ENVIRONMENTAL IMPACT ASSESSMENT OF THE S. VICENTE WIND FARM ON THE *TARENTOLA CABOVERDIANA SUBSTITUTA* GECKO

– FINAL REPORT

Vasconcelos, R[1,2,3]; Santos, X.[4]; Perera, A.[1]; Carretero, M.A.[1] and Harris D.J.[1,2]

1. CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Campus Agrário de Vairão, 4485-661 Vairão, Portugal.
2. Departamento de Zoologia e Antropologia, Faculdade de Ciências da Universidade do Porto, Pr. Gomes Teixeira, 4099-002 Porto, Portugal.
3. Institute of Evolutionary Biology (CSIC-UPF) CMIMA, Passeig Marítim de la Barceloneta, 37-49 E-08003 Barcelona, Spain
4. Departamento. Biologia Animal, Universitat de Barcelona, Av. Diagonal, 645, E-08028, Barcelona, Spain.

STUDY SUPPORTED BY INFRACO

CONTENT

ABSTRACT

Wind energy is part of a sustainable development for the Cape Verde Islands considered by the National Government in the 2003-2010 Energy Plan. However sustainable development is also synonym of habitat alteration with direct and indirect impacts on fauna. Therefore it is important to assess its impact, especially on endemic species like the *Tarentola caboverdiana substituta* gecko, exclusive to S. Vicente Island. In this study we have performed a preliminary diet and behavioural study of this species. The intention was to identify their main prey in relation to the spectrum of available invertebrates and analyze activity patterns, refuge selection and thermal ecology in order to gather knowledge on some ecological aspects of the species that were unknown until the date. With this information we can provide some mitigation measures for this gecko regarding the construction of a wind farm in S. Vicente Island and contribute with valuable data to the conservation of the herpetofauna of the Cape Verde Islands.

1. INTRODUCTION

Wind farms are part of a sustainable development for the Cape Verde Islands considered by the national government in the 2003-2010 Energy Plan in order to reduce its external economical dependence and preserve the environment (PND, 2003). However, until now, the wind energy power generation in the country by windmills is lower than 3,000 kilowatts per hour (kw/h) (INE, 2004). S. Vicente is an island with predominance of strong winds mainly from the northeast reaching 29.5 km/h (INMG 1920-1950). Nevertheless, in this island only 3x 300 kw/h of wind power capacity is installed and the annual values of generated energy is now 4,386,339 kw/h (Electra, 2008). Currently, in S. Vicente the total wind energy produced makes up roughly 68% of the total wind energy production of the country (Electra, 2008).

Nevertheless, although wind energy will increase the sustainability of the development in Cape Verde, its production is not free of environmental impacts (EWEA, 2008). Environmental impacts are especially dangerous if it happens on islands (Butterfield *et al*., 1997), where the number of endemic species is higher (Whittaker, 1998) and ecosystems are more vulnerable (Shine *et al*., 2000). Therefore it is necessary to understand the impact of wind farms on the endemic fauna. One of the groups that might be affected by the wind farms, not directly by their operation but by their related construction of infrastructures, are reptiles. Thus, it is critical to assess the nature and intensity of this impact on them as they are ground-dwelling species extremely habitat-dependent due to their low dispersal capacities.

In the Cape Verde Islands all of the 13 native reptile species are endemic. Being an oceanic archipelago, colonization and speciation processes have shaped exclusive forms in each island. Their extinction would constitute an irreversible loss for the biodiversity. Thus the importance of this study is increased in a conservation perspective.

São Vicente is an island belonging to the *Barlavento* group with a total area of 225 km^2 and altitudes reaching 725 meters in Monte Verde. In this island there are two endemic reptile forms, the *Mabuya stangeri* skink and the *Tarentola caboverdiana substituta* (Joger 1984) gecko, being the latter exclusive to this island. The later is classified as Data Deficient (DD) on the national red list, meaning that information on this particular gecko is very scarce and insufficient to decide a conservation category (Schleich 1996). Studies on the morphology (Joger, 1984, 1993; Schleich, 1984, 1987, 1996) and phylogeography (Carranza *et al*., 2000; Jesus *et al*., 2002) of this taxon have already been conducted. However, no ecological or ethological studies have been performed to this date. Therefore, all possible gathering of scientific information pertaining on the species at this level will be of great value for better understanding of the Cape Verdean herpetofauna in general and for the conservation of this species on this island in particular.

1.1. Objectives

1.1.1. Preliminary Diet Study: invertebrate availability and diet analysis

The intention is to evaluate which of the invertebrates the species feeds on in relation to the spectrum of available prey. Through an analysis of the composition of the faecal samples, it is possible to identify the proportions relevant to each group of available invertebrates being consumed, in order to identify the importance of each group in the alimentation of this species. Through comparison of the invertebrates present in the diet with those obtained in the standardized samplings simultaneously conducted in the area, it is possible to determine the level of selection of the different prey.

1.1.2. Preliminary Behavioural Study: activity patterns, thermal ecology and refuge selection.

The aims are to identify time periods of activity of the species with particular references to the thermal constraints; if there are preferences relative to size, location and temperature of the refuge rocks used and if any of these factors (activity period and refuge preferences) are associated with the size or sex of the specimen.

2. METHODOLOGY

2.1. Study Object

Tarentola caboverdiana is present in the Barlavento islands. However, due to isolation and speciation processes, those islands harbour four different subspecies. *T. caboverdiana substituta* is one of them, only present in the island of S. Vicente.

The *Tarentola caboverdiana substituta* is a gecko with a robust body, long tail with an approximately rounded section, and a delicate head with relatively long and sharpen snout (figure 1). It presents smaller scales than the other subspecies and therefore a higher number of scales around mid body (146-167). The length of the anterior limbs is shorter than the length of the head in contrast with other endemic *Tarentola* from the Cape Verde Islands. It presents four to five dorsal bands from the neck to the caudal region sometimes surrounded by white tubercles. The maximum snout-vent length is 60 mm. The adult state was indirectly assessed through the body size. Geckos longer than 44 mm of SVL were considered adults.

Figure 1. Dorsal (A) and lateral (B) view of the endemic gecko subspecies of S. Vicente Island, *Tarentola caboverdiana substituta.*

2.2. Study Area

The study area is located in the northwest side of S. Vicente Island, at approximately 5 km Northwest of Mindelo and 3 km east of the airport (figure 2). In this study we evaluate the potential impact of the wind farm on the gecko *T. caboverdiana substituta* mainly along the area that will be directly affected by the road construction.

