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Distribution of the forest nocturnal reptiles of Anjouan Island, their main habitats significances and conservation status

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Abstract

Comoros contains a unique diverse fauna and flora such terrestrial as marine. One of the 4 islands of the archipelago, Anjouan has fragmented forests surely inhabited by endemic animals and plants. The preliminary information from diverse authors on the reptilian biology and ecology is spread away. The data on the nocturnal reptiles' distribution and habitats are rare because the studies done on them are not published. So, to determine the features, the distribution, the density, and the conservation status of the nocturnal reptiles of Anjouan Island, field researches have been conducted there from March to June 2011 in 17 sites. By means of different methods such as method of transect surveyed and point mark of the reptile location with GPS in the forests, the following results are obtained. One hundred and fifty eight individuals of nocturnal reptiles have been identified. They belong to 2 families and 5 genuses. One species of one genus belongs to one family Colubridae which is *Lycodryas sanctijohannis*. And all 4 remaining genus belong to the family of Gekkonidae with 6 species which are *Hemidactylus platycephalus, H. mercatorius, H. brooki, Geckolepis maculata*, *Paroedura sanctijohannis* and *Ebenavia inunguis*. They are nocturnal, cathemeral and diurnal. They are distributed all over the 17 sites in a heterogeneous way, dwelling in different altitudes and habitats. On the 21 indigenous Comorian reptiles, 6 unknown species and 8 identified ones have been found in Anjouan. Among these last only 2 are endemic in the Comoros. Nocturnal Comorian reptiles are threaten by deforestation.

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Introduction

Reptiles are known owing to their role and their natural balance (Louette *et al*., 2004, Meirte, 2004), their use in teaching physiology and anatomy (turtles and Red-eared sliders), in the investigation effects of microgravity on orientation (turtles) (MORI, 1995), in investigation into stress and behavior (lizards), in chemoreception and behavior studies (snakes), in production of antivenins and therapeutic agent (snakes), in neuroanatomy and neurophysiology (crocodiles), in the production of artificial blood and perfection of trans myocardial perfusion technique (alligator) (Dyer, 1995). Reptiles are divided into two lineages: Anapsida and Diapsida. Which includes lizards, snakes crocodiles and so on (Dorcas, 2002), Lizards and snakes are the largest group of reptiles represented with more than 5000 species in worldwide (Dorcas, 2002). Reptiles are distinguished from other vertebrates by a waterproof skin because it has an outer epidermal layer cornea forming welded scales or plates (Huey, 1982), and most of reptiles are oviparous except some species of snakes and lizards bogs which are essentially ovoviviparous (Meirte, 2004). Reptiles' body temperature varies and depends on their environment, unlike mammals and birds that regulate their temperature by internal physiological processes (Sartorius, 2002). They tend to prefer worm temperature for the reproduction, growth, immune function and digestion (Dorcas and Schumacher, 2002, Sartorius *et al.,* 2002). Although each species has a body temperature characteristic value and is genetically adapted to different environmental conditions ranged at which it should be maintained. In temperate regions they hibernate during cold weather (Vences *et al.,* 2001, Hawlitschek, 2008). Some species, when they are active, maintain their body at a higher temperature (Boulenger, 1885, CARRETERO, 2005**,** Arnold, 2008). (Ergo and De Halleux, 1984, Greenbaum *et al.,* 2007) have reported that some species of reptiles are resistant to cold and moisture and they can get active at lower temperatures than others. This is explained by the presence of molecules that play a role in their antifreeze san (Günther, 1879b). Typically these individuals have a dark color which facilitates the rapid warming of their blood during exposure to sunlight, especially during the clear days of winter or spring (Manley, 1970, Huey, 1982).

Comoros situated in Indian Ocean is one of zones which the biodiversity still higher and threatened (Abdourabi *et al.,* 2009). Comoros Islands contains unique fauna diversity, marine and terrestrial and other diverse natural patrimony by dint of his topography and heterogeneity of its ecological conditions (Louette *et al*., 2004, MDDR, 2006). Comorian flora is estimated contain over 2000 species (Adjanohoun *et al.,* 1982a, Adjanohoun *et al.,* 1982b) and has a great similarity with that of Madagascar and East Africa. Comorian flora is rich within endemism rate considerably higher and balanced (Douzery *et al*., 1999, la CROIX *et al*., 2002, Hermans and Bosser, 2003, Andiliyat, 2007, Fischer *et al.,* 2007, Hawlitschek, 2008, Micheneau *et al.,* 2008, Anllaoudine, 2009, Martos *et al.,* 2009, Droissart *et al.,* 2010, Rakotoarivelo *et al.,* 2013, Hervouet *et al.,* 2014). However, Comorian fauna is poor in large mammals, but all zoological groups are represented (Turlin, 1994, Paris, 1999, Louette *et al.,* 2004, Andiliyat, 2007, Anllaoudine, 2009). The Comoros Islands constitute the habitat of some unique species, emblematic which have an international scientific interest. Such us sea turtles dugong, the lemur mongoz the fruit bat Livingstone the Coelacanth, whales, Dolphins and sea cucumbers (Pellegrin, 1933, Beudard, 2003, 2005, Keith *et al.,* 2006). Comorian fauna includes 11 mammals' species with 2 endemic species, 64 species of birds 101species of butterflies (Chakira *et al.,* 2015)and 28 species of reptiles (El-yamine, 2012). Among terrestrial Comorian reptiles, 13 out of 28 (46.4%) recognized species are endemic, but most of the non-endemics are introduced; if only native species are taken into account, endemism rises to 76.5% (El-yamine, 2012). For conservation issues, Comoros ratified almost all international conventions for environment and natural resource protection such us Convention of Biodiversity.

