standardized by time effort and encounter rate (geckos/pers./hours) to provide indices of population density. For each research event, the number of geckos found was divided by the number of people searching and by the number of hours spent searching, to give a measure of geckos encountered per person per hour (Hofer & Bersier, 2001; Bullock *et al.,* 2002; Rovito *et al.,* 2009).

[1] Because *P. inexpectata* is an extremely sensitive species and that cartography of its restricted area is too specific, in order to prevent illegal collection, distribution mapping is not provided.

All counts were conducted during daytime from 08.00 to noon and from 14.00 to 18.00. Geckos shorter than 10 cm were defined as immature, the others were considered as mature. The size was estimated by eye, without involving capture.

RESULTS

Distribution study

Current distribution

Since 1995, a total of 12 sub-populations have disappeared. The local extinction has been mostly recorded in or near urban areas (< 50 m to habitation or road). This extinction concerns the restricted and isolated sub-populations but also two large coastlines longer than 500 m, very close to sugar-cane fields.

Populations delimitation

The distribution study and the cartographic analysis allow us to identify 15 distinct populations. All are located on an 11 km littoral fringe (< 200 m altitude) between Saint-Pierre (west) and Saint-Joseph (east): eight populations are located in or near urban habitats, while only seven were detected in the littoral cliff habitats where indigenous vegetation remains. The principal barriers between the populations are roads, sugar-cane fields and large patches of invasive plants.

Extent of occurrence

The surface of the minimal convex polygon which contains all the sites of *P. inexpectata* occurrence measures 6 km².

Area of occupancy

103 metric squares (100 m²) contain sub-populations, thus *P. inexpectata* approximately occupies an area measuring 100 ha or 1 km².

Table 1. – Phelsuma inexpectata *populations: total counts, adults, habitat type, sampling effort, encounter rate and survey method.*

Population	Counts	Adults	Habitat type	Sampling effort (min)	encounter rate (gecko/pers/h)	Method
1	8	8	Urban	45	10,67	2
2	64	48	Wild	587,5	6,54	1&2
3	22	12	Wild	60	22,00	2
4	3	3	Wild	35	5,14	2
5	6	6	Wild	60	6,00	2
6	73	61	Wild	369	11,87	2
7	95	57	Wild	142,5	40,00	1&2
8	1	1	Urban	75	0,80	1&2
9	7	7	Urban	45	9,33	1
10	210	143	Urban	495	25,45	1
11	11	9	Wild	135	4,89	1
12	5	3	Urban	22,5	13,33	1
13	38	24	Urban	75	30,40	1&2
14	62	43	Urban	202,5	18,37	1
15	26	12	Urban	150	10,40	2
Total	**631**	**437**	**-**	**2499**	**-**	**-**

Population size and density

A total of 631 geckos were observed, 437 (i.e. 2/3) were mature (Table 1). The number of observed geckos varied among populations, from less than 20 individuals (n=7) to more than 100 individuals (n=1). The encounter rate varying between 0.8 and 40 gecko/pers./hour (average=14.45; SD=10.90).

DISCUSSION

Distribution

Current distribution

P. inexpectata is mainly distributed along a 11 km littoral fringe of < 200 m elevation between Saint-Pierre and Saint-Joseph. This restricted distribution may represent a refuge after displacement by urban and agricultural pressures, which are particularly strong on la Réunion coast (Sanchez *et al.,* 2009). The destruction of native habitat for urbanisation and agriculture, seems to be responsible for this restricted distribution. This potential shift may be exacerbated by the invasion of alien plants, notably *Schinus terebinthifolius*.

This research revealed numerous local extinctions, mostly in the urban habitat. On these spots, although the suitable habitat is still present, it is often notably more degraded than during the Bour *et al.* study, in 1995. Among these extinctions, two were located on a stretch of littoral fringe longer than 500 m, between the sea and the sugar-cane fields. One of them was an important population with more than 100 geckos (Probst & Turpin, 1997). Urban populations seem to be more sensitive to the extinction than wild populations (mainly located on the littoral cliffs). This could be due to their highly damaged conditions, urbanisation pressures, more exposition to the pollution from crops (chemical insecticides and other contaminants) and to the abundance of exotic predators on the urban habitat (Courtney & Fenton, 1976; Thorington & Bowman, 2003; Sims *et al.,* 2008).

Extent of occurrence and area of occupancy

The Manapany day gecko`s EOO is very restricted, estimated to only 6 km². The AOO is even more limited, around 1 km².