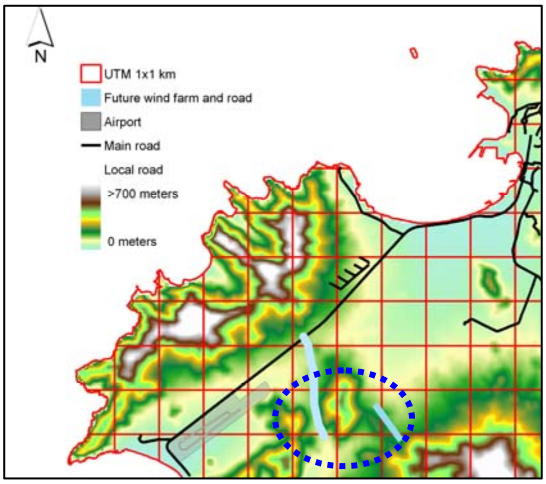


Figure 2. Location of the study area marked in a blue circle.

It is a very dry area with two plain narrow valleys surrounded by hills, with altitudes reaching 200 m, some with abrupt slopes and others with smooth ones (figure 3). The vegetation community is composed by the following dominant plant species: *Cleome viscosa*, *Sclerocephalus arabicus* and *Zygophyllum simplex*. Furthermore in the valleys there are some sparse trees of *Prosopis juliflora* and *Calotropis procera.*

Figure 3. General view of the study area showing trees of *Prosopis juliflora* and *Calotropis procera*.
A) North-South valley; B) East-West valley

The daily variation of the air temperature and air humidity in the selected site during the study period is presented in figure 4.

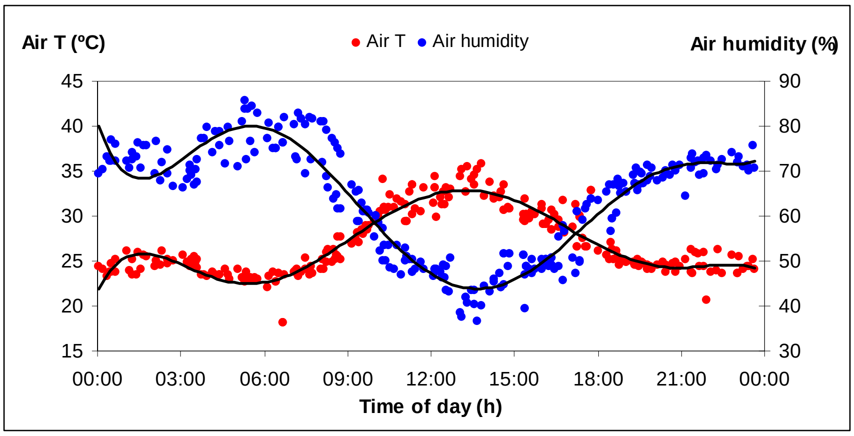


Figure 4. Air temperature and humidity daily variation in the selected site during the study.

2.3. Preliminary Diet Study

2.3.1. Arthropod sampling and identification for reference collection

Quantification of arthropods existing in the area of study was achieved by two different methods: pitfall trapping and biocenometers.

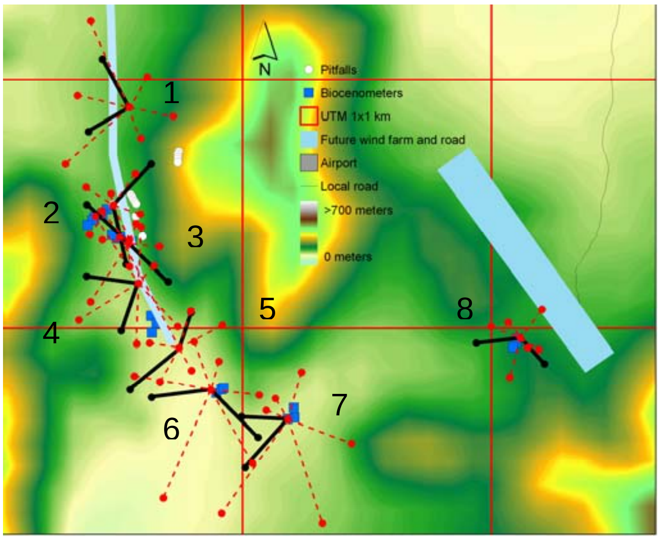


Figure 5. Location of the placement of the biocenometers and pitfall traps and of transects walked for capturing the geckos (red lines) and to access the refuge availability (black lines).

Pitfall trapping: consists of small jars filled partially with salty water and sunk into the ground. Arthropods fall into the jar and drown at the bottom of the trap. It is a good method because of its simplicity and ease of operation, and because it is highly efficient to sample ground surface-active arthropods. A total of twenty pitfalls were placed for 10 days in four different habitats (five pitfalls per habitat): water line (plain and sandy area with vegetation), vegetation (area covered with acacia bushes), plain (rocky plain area with no vegetation) and altitude (rocky hill area at medium altitude).

Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), ICETA, Universidade do Porto
Campus Agrário de Vairão • Rua Padre Armando Quintas, Crasto • 4485-661 Vairão
Tel.: (351) 252 660 416 • Fax. (351) 252 661 780
ICETA - Universidade do Porto

The sites of the pitfall traps placement are detailed in figure 5. Traps were checked on the last sampling day and jars with invertebrates that fell inside were collected for analysis in the laboratory.

Biocenometer: a portable trap device used to capture not only terrestrial but also flying prey. It consists of a wooden structure of 1 m^3, with lateral and top sides sealed with net. The structure was held to the ground and all arthropods inside the biocenometer were collected using a portable vacuum cleaner (figure 6). In this study, the animals collected in the 24 biocenometers (5 sampling sites with replicas) were analysed and grouped into three daily periods: 06:00 to 14:00h, 14:00 to 22:00h and 22:00 to 06:00h. The placement site of the biocenometers is detailed in figure 5. In all cases, vacuuming of all invertebrates present in the interior of this volume was performed throughout a period of 30 minutes.