It was reported that generally reptiles are well installed in Comoros (Censky *et al.*, 1998, Carranza *et al.,* 2000, Hawlitschek, 2008). However compared to the similar system of the islanders, the Comorian herpetofauna is poor and unbalanced (Carretero and Harris, 2005). From the beginning of the 20th century, this fragile and endemic Comorian biodiversity attracted little attention from scientists, counter to the biodiversity of Madagascar which knows very extensive research (WHITING *et al.,* 2004). Data sampled by searchers, large party of have not been revised and local data are often inaccurate or incorrect (Hawlitschek, 2008).Thus, Information about description of Comorian reptiles taxonomic, biological and ecological are dispersed, Consequently remain unknown, whatever they have been treated and written by several authors such as (Günther, 1879a, Günther, 1879b, Boulenger, 1885, 1887, Boulenger, 1893, Boulenger, 1896, Glöer *et al.,* 1980, Meier, 1986, Meier and Theakston, 1986, Meirte, 1992, Meirte, 1993, Köhler *et al.,* 1998, Nussbaum and Raxworthy, 1998, Louette *et al.*, 1999, Vences *et al.,* 2003, Louette *et al.*, 2004, Vences *et al.*, 2004, Rocha *et al.,* 2005a, b). However it still known that five classes are present in the Union of Comoros: Geckkonidae (Geckos), Iguanidae or Opluridae (Iguanas, Inoles), Chameleonidae (Chameleons) and Scincidae (Skinks) and Agamidae (Louette *et al.,* 2004, Meirte, 2004, Hawlitschek, 2008). Comorian's snakes are poor and represented by just two classes, Colubridae and Typhlopidae (Louette *et al.,* 1999, Hawlitschek, 2008, HAWLITSCHEK and GLAW, 2013). This present work aimed (i) to update Comorian herpetofauna in number and species, (ii) to study the distribution and investigate the nocturnal reptile's habitat in Anjouan Island.

Materials and methods

Site selection

Anjouan locally called "Ndzouani" is one of the Comoros Union Island located on east of the country within 424 km² (Hawlitschek, 2008). Comoros Island are located in the Western Indian Ocean (WIO) at the northern entrance to the Mozambique Channel, about 300 km from the African coast and the northern tip of Madagascar between 11° 20' and 13° 04' south latitude and 43 14' and 45 ° 19' east longitude (Andiliyat, 2007, Rakotoarivelo *et al.,* 2013) (fig. 1).

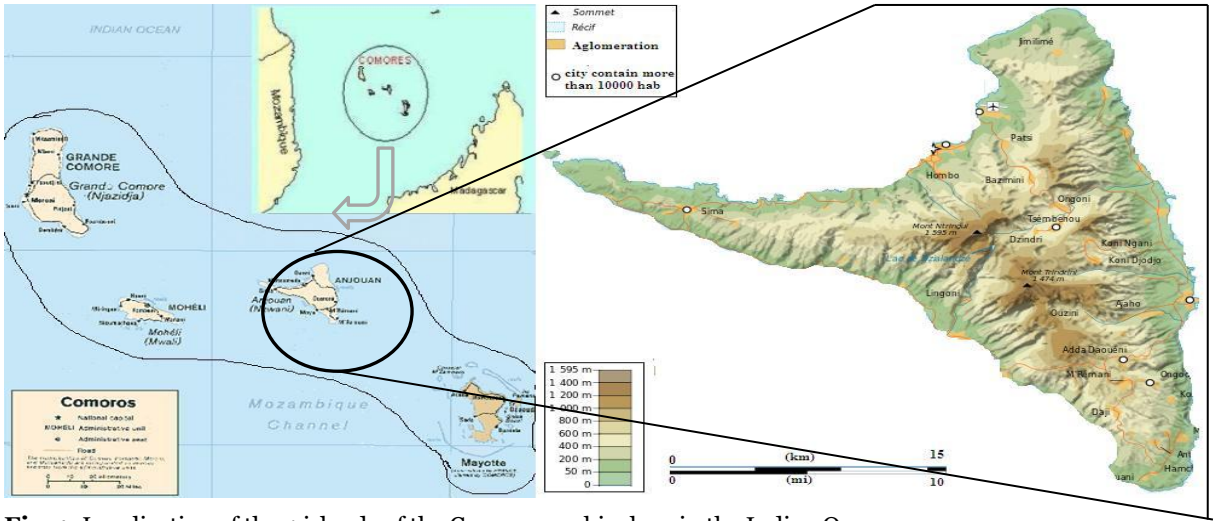


Fig. 1. Localization of the 4 islands of the Comoros archipelago in the Indian Ocean**.**

On the Geochronology plane, the most recent data for the age of the islands show that Anjouan appeared there is 5.40 million years ago (Emerick and Duncan, 1982, Nougier *et al.*, 1986). Comoros islands are the most recent land of the globe (WHC-UNESCO, 2010). Anjouan is characterized by two seasons: a hot/humid season and dry/cold season. Main temperature is around 25° C in high altitude and 28° C in low altitude during the year. It decreases with altitude about 0.7° C per 100m(Battistini and Vérin, 1984,

Ergo and De Halleux, 1984). In Anjouan, the average annual rainfall varies from 1371mm to 3000mm in the central area of the island (Ergo and De Halleux, 1984, Hawlitschek, 2008). The rivers have their source in the highlands (WTTC and IFTO, 2004). The lake Dzialandzé within 50000 square meters and a depth greater than 300 situated in this Island is the biggest in the Comoros Union. One other lake "Dziya Lautsunga "with an area of 20000 square meters and around 200 m of depth is also one of the lakes of this Island. In this island we can also mention on the southwest coast, the existence of a swamp area which 0.2 ha of area and 0.20 m of depth (WTTC and IFTO, 2004, WHC-UNESCO, 2010).