Population size and density

The study of the population size has allowed us to observe only 437 mature geckos. Moreover, our survey shows that into around half of sampled populations (n=7), we have counted less than 20 individuals. Eight populations show a size above 20 geckos and among them only one (Manapany-les-Bains) had more than 100 individuals. The sampling effort by population is relatively low (22.5 to 587.5 minutes) and does not provide a comprehensive size sampling. The estimations of the population size based on usual methods such as capture–mark–recapture (CMR) or accumulation curve methods (ACM) only, would have given a better assessment of the sizes by sub-population (Wanger *et al.,* 2009). These sampling methods are different from the Bour *et al.* (1995) protocol, so it is difficult to identify increase or decrease of the size of a population. Moreover, knowing the dynamic of the population is important for future evaluations. The protocol and the results provided here could be used as a basis for a long-term survey of the population.

During field works it was difficult to survey all suitable habitats, one sub-population was on a private property and another was located on a remote cliff. Moreover, it was impossible to count all individuals of a population, so the total number of geckos observed here (n=631) is an underestimation of the population size. For example, Bullock (1986) estimated that when a count of

Phelsuma ornata Gray, 1825 is performed from the ground on Round Island (Mauritius), 30% of them are missed because located on the palm crown leaves (*Latania* sp.). A study done at Manapany-les-Bains, proved the importance of the survey hours in one transect: the number of observations can vary up to threefold (Sanchez, 2008, unpublished). We can suppose that by the transect method survey we miss up to around 66% of the total gecko population. In 1995, Bour *et al.* estimated that the total number of *P. inexpectata* was 5 000 to 10 000 individuals. Today, we can estimate that this figure is 3 000 to 5 000 individuals. According to the mature/immature ratio (2/3), the estimates give 2 000 to 3 300 mature geckos. Yet, a conservation priority is identified on a 2 km littoral fringe, where 3 populations (n°6, 7 and 10) i.e. 60% of all observed geckos (n=378) are concentrated, but also about 60% of all observed mature geckos (n=261).

The encounter rate is highly variable between sub-population (min-max=0.8-40 gecko/pers/hour). Gecko density does not seem to depend on the kind of habitat, because wild and urban populations can both show high densities. We can note that the encounter rate for one population does not mean the density of all its sub-populations. This is due to the gregarious behaviour of *P. inexpectata* and to the place availability (nest site, food, retreat site...). Some sub-populations often present a high density and all the others have a low one. According to Bullock *et al.* (2002), the encounter rate obtained by visual counts is always underestimated. Moreover, as the research effort was often low (min-max=22.5-587.5 minutes per population) and with only one sampling by population, this index is not representative of the real density: the number of observations along the same place can vary sharply, notably with the time of day, weather or season. This is especially true for the populations with a brief sampling time (i.e. pop. n°4 and n°12).

Threats

Fragmentation

The populations are severely isolated and the distribution appears strongly fragmented. Several populations are dissociated from the others, which are yet never very distant. The fragmentation is due to a physical barrier as agriculture areas, habitations, roads and the vegetation damaged by invasive plants. That concerns not only the small, but also the large populations. Such fragmentation may hinder gene flow between subpopulations and lead to inbreeding depression, and ultimately to the extinction of the isolated small populations. The small isolated populations are also more susceptible to demographic stochasticity (natural fluctuation in population change or sex ratio) and environmental stochastic events (natural catastrophe as hurricane, disease and parasite, climate change or increase of predation) (Primack, 1995).

Habitat loss

Historically, habitat loss has begun early with human colonisation. The lowland semi-dry savanna, with *Terminalia bentzoe* (L.) L.f. and *Latania lontaroides* (Gaertn.) H.E. Moore, which might have been a *P. inexpectata* native habitat (Sanchez *et al.,* 2009), has progressively disappeared, replaced today by urbanization, agriculture and by a secondary grassland dominated by fire-resistant grasses (Lavergne *et al.* 2004; Lavergne *et al.,* 2005). Moreover, according to Bory de Saint-Vincent (1804) (Lavergne, 2006), the endemic palm tree, *L. lontaroides*, was abundant in Saint-Joseph and widely used to build houses (Billiard, 1822; Lavergne *et al.,* 2004). In 1822, Billiard already noted that the savanna was damaged, with *L. lontaroides* becaming scarce (Billiard, 1822; Lavergne, 2006). Moreover, during the 19th century, the acreages of the sugar-cane fields increased dramatically, representing a large destruction of the habitat (Cheke & Hume, 2008). Currently, the most important endemic remnants of the palm population are located on the southern coast: Saint-Pierre, Petite-Ile and Saint-Joseph (Lavergne, 2006).