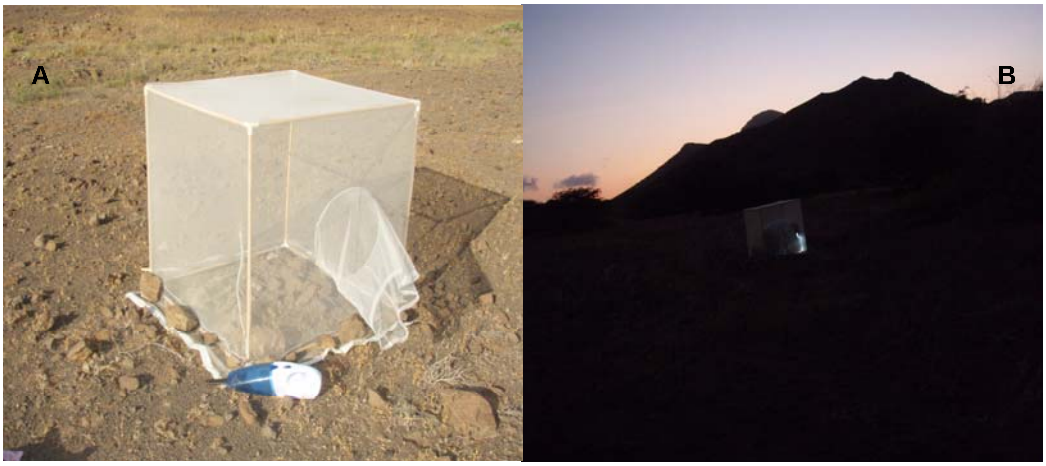


Figure 6. A) Biocenometers: trap device for arthropods. B) Nocturnal sampling.

Once in the laboratory, invertebrates from both sampling methods were separated from other remains and identified under a binocular dissecting microscope at least to Order level, except Formicidae which we separated from the other Hymenoptera due to their different habits. We counted abundance (A – frequency of each prey group) and relative abundance (percentage of each prey group in relation to the total number of prey) for each category of habitat (in the case of pitfall traps) and period of the day (in the case of the biocenometers). Animal prey were grouped into three typological categories: flying (i.e. Diptera, Lepidoptera, Hymenoptera and Odonata), jumping (i.e., species with ability to fly, but with more terrestrial habits; Orthoptera, Hemiptera and Coleoptera) and terrestrial prey (the remainders).

The combination of both sampling methods allowed an accurate estimation of the arthropod species existing in the area. Those specimens will be used for the identification of arthropod remains found in the pellets of *T. caboverdiana substituta*.

2.3.2. Analysis of faecal pellets

Geckoes were detected along transects (see sites in figure 5) and individuals were captured by hand, categorised by sex, and measured after collecting behavioural data (see section 2.4). Fresh faecal pellets were obtained during handling, thus all pellets were individually assigned. All animals were manipulated for as little a period of time as possible in order to minimize the stress and were released in the same place where they were captured. We grouped the animals in three age/sex classes: adult males, adult females and juveniles.

Faeces were immersed in alcohol 70º and analysed under a binocular dissecting microscope. All the animal remains were identified to Order level, except Formicidae (see section 2.3.1). For each food category and sex/age class we calculated the occurrence (P) and relative occurrence, that represents the number and percentage of animals consuming a certain prey respectively; and the abundance (A) and relative abundance (see section 2.3.1).

We estimated the diversity of the diet by means of the Levin's index of niche breadth namely B_s (in its standardized version, Hurlbert, 1978). This index ranges from 0 to 1. Values near one indicate equal consumption of all the classes of invertebrates, which means that the gecko do not select actively any kind of prey, while values near 0 are indicative of maximum specialization (Krebs, 1999). However, as this value depends on the availability of the different invertebrate groups, we also estimated the Ivlev's electivity index E (with Jacobs modification, Jacobs, 1974) in order to quantify prey selection taking into account invertebrates availability. This index ranges from –1 (total avoidance) to 1 (total preference).

We analysed differences in diet composition and frequencies of terrestrial and flying prey with a Pearson chi-square (Sokal, 1995). Finally, we compared the similarity of the diet between males, females and juveniles by using Pianka's measure of niche overlap (Krebs, 1999). The significance level for all test was $p = 0.05$.

2.4. Preliminary Behavioural Study

2.4.1. Activity Patterns

During the capture of individuals for the study described in section 2.3., the activity status of the animal (active/inactive) and their body temperature at the time of capture was noted as well as temperature measurements of the species' environment (substratum and air). The hours and minutes of capture were also recorded. We have considered active animals the ones not under rocks and inactive the ones under rocks.

2.4.2. Thermal Ecology

During the capture of individuals for the study referred to in section 2.3., the temperature, type and size of the refuge was registered. In order to minimise gecko disturbance, body temperatures were measured using an infra-red thermometer (Fluke 68, precision 0.1ºC). The temperatures of the substrate on which the gecko was observed and measured on the lower surface of the rock and the soil underneath it were recorded with the same device. Air temperature and humidity were measured with a digital higrothermometer (Fluke 971, precisions 0.1%, 0.1ºC), placed 5 cm above ground. All temperatures were recorded shading the area of the measurement. The temperatures of activity/inactivity and the relation between body and environmental temperatures were calculated as well as the variation between the types of refuge, time periods, sex and age. We also have placed data loggers (i-buttons) that registered temperatures each five minutes on the different available habitats (under vegetation, a rock pile, a small and medium rock and a crevice in a valley – low – and a hilly slope – high; see results in section 3.2).

2.4.3. Refuge Selection

During the capture of the animal for the study referred to in section 2.3., the type of refuge where the geckos were found was categorized according to refuge size, rock agglomeration, vegetation presence and soil type. At the same time, random transects for the evaluation of the available refuge (see sites location on figure 5) were conducted in order to determine if there is selection in relation to specific refuges and what this selection consists of – results presented in section 3.2.

3. RESULTS

3.1. Study Object

A total of 261 geckos were collected. Of those, 167 were adults and 94 were non-adults (juveniles and sub adults) and that will be referred to as juveniles hereinafter. The size of the animals (snout-vent length) varied between 27 to 65mm, juveniles being considered the ones below 45 mm (table 1 and figure 7 A).

Table 1. Mean, minimum, maximum and standard error of the snout-vent length for adults and juvenile geckos.