Data collection method

Nocturnal reptiles, abundance data and habitat data were collected using visual transect surveys at each site (Ganzhorn 1994, Rasolofoson *et al.,* 2007a, Rasolofoson *et al.,* 2007b). The area was scanned within walking at a constant speed of 0.4 km / h in a long transect of 1200m and 5 m of large, crossing all different types of micro-habitats and altitudes (Vitt *et al.*, 1997, Whitfield and Pierce, 2005). Time spent identifying species was not counted. The orientation and shape of transects were often dictated by roads, in which case it was walked once on each side. Each site was surveyed once during the night from 19h to 23h from March to June. Surveys were varied to accommodate the range of conditions in which different species were active (temperature, wind, cloud cover, rainfall). Unidentified reptiles were not included in abundance estimates.

The method of any occurrence (Altmann, 1974) recommends that when an individual of reptile was met, we stopped and noted the variables such us habitat type, meeting time, species name geodesic coordinate, number of individuals view, distance in the transect, support type, temperature, fog percentage. After detecting individual using torches, the identification of species was making by looking the references records containing different reptile species already known.

Data Analysis Tools

The digital data analysis was made using Microsoft Excel 2013 and statistical data analysis within STATISTICA 6.0 and SPSS.16 software followed by the Duncan test between the means of treatments to determine significant differences. The significance difference between means was tested at $P<0.05$.

Spearman correlation test

The correlation test of Spearman was used to calculate statistically and to test the linear correlation between two independent random variables measured on the same individuals. And it is suitable for small samples with an effective $5< n < 31$. This correlation is very strong when $rs \rightarrow +1/-1$ and nonexistent near 0. The higher level risk α is always defining before the calculation and is generally equal to 0.05.rs is calculated using the following formula

$$rs = 1 - 6 \sum_{i=1}^{n} \frac{di^2}{n^3 - n}$$

n = number of values for each variable

di = difference in rank values

The value of this coefficient is compared with the rs values in the Spearman table for risk $\alpha = 0.05$ and for n value corresponding to. If the calculated coefficient rs is greater than the value in the table, the two variables are correlated, otherwise, they are not.

Khi Test (χ2)

The Khi test was used to test the independence between the two variables observed in several samples. Hypothesis h_0 supposed variables are independent, while hypothesis h_1 supposedthe opposite i.e. variables are related. If the Khi calculated or observed is higher than theoretical Khiread in the table, with threshold defined in advance, h_0 is rejected. The value of χ^2 in this approach is distributed with a freedom degree (d.d.l= (k- 1), ℓ - 1), which ℓ is the lines, number and *k* is the columns number

$$X^2 = \sum_{i=1,j=1}^{k=l} (Oij - Tij)^2/T - x$$

Oij is the observed frequency for the i[th] line and the i[th]column, *Tij* is theoretical frequency under the null hypothesis of the i[th] line and the i[th] column.

Results

Abundance relative

158 individuals of nocturnal reptiles were collected and identified in fifty two transects accrued in over the whole forest of the Island (table 1). In 17 invested sites, individuals encountered belonging to two families Colubridae, and Gekkonidae within 6 genus and 10 species which are nocturnal and 3 diurnal. Colubridae was represented by only one genus and one species *Lycodryas sanctijohannis* (*Ls*). This species was found in four different places and represented by only one individual in each location. Three of these four locations are all in west of the island from north to south and at different altitude ranging from 15m to 504m.The second family, Gekkonidae, is represented by five genus and 6 species. The genus Hemidactylus with 3 species is the most encountered includes 68 individuals and represent 43% of the total number of nocturnal reptiles encountered. *Hemidactylus platycephalus* (*Hp*) is the most abundant represented 82% of total individuals of this genus. This species was found in 9 sites out 11 containing at least one reptile individual. These nine sites distributed mainly in the south west of the island and at different altitude ranging from 5m to 686m.

Paroedura was the second genus of Gekkonidae found within one specie *Paroedura sanctijohannis* (*Ps*). This species was the second most abundant species represented30.19% of total individuals found in 7 sites out11 containing nocturnal reptiles. These individuals are spread all over especially in the south west and also at altitude ranging from 5m to 686m. Geckolepis was represented by only *Geckolepis maculata* within 30 individuals represented 19% of the total individual's number found. *Geckolepis maculata* is found in 4 sites out11, distributed mostly in the west from north to south at altitude ranging from 5m to 109m.1 to 4 individuals for 3 other species were seen sporadically in one of the six sites where encountered three abundant species were found. These three species belong to two identified families Colubridae and Gekkonidae and 3 different genus Lycodryas the only snake encountered and Ebenavia. Six other sites of 17 (more than 35%) seem to contain any reptile. This could be explained by the fact that the observations were carried out during the cold/dry period when the majority of species are in hibernation. It has been seen that individuals are sighted at different altitudes ranging from 5m to 686m and the most populated site in reptiles, containing 71 of 158 individuals (45%) is Dar-es-Salaam located at 109m above sea level. The Spearman correlation test demonstrated that the altitude is not correlated with the abundance of reptiles in the observation period (rs = -0, 2079, n = 14).