Today, the causes of the habitat loss are urbanisation and invasive plant species. The expansion of the sugar-cane cultivation is less problematic, because almost all the surfaces that could support sugar-cane crops are cultivated or inhabited on the distribution area of the species. Conversely urbanisation pressure is continuing. There are still projects for road and building development (as a hotel project) within the current range of *P. inexpectata*. The damage and loss of habitat, due to the expansion of invasive plant species constitute another major threat. Especially, the invasion by *Schinus terebinthifolius* leads to displacement of the suitable native vegetation for the gecko, hence loss of habitat (Sanchez *et al.,* 2009). Because of the invasive plants, during the last ten years, the damage of the habitat has increased and some *Pandanus* tickets have disappeared or have been reduced in area (*Fig. 3*). Currently the suitable habitats are very restricted, often smaller than 100 m². On another scale, poaching of *Pandanus* thickets contributes to habitat destruction.


3a


3b

Figure 3. – Examples of coastal cliff habitats: *3a)* a well preserved indigenous vegetation and *3b) Pandanus* thickets invaded by *Schinus terebinthifolius*. Photos by M. Sanchez.

Other threats

Other threats include predation and competition by alien animals (principally mammals, birds and reptiles) (Deso & Probst, 2007), but also environmental pollution in the form of the chemical insecticide used to control the chikungunya vector, and the agricultural practices. According to Probst & Turpin (1997), an important population located in Saint-Joseph has probably disappeared after agricultural pesticide or biocide sprayings.

Limiting factors

Understanding the factors that have driven the decline and that are currently preventing population expansion, is an essential point to provide actions for an adequate conservation. Compared with the closely related Ornate Mauritian gecko, *Phelsuma ornata,* the Manapany day gecko has occupied a small range of natural habitat (Sanchez *et al*., 2009). Today, because of the expansion of invasive plant species, the indigenous suitable vegetation (*Pandanus* thickets, *Scaevola taccada* / *Psiadia retusa* association) is scarce, and it seems difficult for the small gecko sub-populations to survive, on these restricted patches, particularly given the other concomitant pressures such as predation by and competition with alien species. Thus, the first identified limiting factor is the quality of habitat and the second factor is the predatory and competition pressures.

Main results and conservation status

Here, the main results of the studies are synthesized and the IUCN conservation status is discussed.

Main results

Concerning the distribution of *P. inexpectata*, the extent of occurrence (EOO) is estimated to be less than 100 km², restricted to 6 km², and the area of occupancy (AOO) is limited to 1 km². The populations are located in natural and urban habitats. These populations are fragmented by urbanisation, agriculture and damaged habitat. Moreover, the species is threatened by predation and competition by invasive animals, and by chemical pollutions. The research shows a continuing decline of the occupied locations.

IUCN conservation status

The Manapany day gecko has been listed as Critically Endangered according to the IUCN's Red List criteria (IUCN France & MNHN, 2010), based on the 2001 and 2003 guidelines (IUCN 2001, 2003) with the author's first data, available on December 2009. The results supplied in this work confirm this classification and give an argument for the criteria and sub-criteria used (B1ab (ii,iii,iv) + B2ab (ii,iii,iv)) and exposed below :

B. Geographic range in the form of both B1 (EOO) and B2 (AOO):

1. *Extent of occurrence is less than 100 km²,*
2. *Area of occupancy is less than 10 km²,*
   and field observations indicate:
   - *a. Severely fragmented*
   - *b. Continuing decline observed in:*
     - *(ii) area of occupancy,*
     - *(iii) area, extent and quality of habitat,*
     - *(iv) number of locations.*

The Manapany day gecko is an endemic species for la Réunion. So, we propose the Critically Endangered status for the IUCN World Red List.

Conservation strategy

The Manapany day gecko survives in a short and thin littoral fringe in a natural and, more often, in an urbanized habitat. In this complex and particular context, three axes of priority for its conservation can be defined: (1) securing habitats, (2) stopping habitat losses, (3) preventing and reducing the predation and competition pressures. These axes are classified according to the urgency.