AGE	Mean	Minimum	Maximum	Standard error
Adults	51.6	45.0	65.0	3.64
Juveniles	38.6	27.0	44.0	3.72

There were no significant differences between the size of all males and females, adults and juveniles mixed. However, regarding to adults, males were significantly larger than the females, although this difference was not very statistically very strong (Mann-Whitney Test, U=2856.5, p=0.045; figure 7 B).

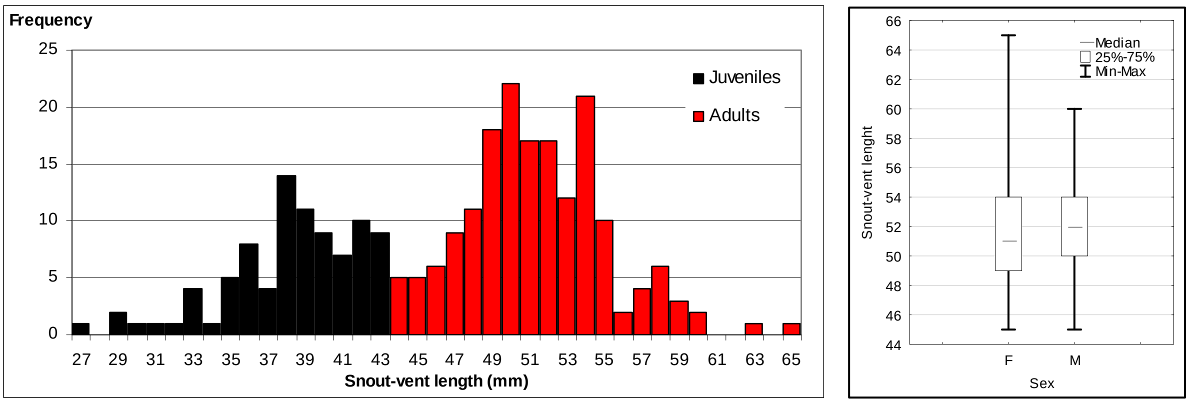


Figure 7. A) Frequencies for each size class of adults and juvenile geckos. B) Size differences between adult males (M) and females (F).

3.2. Study Area

After running the 16x200 m random transects for assessing the refuge availability we can conclude that the vegetation density and presence of big loose rocks is very low. Small rocks are the more abundant, covering almost 65% per m^2 of the soil (table 2).

Table 2. Refuge availability for geckos with total, mean and percentage of cover of bushes as well as smalls, medium and big rocks found along the 16 200m transects.

REFUGE	Bushes	Small rocks	Medium rocks	Big rocks
Total	276	2066	313	23
Mean	17	129	20	1
% Cover	8.63	64.56	9.78	0.72

The data loggers that registered the temperatures during the sampling days indicate that temperatures raised both earlier and higher under vegetation than in the remaining habitats (table 3). On the other hand the crevices are cooler and take longer to heat (figure 8). We also see in figure 8 that smaller rocks reach much higher temperatures than rock piles and medium rocks, being the latter the habitat with the shortest temperature range.

Table 3. Mean, minimum, maximum and standard deviation of temperatures registered in each habitat.

HABITAT	veg. low	veg. high	rock pile low	rock pile high	small rock low	small rock high	medium rock	crevice
Mean	26.7	27.1	26.3	24.9	28.1	27.9	26.7	25.2
Min	22.0	21.5	22.0	21.5	21.5	23.0	23.0	22.0
Max	42.5	44.0	39.0	35.0	42.0	40.0	34.0	36.0
Stdv	4.31	4.98	3.56	2.79	5.26	4.41	2.55	3.00

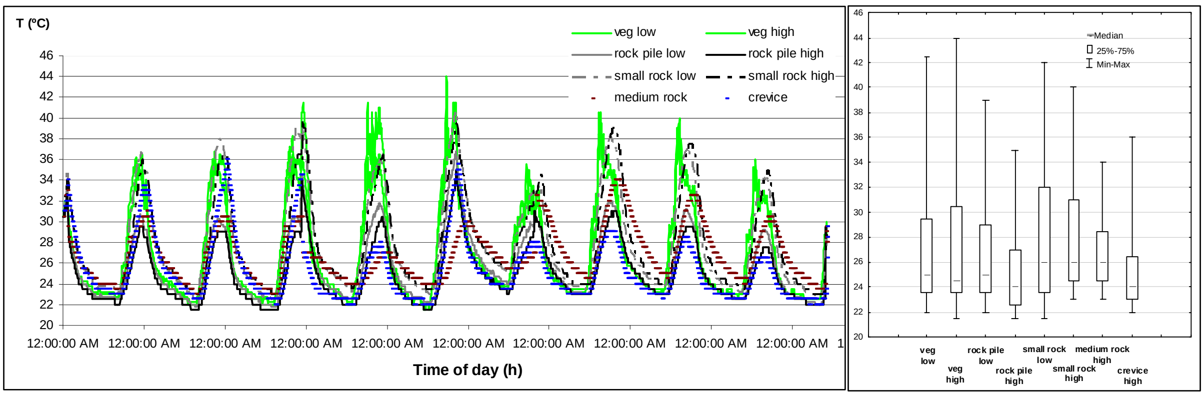


Figure 8. Temperatures registered in the different habitats with the data loggers. A) Daily variation during the sampling days. B) Median, maximum and minimum values registered.

The Kruskal-Wallis test confirms that there are differences in the temperatures variation in the different habitats (H 7, 22616 =1714.030; p <0.001). Executing a post-hoc multiple comparison test (2-

tailed p-values) we find that there are significant differences in the temperatures between all the habitats except between small and medium rocks, where animals are preferentially found.

3.3. Preliminary Diet Study

Regarding food availability, a total of 20 pitfalls and 24 biocenometers were analysed. We also present the results of the diet of *T. caboverdiana substituta*, based on 96 pellets from 36 males, 30 females and 30 juveniles

3.3.1. Arthropod sampling and identification for reference collection

Pitfall traps

The content of 20 pitfalls from four different habitats, including water line, altitude, vegetation and plain areas was analysed.

Table 4. Results of the analysis of pitfall traps in the total and in the four analyzed habitats: altitude, water line, vegetation and plain. For each area, the frequency (A) of the different arthropod order is given.