Table 1. Reptile's species encountered in the whole studied sites.

Site	Species										Altitude	Cardinal point	Total
	L.s	*H.p*	*P.s*	*G.m*	*H.m*	*T.c*	*H.b*	*E.i*	*P.l*	*P.v.v*			
Dar-es –Salam	1	18	20	25	5	1	0	1	0	0	109 m	SW	71
Ongoni	0	11	2	1	0	0	0	0	0	1	5 m	NE	15
Lingoni	0	4	4	2	3	1	0	1	0	0	74 m	SW	15
Bazimini	1	0	9	0	0	1	0	0	1	0	504 m	NW	12
Nindri	0	3	2	2	0	0	4	0	0	0	24 m	SW	11
KoniNguani	0	1	8	0	0	1	0	0	0	0	686 m	CE	10
Nkozini	0	8	0	0	0	0	0	0	0	0	15 m	SW	8
Kowet	1	3	0	0	0	0	0	0	0	0	15 m	SW	4
Jandza	0	6	0	0	0	0	0	0	0	0	389 m	SE	6
Hajoho	1	2	0	0	0	0	0	0	0	0	30 m	NE	3
Pagé	0	0	3	0	0	0	0	0	0	0	5 m	CW	3
Dzialandzé	0	0	0	0	0	0	0	0	0	0			0
Hombo	0	0	0	0	0	0	0	0	0	0			0

Site	Species										Altitude	Cardinal point	Total
	L.s	*H.p*	*P.s*	*G.m*	*H.m*	*T.c*	*H.b*	*E.i*	*P.l*	*P.v.v*			
Mjimadra	0	0	0	0	0	0	0	0	0	0	490 m	SW	0
Outsa	0	0	0	0	0	0	0	0	0	0	687 m	SE	0
Trindrini	0	0	0	0	0	0	0	0	0	0			0
Ouzini	0	0	0	0	0	0	0	0	0	0	665 m	SW	0
Total general	4	56	48	30	8	4	4	2	1	1			158

L.s (Lycodryas sanctijohannis), H.p (Hemidactylus platycephalus), P.s (Paroedura sanctijohannis), G.m (Geckoloepis maculata), H.m (Hemidactylus mercatorius), T.c (Trachilepis comoriensis, H.b (Hemidactilus brooki), E.i (Ebenavia inunguii), P.l (Phesuma laticoda), P.v.v (Phesuma v nigra v niigra).

Density of reptiles

The three species found in 4-9 sites of 11 are explained by their respective estimated density in 11 sites. In the table 2 are represented the results for the density of reptiles encountered. The 3 most abundant species are, 28, 13 and 4 times more dense than the 7 other species, ranging from 302.7±1.02 in d/km²; 259.46±0.6 ind/km² 162.16±1.01 ind/km² respectively, while for the 3rarest, their density is ranging from 10.81±0.01 to 12.62±0.3 ind/km² which are *E. inunguii*, *H. brookii* and the snake *L. santijohannis* respectively. It is to note for this results that, in 1 km² 23 individuals of *H. platycephalus*, can be found before finding an individual for *E. inunguii, L. sanctijohannis* or *H. brookii*; or find 6 individuals of *P. santijohannis* before finding an individual of *H. mercatorius*. Contrariwise in 1km², may be encountered at the same rat one individual of *H. platycephalus* and one individual *P. santijohannis*. We can also find 2 individuals of the latter 2 above species before finding 1individu of *G. maculata* in this same area.

Table 2. Density for each species encountered.

Species	Density (ind/km²)
H. platycephalus	302,7±1.02
P. santijohannis	259,46±0.6
G. maculata	162,16±1.01
H. mercatorius	43,24±0.5
H. brooki	12,62±0.3
L. sanctijohannis	12,62±0.02
E. inunguii	10,81±0.01

Abundance index

The relative abundance index of the seven denser species of reptiles is represented in the table 3. *G. maculata* is the most abundant in Dar-es- Salaam following by *P. sanctijohannis* and *H. platycephalus* with an abundance index P = 0.35,P = 0.28 and P = 0.26 respectively. Obviously if they are found more often, it is because they are the most abundant compared to other species. Indeed *E. inunguii* and *L. sanctijohannis* seem to be less abundant in this site with P = 0.1 each other. As Dar es Salam, Lingoni and Nindri are rich sites in species within respectively 5 and 4 species. *P. sanctijohannis*, *H. platycephalus, H. Brookii*within P = 0.28, P = 0.28 and P = 0.36 respectively are most abundant in those two sites. Nindri, is the only site where the last specie was more abundant than the other 3 mentioned above. Consequently nocturnal reptile's species are distributed heterogeneously in all sites where the studies were conducted.

The average abundance index summarizes the abundance of species from one another in all the study sites. The Table 4 shows that *H. platycephalus*is the most abundant in all sites following by *P. sanctijohannis* which is also following by *G. maculate* within an abundance index P = 0.36,P = 0.32 and P = 0.2 respectively. *H. mercatorius, H. brookii* ,the snake *L. sanctijohannis* and *E. inunguii* are less abundant in all study sites within an abundance index ranging from P = 0.013 to 0.026.