(1) A conservation priority is identified on a 2 km littoral fringe which encompasses a substantial part of the total population. The protection of this littoral fringe is the most important objective of the conservation strategy. Confronted by the urgency, a secured reserve must be rapidly created. The "Arrêté Préfectoral de Protection de Biotope" reserve principle (Degryse, 2004), could be an adapted regulation tool in this conservation context. This tool can regulate all the actions that can be injurious for the habitat of the gecko (installation of infrastructures or roads, new negative activities of leisure etc.) and it does not depend on political changes.

(2) In order to preserve a global distribution and to retain all populations, it is necessary to stop habitat loss, mitigate fragmentation and, on the longer-term, reconnect the populations. In the natural habitat, a restoration program of native littoral vegetation is necessary. Restoration programs of the littoral vegetation have recently begun in la Réunion (Triolo & Zoogones, 2009; Zoogones & Triolo, 2009) and appear promising (J. Triolo *pers. comm*.). Moreover, in the cliff habitat, such an operation could prove less amenable. In view of the hazard of the present planning in urban area, it is important to preserve and to restore the wild populations, or at least the largest of them. In the urban areas, it is essential to conserve and to promote the suitable habitats. Here, this objective could succeed through a consistent and voluntary town plan by the municipalities concerned by the gecko survival: Saint-Pierre, Petite-Ile and especially Saint-Joseph which contain most of the urban populations. This plan should consist in the preservation and the rehabilitation of the gecko habitat by a promotion of the indigenous suitable vegetation in the green urban space. In this step, a public sensitization and involvement in the gecko survival are essential. In the short term, such a policy would help avoid the waning of the gecko populations. In the long term, this voluntary policy of conservation could permit the creation of ecological corridors between the disconnected sub-populations.

(3) The last important point for the conservation of the Manapany day gecko is the prevention against dramatic events as new introductions of invasive predators/competitors or a local stochastic decline. Numerous exotic species are frequently introduced into the natural habitat (mammal, bird and reptile) and some of them are acclimated today (Probst, 1997; Guillermet *et al.,* 1998; Cheke & Hume, 2008; Sanchez & Gandar, 2010a). Coming from merchandise or ranch escapes, these invasive animals could represent an important threat for the Manapany day gecko. Among the acclimated reptiles which can compete with or predate on *P. inexpectata*, the introduced *Phelsuma* species (as Broad-tailed Day Gecko, *P. laticauda* (Boettger, 1880) and Giant day gecko, *P. grandis* Gray, 1870) and an Agamid (Rainbow lizard, *Agama agama* L., 1758), are in constant expansion in la Réunion. The introduction and the expansion of these invasive species in the *P. inexpectata* range could be catastrophic. *P. grandis* and *P. laticauda* have been introduced in the *P. inexpectata* area, but rapidly controlled and removed (P. De-Vos, *pers*. *comm.*; Sanchez & Gandar, 2010b). Currently, the impact of these new predators and/or competitors on the *P. inexpectata* distribution is unknown. Furthermore, the loss of the last important populations of *P. inexpectata* could signify the extinction of the species in the wild; so, it appears necessary to monitor the population. This survey would help in preventing the decline of *P. inexpectata* or spread of newly introduced invasive species, and if the need arises, to rapidly initiate conservation actions (securing mature geckos, providing artificial nests, controlling invasive species, etc.).

CONCLUSION

The Manapany day gecko *Phelsuma inexpectata*, is facing an extremely high risk of extinction in the wild and could become extinct in the next 100 years. When, among the seven species of native terrestrial reptiles, four are regarded as extinct, the *P. inexpectata* survival appears as a major stake for the conservation of la Réunion`s fauna. Moreover, like the Mauritian *Phelsuma* species (see Hansen *et al.,* 2006; Hansen *et al.,* 2007), *P. inexpectata* has an important role in its habitat: it is known to probably contribute to the pollination of threatened plants and to the seed dissemination (Deso *et al.,* 2008; Sanchez & Lavergne, 2009). If nothing is done, *P. inexpectata* could disappear and with it, the sum of interactions which contributes to maintain the ecosystem. In order to realize the conservation strategy proposed here, a recovery program like a "Restoration Plan", the "Plan National d'Action", must be rapidly conducted to avoid the species extinction (Sanchez & Caceres, 2011). With a particular urban distribution, the survival of the species will greatly depend on the policy plan and the inhabitants` active involvement. Thus in the future, the municipalities of Saint-Joseph and Petite-Ile will have a capital role in the conservation of the Manapany day gecko.

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