	ALTITUDE		WATER LINE		VEGETATION		PLAIN		TOTAL	
ARTHROPOD ORDERS	**A**	**A (%)**	**A**	**A (%)**	**A**	**A (%)**	**A**	**A (%)**	**A**	**A (%)**
Araneae	8	3.8	15	7.9	12	3.4	5	22.7	40	5.2
Thysanura	9	4.3	0	0.0	1	0.3	2	9.1	12	1.5
Orthoptera	4	1.9	11	5.8	3	0.8	2	9.1	20	2.6
Isoptera	0	0.0	0	0.0	1	0.3	0	0.0	1	0.1
Hemiptera	16	7.7	30	15.9	14	3.9	8	36.4	68	8.8
Diptera	0	0.0	7	3.7	7	2.0	0	0.0	14	1.8
Lepidoptera	3	1.4	4	2.1	0	0.0	3	13.6	10	1.3
Coleoptera	164	78.8	113	59.8	285	79.8	0	0.0	562	72.4
Hymenoptera	4	1.9	4	2.1	3	0.8	0	0.0	11	1.4
Formicidae	0	0.0	5	2.6	31	8.7	1	4.5	37	4.8
und. larvae	0	0.0	0	0.0	0	0.0	1	4.5	1	0.1
Terrestrial prey	17	8.2	20	10.6	45	12.6	9	40.9	91	11.7
"Jumping" prey	184	88.5	154	81.5	302	84.6	10	45.5	650	83.8
Flying prey	7	3.4	15	7.9	10	2.8	3	13.6	35	4.5
NUMBER OF PITFALLS	5		5		5		5		20	
NUMBER OF ITEMS	208		189		357		22		776	
NUMBER OF TAXA	7		8		9		7		11	

We found a total of 776 arthropods from 11 taxa (table 4). Globally, Coleoptera were the most abundant arthropod representing the 72% of the specimens found in the pitfalls, followed by Hemiptera (8%) and Araneae (5%). All other groups were found in lower proportion (<5%; table 4).

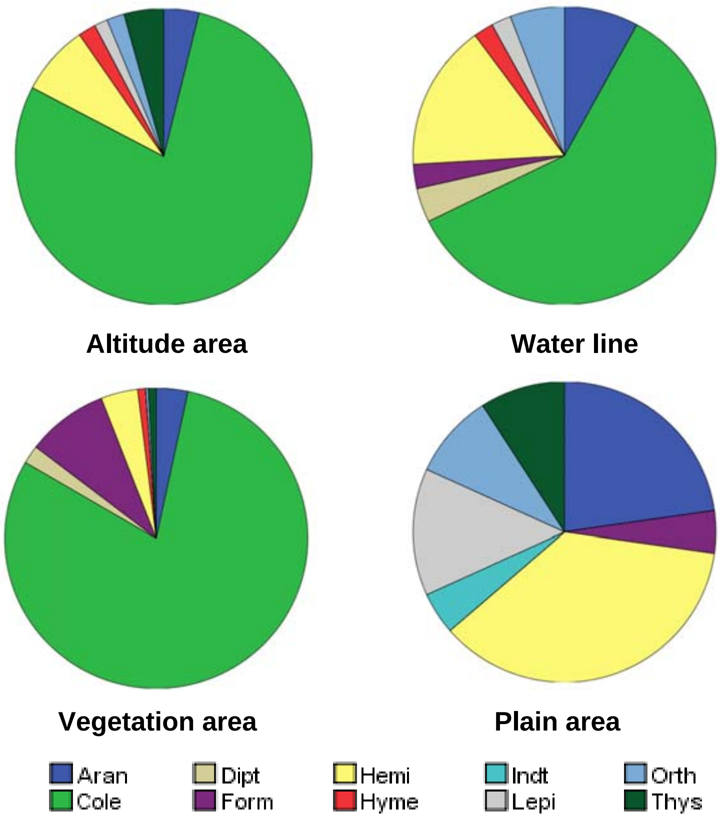


Figure 9. Arthropod abundance in the four habitats analyzed based on the analysis of pitfall traps (see text for more details).

Different habitats had different arthropod composition (G=221.82, d.f.=27, p<0.001). Regarding the total number of arthropods, only 22 were captured in the “plain” pitfalls, while in the other three habitats, more than 150 arthropods per pitfall group were collected on each habitat (see table 4 for more details). This represents a substantial difference between areas. Such differences were mostly due to the high number of Coleoptera found. This taxon represented 80% of the total of invertebrates found in “altitude”, “water line” and “vegetation” areas, but surprisingly they were not found in any of the “plain” habitat pitfalls (table 4). In the plain area, instead, Hemiptera was the most abundant arthropod (table 4 and figure 9). Certainly, those differences may be due to the absence of vegetation.

Moreover, there are other differences in some other minor groups. For example, ants were more common in areas near bushes, while Thysanura were more abundant in “altitude” (table 4). Interestingly, we did not find any pseudoscorpion in the pitfalls.

Biocenometers

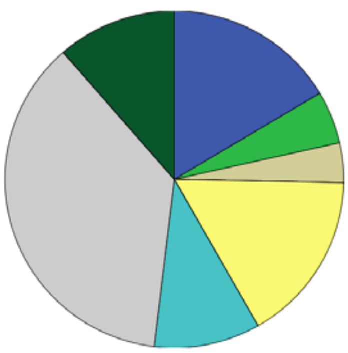
A total of 24 biocenometers were collected and grouped in three time periods for analysis (see material and methods for more details).

We found 751 arthropods belonging to 10 arthropod categories. In general, Hemiptera and Formicidae were the more common arthropod collected in the biocenometers, while beetles, the most common arthropods captured in the pitfalls, were found occasionally using this methodology (table 5 and figure 10).

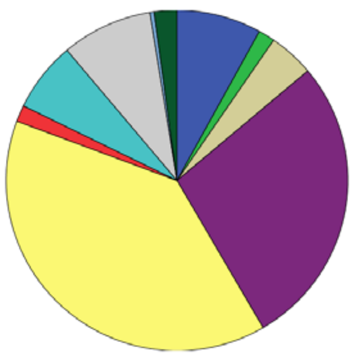
Table 5. Biocenometer composition along three daily periods: night (22:00 to 06:00h), morning (06:00 to 14:00h) and evening (14:00 to 22:00h). For each area, frequency abundance (A) and percentage of the different arthropod categories and arthropod groups (terrestrial, “jumping” and flying prey) is given.