Activity's time

The result found in the present study shows that usually reptiles are most active between 19h to 23h.

The fig. 2A shows that between 19h and 21h the number of individuals decreases gently, to be abrupt between 21h and 22h. The number of active individuals of any species diminishes more and more towards 23h. However each species has preference characteristic time value genetically adapted to different environmental conditions. The fig. 2B present the activity time for nocturnal reptiles found. *H. platycephalus* was found any time even in a small number.

Table 3. Abundance index for each species in studied sites where it was encountered.

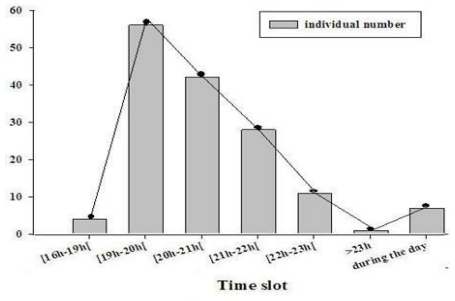
Sites	Species														Total
	L.s		*H.p*		*P.s*		*G.m*		*H.b*		*Hm*		*E.i*		1
	N	P	N	P	N	P	N	P	N	P	N	P	N	P	1
D-e-S	1	0.01	18	0.26	20	0.28	25	0.35	0	0	5	0.07	1	0.01	1
Ong	0	0	11	0.76	2	0.17	1	0.07	0	0	0	0	0	0	1
Ling	0	0	4	0.28	4	0.28	2	0.15	0	0	3	0.21	1	0.05	1
Baz	1	0.1	0	0	9	0.9	0	0	0	0	0	0	0	00	1
Nindri	0	0	3	0.28	2	0.18	2	0.18	4	0.36	0	0	0	0	1
Ko Ng	0	0	1	0.12	8	0.88	0	0	0	0	0	0	0	0	1
Nkoz	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
Kowet	1	0.25	3	0.75	0	0	0	0	0	0	0	0	0	0	1
Jandza	0	0	1	1	0	0	0	0	0	00	0	0	0	0	1
Hajoho	1	0.34	2	0.66	0	0	0	0	0	00	0	0	0	0	1
Pagé	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1

D-e-S (Dar-es-Salam), Ong (Ongoni), Ling (Lingoni), Baz (Bazmini), Ko Ng (KoniNgani), Nkoz (Nkozini).

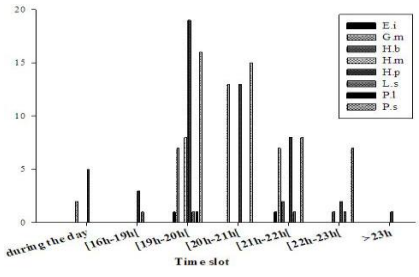
Table 4. Abundance relative per species in the whole studied sites.

	Species						
	L.s	*H.p*	*P.s*	*G.m*	*H.b*	*Hm*	*E.i*
P	0.026	0.36	0.32	0.2	0.026	0.05	0.013

We can suppose that this species is a cathemeral species. *H. platycephalus* and *G. maculata* were seen even during the day between 9a m to 12 p m. *G. maculata* and *P. sanctijohannis* are both active between 19h and 22 h. However *G. maculata* seems to stop beyond 22h, while *P. sanctijohannis* still active until 23h. *H. brooki, H. mercatorius and E. inunguis*are less represented in number in fact the results for these three species are statistically small, it is more appropriate to exclude them results for the different parameters following like the distribution according to habitat. Although those for *L. sanctijohannis* will be kept to get an idea about the distribution of the unique species of snake found in the island with some reservation for their meaning.



A



B

Fig. 2. Time activities for nocturnal reptiles.

Distribution according to habitat type

Nocturnal reptiles are more abundant in agro forestry within 52% of the total number of encountered reptiles compared to others three types and plantations contain the least within 13%. Natural forest contains a considerable number of reptiles, 26%of the total number of reptiles found in the whole Island fig. 3.

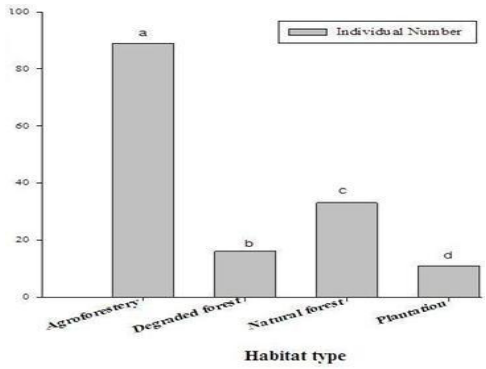


Fig. 3. Distribution of nocturnal reptiles in the four habitat types differing letters denote significant differences ($p<0.05$).

However the four most abundant species of nocturnal reptiles have each its preferred habitat type. *H. platycephalus* frequent all the different classes of habitat, for the 9 sites where it was found. Agroforestry seems its preferred habitat wherethis specie is represented with 59% of the total individuals found, as it fits well in plantation with 29%. Natural forest and degraded forest are less frequented by this species within 3% and 9%respectively. This suggests that *H. platycephalus* is landscaped environments instead of natural environments specie.

P. Sanctijohannis frequent all the different classes of habitat for the 7 communities which it invests with various preferences. Natural forest and agroforestry are the favorite with 38% and 31% of individuals respectively and plantation is less crowded with 6%. *P. sanctijohannis* is also well suitable in the degraded forest with 25% of individuals. Therefore, this species is essentially forest.

Table 5. Distribution of each species in the four habitats types.

H. platycephalus

Habitat type	D-e-S %	Ong %	Nkoz %	Jand %	Ling %	Kowet %	Nind %	Haj %	K.Nga %	Total
Agroforestry	73	73	0	100	25	67	0	100	100	59
Plantation	6	9	100	0	75	33	67	0	0	29
Degraded forest	22	0	0	0	0	0	33	0	0	9
Naturel forest	0	18	0	0	0	0	0	0	0	3
Total number	18	11	8	6	4	3	3	2	1	56

P. sanctijohannis

Habitat type	D-e-S %	Baz %	K.Nga %	Ling %	Nindri %	Ong %	Page %	Total
Agroforestry	40	0	63	0	50	0	33	31
Plantation	0	0	12	0	0	0	67	6
Degraded forest	10	100	0	0	50	0	0	25
Naturel forest	50	0	25	100	0	100	0	38
Total number	20	9	8	4	2	2	3	48

G. maculata

Habitat type	D-e-S %	Ling %	Nindri %	Ong %	Total
Agroforestry	48	100	100	100	57
Plantation	0	0	0	0	27
Degraded forest	32	0	0	0	16
Naturel forest	20	0	0	0	0
Total number	25	2	2	1	30

L. sanctijohannis

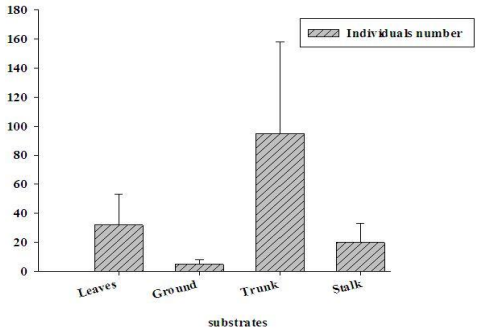
Habitat type	D-e-S %	Baz %	Haj %	Kowet %	Total
Agroforestry	0	100	100	100	25
Plantation	0	0	0	0	0
Degraded forest	100	100	0	100	75
Naturel forest	0	0	0	0	0
Total number	1	1	1	1	4

G. maculata in the four localities where it was found, agroforestry is its favorite habitat with 57% of individuals encountered for this species, degraded forest and natural forest are frequented respectively within 26.67% and 16.67% of the individuals encountered. Plantation seems not contain any individual.

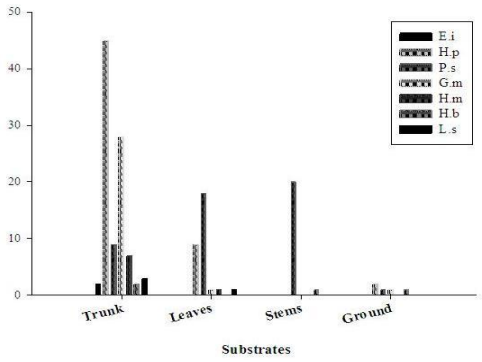
At the end, the four individuals of *L. sanctijohannis* encountered were in 4 of the 11 localities invested. 3 of the 4 were found in degraded forest and only 1 individual in agroforestry. Natural forest and plantation seem to contain any individual of this species of reptile. However the number was so small, thus any conclusion maybe taking about the distribution following habitat type.

Distribution of reptiles following substrate

The distribution of nocturnal reptile species depending on the substrate supporting them, the fig 4A shows that nocturnal reptiles are found more frequently (63%) on the trunks of trees and rarely on the ground (3%). However the seven identified species of nocturnal reptiles, each has its preferred substrate. Fig 4B shows the distribution of each species depending on the substrate where they were found. Most individuals of all 5 species are found on the trunks of trees. While most individuals of *P. santijohannis*, were encountered on stems and leaves of ferns, vines and other lower plants and rarely on the trees. Only 1 or 2 individuals of the 5 species: *E. inunguii*, *G. maculata*, *H. platycephalus*, *P. santijohannis* and *H. brooki*were encountered on the ground: These various substrates except the ground, present a certain height which were found the nocturnal reptiles.



A



B

Fig. 4. Distribution of nocturnal reptiles according to the substrates**.**

Discussions

Over the whole of Anjouan Island, 7 species of nocturnal reptiles were inventoried and identified in the different cardinal points of the island. Some species have been almost found in the forest because, probably, of hibernation; but also because of they are diurnal and rather prefer urban settings. The study of habitat and landscape in different areas showed their heterogeneity, which greatly influenced the distribution of species in those different zones. The majority of these species were observed in agroforestry at varying altitudes.

Lifestyle of each species

Ebenavia inungui (BOETTGER, 1878)(Nussbaum and Raxworthy, 1998)

Distribution and habitat: *Ebenavia inunguis* is the least abundant of all species of nocturnal reptiles identified in degraded and natural forests from 19h to 21h between 600-800m altitude. This observation differs in part from those of (Hawlitschek, 2008) and (CARRETERO and HARRIS, 2005) who affirm that this species is mainly forest and its preferred habitats are located at high altitudes. We can hypothesis that this species is mainly forest. This can be justified once by the fact that the only species encountered with the latter in the same transect is *Paroedura sanctijohannis*. This two species should have a competition this would explain the small numbers found for this species unlike the other. (CARRETERO and HARRIS, 2005)overlooking this species on the forest tree, but in this study it was on shrubs / vines and agroforestry tree at a height not exceeding 1.5m (result unpublished). The small number of individuals found does not allow us to compare the results of this study with those of others, Nevertheless data not yet published have been obtained and supported that the two individuals were encountered where the temperature was between 34-35 °C, with clear sky without fog, great weather without rain and no wind.