	NIGHT		MORNING		EVENING		TOTAL	
PREY ITEMS	**A**	**A (%)**	**A**	**A (%)**	**A**	**A (%)**	**A**	**A (%)**
Pseudoescorpionidae	0	0.0	2	0.4	1	0.6	3	0.4
Araneae	13	16.5	41	8.0	17	10.6	71	9.5
Thysanura	9	11.4	11	2.1	29	18.1	49	6.5
Orthoptera	29	36.7	44	8.6	11	6.9	84	11.2
Hemiptera	13	16.5	200	39.1	42	26.3	255	34.0
Diptera	3	3.8	22	4.3	6	3.8	31	4.1
Lepidoptera	8	10.1	34	6.6	20	12.5	62	8.3
Coleoptera	4	5.1	8	1.6	25	15.6	37	4.9
Hymenoptera	0	0.0	8	1.6	4	2.5	12	1.6
Formicidae	0	0.0	142	27.7	5	3.1	147	19.6
Terrestrial prey	22	27.8	196	38.3	52	32.5	270	36.0
"Jumping" prey	46	58.2	252	49.2	78	48.8	376	50.1
Flying prey	11	13.9	64	12.5	30	18.8	105	14.0
NUMBER OF TRAPS	8		8		8		8	
NUMBER OF ITEMS	79		512		160		751	
NUMBER OF TAXA	7		10		10		10	

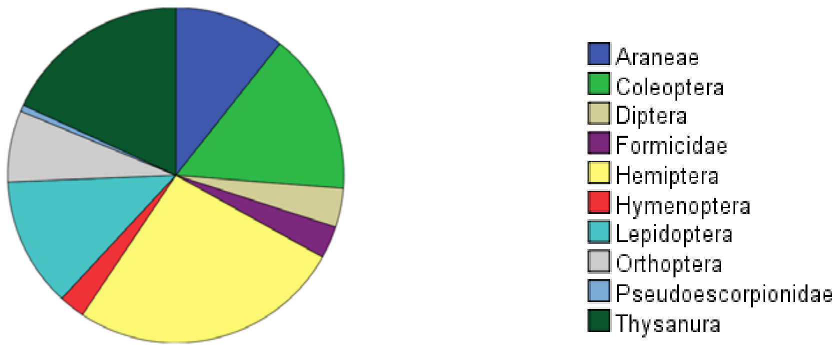
Considering the abundance of arthropods captured in the three periods, morning was the period with higher insect abundance (512 arthropods), and night the lowest (79 arthropods, see table 5). During the day Hemiptera was the most abundant taxa, but during the night Orthoptera were more frequently captured. Formicidae, Hymenoptera, Diptera, Orthoptera and spiders were more abundant during the morning, and Thysanura, Coleoptera and Lepidoptera (basically, moths) in the evening (table 5 and figure 10). Pseudoscorpions were only captured during the day.



Night (22:00 – 06:00)



Morning (06:00 – 14:00)



Evening (14:00 – 22:00)

Figure 10. Arthropod abundance in the three time periods analyzed based on the analysis of biocenometers (see text for more details).

Pitfall and biocenometer sampling methods are useful to infer the number of species and groups of arthropods living in the area. However, these results, although informative, might not represent the real availability in the field as there are some invertebrate groups that due to their habits are less susceptible of being sampled using these methods.

3.3.2. Analysis of faecal pellets

A total of 759 arthropod remains grouped in 12 different taxa were identified (table 6). However, only 3 groups were dominant in the diet (abundance >5%): Hemiptera, Lepidoptera and Hymenoptera. We found occasional occurrence of other remains such as seeds (4 pellets) or vegetal remains (in 5 pellets). However, the small proportion found in the pellets indicates that this species is not herbivorous. Interestingly, an 11,5% of the pellets had remains of pseudoscorpions.

The low values of B_s observed in *T. caboverdiana substituta* (table 6) are indicative of a relatively specialized diet. In effect, 80% of the global diet is composed by the three more abundant groups (Hemiptera, Lepidoptera and Hymenoptera).

In general, males, females and juveniles consumed differently the more abundant items (Pearson Chi-square=32.07, d.f.=12, p<0,01). After grouping the prey, we found differences between the three classes in the consumption of terrestrial, flying and jumping species (Pearson chi-square=43.54, d.f.=4, p<0.001). So, females have a higher consumption of “jumping” arthropods mainly Hemiptera, while adult males and juveniles feed on flying prey, basically Hymenoptera.

Table 6. Diet composition. Number, abundance and occurrence of each prey item found in the faecal pelles analised for the different classes of age and sex. B_s= Levins' standardized index of diversity.

	MALES			FEMALES			JUVENILES			TOTAL		
PREY ITEMS	**N**	**A (%)**	**P (%)**	**N**	**A (%)**	**P (%)**	**N**	**A (%)**	**P (%)**	**N**	**A (%)**	**P (%)**
Pseudoescorpionidae	4	1.2	11.1	2	1.2	6.7	7	2.7	16.7	13	1.7	11.5
Araneae	9	2.7	22.2	8	4.8	26.7	8	3.1	26.7	25	3.3	25.0
Thysanura	1	0.3	2.8	3	1.8	10.0	-	-	-	4	0.5	4.2
Orthoptera	12	3.6	33.3	8	4.8	26.7	3	1.1	10.0	23	3.0	24.0
Hemiptera	70	17.4	83.3	59	35.8	86.7	61	23.4	83.3	190	25.0	84.4
Diptera	1	0.3	2.8	1	0.6	3.3	3	1.1	10.0	5	0.7	5.2
Lepidoptera	25	7.5	55.6	25	15.2	63.3	15	5.7	50.0	65	8.6	56.3
Coleoptera	13	3.9	30.6	8	4.8	23.3	7	2.7	23.3	28	3.7	26.0
Hymenoptera	181	54.4	44.4	32	19.4	36.7	143	54.8	73.3	356	46.9	51.0
Formicidae	5	1.5	11.1	15	9.1	16.7	13	5.0	30.0	33	4.3	18.8
Undeterminated	9	2.7	22.2	3	1.8	10.0	1	0.4	3.3	13	1.7	12.5
Und. larvae	3	0.9	8.3	1	0.6	3.3	-	-	-	4	0.5	4.2
Vegetal remains	2		5.6	1		3.3	2		6.7	5		5.2
Seeds	1		2.8	2		6.7	1		3.3	4		4.2
Und. matter	10		5.6	-		-	-		-	10		2.1
ITEMS CONSUMED		333			165			261			759	
NUMBER OF PELLETS		36			30			30			96	
TAXA CONSUMED		12			12			10			12	
B, Levins diversity index		2.86			4.89			2.75			3.38	
B_s		0.17			0.35			0.19			0.22	

Results on diet overlap show that males and juveniles have an almost identical diet (Pianka's overlap index, O=0,99), and different from females ($O_{male\text{-}fem}$=0.74, $O_{juv\text{-}fem}$=0.76). In fact, around 80% of the diet of males and juveniles is based on the consumption of three arthropod groups: Hymenoptera, Hemiptera and Lepidoptera, being the first the preferred consumed (54% of the prey were Hymenoptera). In females, those three arthropods represent the 70% of the diet, but consumption is more uniformly distributed (Hemiptera 35%, Hymenoptera, 19% and Lepidoptera, 15%). Moreover, females show a higher consumption of other minor items such as spiders, grasshoppers, beetles and ants (table 6).

Electivity analysis

Results on electivity varied depending on the sampling method of arthropod availability compared. When comparing availability based on pitfall trapping and diet, individuals showed high preference for Pseudoscorpionidae, Hymenoptera and Lepidoptera, while they were avoiding termites and beetles. On the contrary, when comparing availability based on biocenometers and diet we found a high preference by Larvae and Hymenoptera and an avoidance of Thysanura. These results illustrate how electivity analysis might vary greatly depending on the sampling method. Pitfall trap is a good method for capturing ground surface-active arthropods, while biocenometers capture a wider diversity of terrestrial, jumping and flying groups.

Table 7. Electivity (E) values for each arthropod trap device. Preliminary results obtained from the comparison of the invertebrate abundance collected from pitfalls and biocenometers and on the diet of *Tarentola caboverdiana*.

ARTHROPOD GROUPS	Pitfalls A%	Biocenometers A%	Diet A%	Electivity pitfalls	Electivity biocenometers
Pseudoescorpionidae	-	0,4	1,7	1,00	0,63
Araneae	5,2	9,5	3,4	-0,23	-0,50
Thysanura	1,5	6,5	0,5	-0,48	-0,86
Orthoptera	2,6	11,2	3,1	0,09	-0,60
Isoptera	0,1	-	-	-1,00	-
Hemiptera	8,8	34,0	25,5	0,56	-0,20
Diptera	1,8	4,1	0,7	-0,46	-0,73
Lepidoptera	1,3	8,3	8,7	0,76	0,03
Coleoptera	72,4	4,9	3,8	-0,97	-0,14
Hymenoptera	1,4	1,6	47,7	0,97	0,96
Formicidae	4,8	19,6	4,4	-0,04	-0,68
Larva undeterminate	0,1	-	0,5	0,69	1,00

3.4. Preliminary Behavioural Study

3.4.1. Activity Patterns

Active animals were recorded only between the 19:00 and 06:12 hours although we could find inactive animals at any time. Considering that the sunset and sunrise times were around 18:04 and 06:48, respectively we can affirm that this gecko has exclusively nocturnal activity (figure 11). For results related with thermal ecology see point 3.4.2.

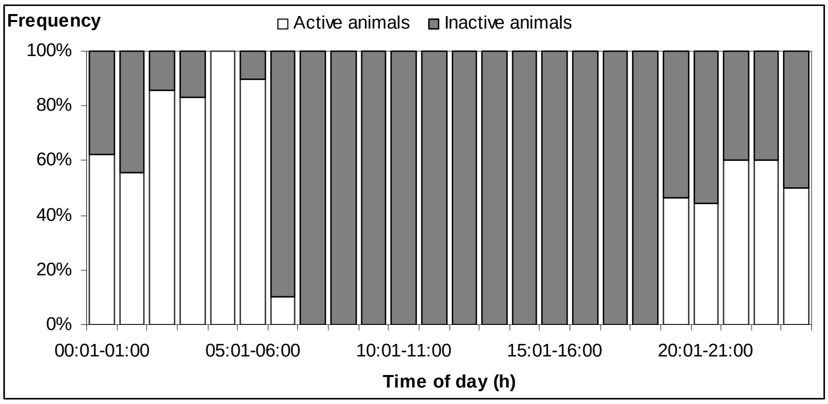


Figure 11. Relative frequencies of active and inactive animals found throughout transects along the different time periods (N=261).

The proportion of active and inactive animals found throughout transects is similar in adults and juveniles. It is also similar in males and females for the total of the animals and in both age groups. This proportion is around 1 active to 4 inactive animals with no significant differences in the Chi squared test between age or sex groups for the total of geckos and within each age group (p=0.05 in all comparisons).

3.4.2. Thermal Ecology

In terms of the activity of these geckos, the interval where active animals are found coincides with the maximum air humidity and lowest air temperatures registered during the day, and consequentially the lowest body temperatures of the animals (figure 12 A).

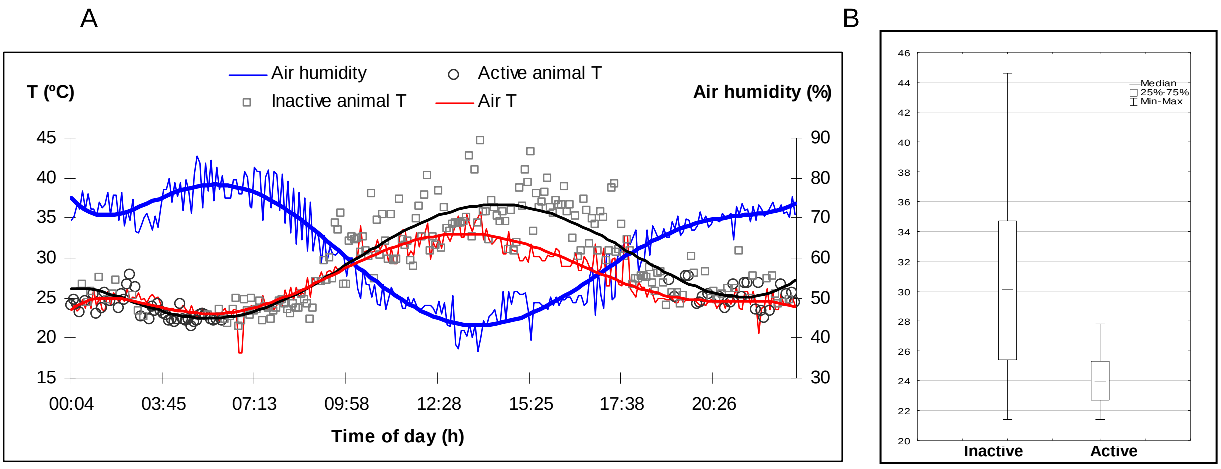


Figure 12. A) Air temperature and humidity and body temperature variation of active and inactive animals (N=261) during the time of day. B) Mean, maximum and minimum body temperatures of active and inactive animals (N_{active}=67, $N_{inactive}$=194).