Conservation status: The most serious threat to this species is the degradation and fragmentation of its habitat, thus *Ebenavia inungui* is classified as endangered in the red list of the IUCN (Commission, 2001).

Geckolepis maculata (PETERS, 1880)

Distribution and habitat: *Geckolepis maculata* is the only species of its genus present in this forest. It is one of the most abundant species observed. Most individuals of this species have been observed in agroforestry and degraded forest between 300-600m. (CARRETERO and HARRIS, 2005), have observed this species in a rainforest between 400-600m above sea level.

The present result allowed us to confirm that, 6 years ago, 400m altitude in Anjouan was met a natural forest. At this time to find rainforest or fragments of forest, we have to climb to the heights. Thus, in this altitude currently agroforestry is the habitat encountered because of an tropic's activities. The similar study made by (Hawlitschek, 2008)in Mayotte, has reported that observations for this species were made in the natural forest between 200-300m above sea level and in Grande Comore it was found in degraded forest between 100- 200m altitude. These observations demonstrate a common point between these three studies, thereby we can suggest that *Geckolepis maculata* is a species which can live in all different types of habitat, except plantation where no individual was observed.

Conservation status: *Geckolepis maculata* is not endemic species. According to the IUCN (Commission, 2001),when the extent of a species is found in less than 5000km², the species is classified as endangered as fast as other threats are applicable. Unfortunately for this species, in only four communities was found and especially in two different classes of habitat. No individual was observed in areas where human pressure is too important as planting, rural and urban areas. However *Geckolepis maculata* could be affected in competitive situations with other species especially nocturnal gecko *Hemidactylus* genus. These factors lead us to suppose that *Geckolepis maculata* could be affected by criteria of fragmentation and habitat degradation (IUCN, 2001b) and a decline in numbers of individuals. Therefore, this species could be listed among the species that are in danger.

Hemidactylus brooki (Graw, 1945)

Distribution and habitat: *Hemidactylus brookii* is one of the least encountered species in the forests. In Comoros, this species is found only in Moheli and Anjouan (CARRETERO and HARRIS, 2005, Hawlitschek, 2008) and was observed for the first time by Glaw in 2002. It is specially observed in agroforestry between 100- 300m above sea level.

This observation is different from that seen by CARRETERO in 2005 who has observed it in plantation. The limited number of these individuals in the forest does not allow categorical statements. Usually the genus Hemidactylus is essentially urban and lives in plantation and especially in lighted areas. Although the number of individuals encountered in this study is not considerable, but this species appears to be present in plantations.

Conservation status: In Comoros, *Hemidactylus brookii* is not present for long time. It was recently brought to Moheli and Anjouan (Vences *et al*., 2004, CARRETERO and HARRIS, 2005,Hawlitschek, 2008). It is able to colonize a new area. Thus because of that this species is considered as an invasive species which its status is safe.

Hemidactylus mercatorius (GRAY, 1842)

Distribution and habitat: this species prefer living in agroforestry and plantation zone between 300-600 maltitude. (Vences, 2004)has observed this species in zone of medium altitude of 1200- 1300 in the island of Madagascar in a living zone. It therefore has considerable ecological valence vis-a-vis its habitat. (Hawlitschek, 2008)has observed this species in the urbanand plantation area between 101- 200m above sea level. The incertitude on the criteria for local scientists and those in passing in Comoros to identify this species makes information more and more complicated. Indeed, this species is often confused with the species *H. Mabua*. However to our knowledge, this species is more urban than forest.

Conservation status: *Hemidactylus mercatorius* is not endemic species. In the four islands of Comoros, this species is very abundant in Mayotte (CARRETERO and HARRIS, 2005, Rocha *et al.,* 2005a,Hawlitschek, 2008). It fits in anthropogenic habitats which it is able to colonize a new surface and coexists with all other species of the genus Hemidactylus, it is no extinction risk for this species.

Hemidactylus platycephalus (PETERS, 1854)

Distribution and habitat: *Hemidactylus platycephalus* is the most abundant of all species of its genus present in Comoros (Vences, 2004, CARRETERO and HARRIS, 2005,Hawlitschek, 2008). It can live both in forests and in urban areas. In the forests it was encountered more in agroforestry between 200- 600m above sea level than in other habitat types. This species frequent less natural forests. Counter to our result, Hawlitschek in 2008, has found that this species preferred the natural forest. Our previous study in urban area has shown that this species is abundant in that area. This result supported that this species prefers low altitude. In Anjouan Island the forest is nearly absent except at higher altitude. Thus, we hypothesis that the zone where natural forest was found 5 years ago now is agroforestry resulted of human activities.

Conservation status: *Hemidactylus platycephalus* is encountered in East Africa, north of Madagascar (Vences, 2004)and in Comoros, which it has the greatest number and the most abundant for its genus. The identification of a haplotype of DNA_{mt} (mitochondrial DNA) of an analyzed sample showed indications that this species would have arrived recently in Comoros archipelago (Rocha *et al.,* 2005b).Competition (Cody, 1974, Schoener, 1974), predation (Morin, 1983, Wilbur and Fauth, 1990), and the history of the eventuality(Losos, 1992, 1994, 1996) have drawn great causative attention for the disappearance of species and speciation. *Hemidactylus platycephalus* was observed together with *Hemidactylus mercatorius* and *Geckolepis maculata* but provided no risk of extinction.

Lycodryas sanctijohannis (Günther, 1879b)

Distribution and habitat: *L. sanctijohannis* is one of the least species observed during the study. It was observed in the degraded forest and agroforestry at various altitudes up to 879m Maximum.

However, Hawlitschek, 2008, has observed individuals in the opened urban, forest and plantation. Meirtein 2004 has reported and observed this species in the forest. This species is locally called the coconut tree snake owing to its present on the coconut trees in agroforestry and plantations. It can be observed in dams. Coconut tree are known to be "low altitude plant". This observation permits us to hypothesis that this species may have preference in agroforestry and plantation.

Conservation status: *Lycodryas santijohannis* is endemic to the Comoros. It has been studied by several authors and some called *L ycodryasmaculata*. Geckos and lizards are the preferred prey of this species (Meirte, 2004). In captivity, it may feed foams seedlings (Kornacker, 1989 in (Martins and Oliveira, 1993). Forest destruction does not appear to affect the population of this species. Fear of snakes causes people to kill the snakes but their number remains high. The potential threat for *L. santijohannis* could arise inter alia by infrastructure expansion and intensification of horticultural, which could lead to the loss of habitat and overcrowding isolated from each other by this fragmentation (Commission, 2001).Another threat could be imposed as quickly if another snake species with similar vital characteristics like *Lycodryas gaimardiicomorensis* recently discovered (Hawlitschek *et al.,* 2012)are introduced to share the same ecological niche(Cole *et al*., 2005). Certainly, none of these criteria are valid until now, but the status that this species is threatened is proposed.

Paroedura sanctijohannis (Günther, 1879a)

Distribution and habitat: It was studied for the first time in Comoros by GÜNTHER in 1879 and defined its endemism. This species at first look resembles to a small crocodile. It is the only species of its genus to be endemic in Comoros (Glaw *et al*., 2001, Jackman *et al*., 2008). The Comorian species for this genus is mainly nocturnal and operates in the natural forest, degraded forest, agroforestry and even in plantations.

Therefore we can say that this species is mainly forest, as pointed out (Meirte, 2004, CARRETERO and HARRIS, 2005, Hawlitschek, 2008) contrary to the other species of this genus which are known from the arid west(Glaw and Vences, 2007). According to the latter author, 80% of individuals of this species were found in the natural forest and 20% in the degraded forest. It is the only species found at higher altitudes (1187 m) in all species of nocturnal reptiles that were identified during this study. In the forest, *Paroedura santijohannis* can be encountered in the process of climbing forest trees, shrubs and ferns. The only species seen in the same transect with this species was *Ebenavia inungui* in Dar es Salama.

Conservation status: Its habitat is threatened by the log and agricultural activities caused by the increased of population (RGPH, 2003). Indeed, in 1990-1995, JOLLY and Fukuda-Parr have calculated an average annual rate of 5.8% of deforestation. Another threat could run *Paroedura santijohannis* is strong anthropic pressure and habitat change caused by agricultural activities (Raxworthy *et al.,* 2008). The total land surface of the Comoros is 2025, 57 km², while the (Commission, 2001)considers any endangered species that its encountered area is less than 5000km². Hawlitschekin 2008 has calculated and reported that *Paroedura santijohannis* occupies 50.53 km². This area is well below the maximum area occupancy (500km²) which is the minimum limit. Thus this species is not classified as endangered according to the criteria of the consensus of the IUCN (2001a). Another tighter calculation found 6.03 km² which is less than 10km², occupancy index of skilled critically endangered species. Therefore, the critically endangered status is proposed for *Paroedura satijohannis* (HAWLITSCHEK and GLAW, 2003).

Conclusion

The study for the distribution and habitat of nocturnal reptiles of the Anjouan Island has permit not only to have knowledge on the state places of the island herpetology but especially important to discover the wealth biodiversity of the island.

Currently, Anjouan Island is under human pressure because there is no forest policy in the country in general and especially in Anjouan. Increasing poverty, ignorance of the people vis-a-vis the richness of the forests, ineffective legislation and lack of implementation of existing ones, and especially the lack of economic alternatives incite the population always to reclaim and to seek new agricultural land, hence the dominance of agroforestry areas Forest.

The study has identified 158 individuals nocturnal reptiles divided into two families, with the exception of six other unidentified individuals:

For all species identified, *H. platycephalus* is the most abundant. It is encountered in different forest even during the day in full operation. Therefore this case can be considered cathemerale species. In forests, this species frequent agroforestry as habitat type located between 201-600m above sea level and rarely frequent the natural forest. *H. mercatorius*, is less abundant in forest and prefers plantations and agroforestry habitat type. *H. brooki*is most prevalent in urban areas and plantations. *Lycodryas sanctijohannis* is one of the least encountered species.

It is mainly forest and degraded forest and also prefers other types of vegetation. *G. maculata* is one of the most abundant species of the island and is mostly forest. It prefers agroforestry located between 400- 600m above sea level to other types of vegetation. *P. sanctijohannis* is one of the most abundant species, as *G. maculata*, it is essentially forest. This species prefers the natural forest located between 800-900m altitude and agroforestry located between 400-700m altitude. *E. inunguis* is the least abundant of all reptile species encountered and is mostly forest. Both individuals were respectively observed in the degraded forest and natural forest between 700- 800m altitude. His study has yet to be deepened during the other seasons.

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