It is shown by the Mann-Whitney U Test that active animals present different body temperatures in comparison to inactive ones. The range of body temperature of the former is from 21.4 to 27.8 ºC and of the latter from 21.4 to 44.6 ºC, being the temperatures of active animals significantly lower than inactive ones by the Mann-Whitney U test (U= 1902.5; p=0.000), as seen in figure 12 B.

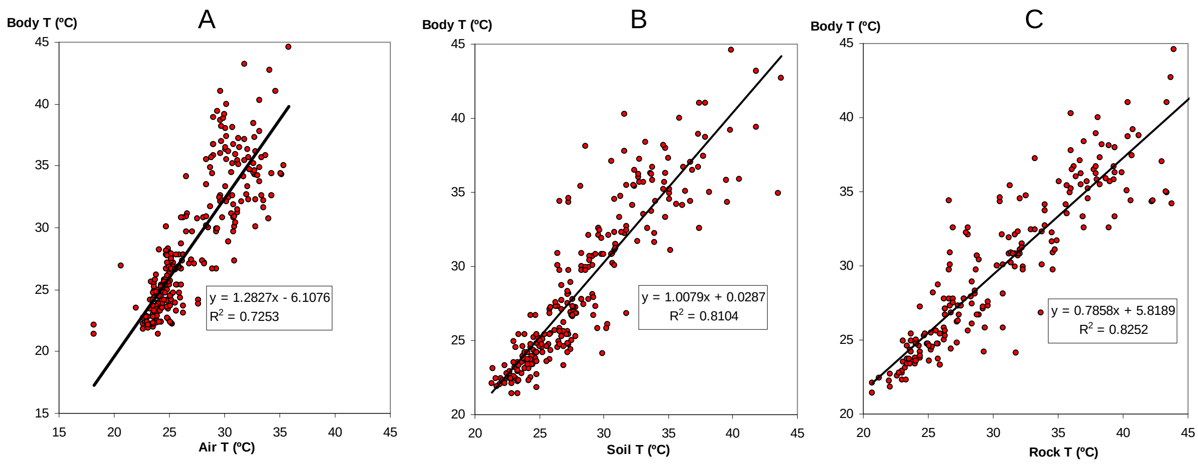


Figure 13. Body temperature (T) variation versus air temperature (A), rock temperature (B) and soil temperature (C) for the total of geckos sampled (N_A=261, N_B=257, N_C=201).

There is a positive and significant correlation between the body temperature of the geckos and the air, soil and rock temperature. These variables present a linear relation between them, as indicated by the high value of coefficient of correlation of Pearson (R^2) (figure 13). As all these variables are also correlated between themselves it is very easy to understand why they present similar curves in the graphs.

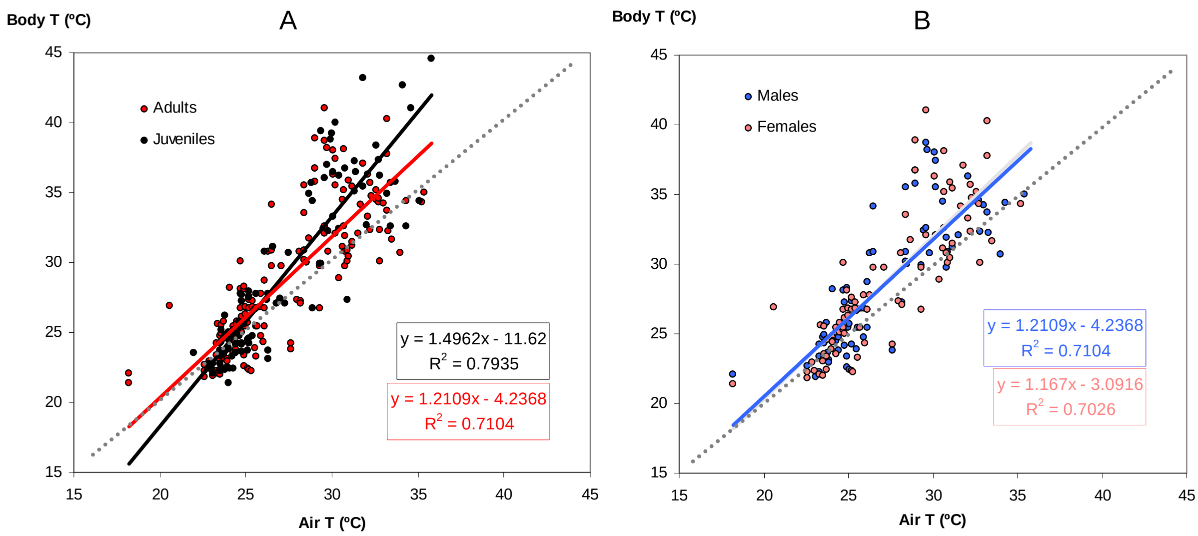


Figure 14. Body temperature versus air temperature in adults and juveniles (A) and in males and females (B). Grey dashed lines represent temperature variation for thermoconformity.

There are no significant differences between the body temperatures registered in adults and juveniles or males and females for all geckos and between each age group (Mann-Whitney U Test, p>0.05 in all cases; figure 14).

Nevertheless we can see in figure 14 that adults have a smaller slope value than juveniles, indicating that when air temperature rises above levels of roughly 25 ºC adults present lower body temperatures than juveniles. This can be explained by physic laws that determine that bodies with smaller masses heat faster and by behavioural factors of refuges selection referred to in section 3.

3.4.3. Refuge Selection

All individuals were found associated with rocks. We did not find any animals under vegetation. Through the Chi squared test (p = 0.05) we can affirm that the choice of rock size is dependent on the age of the gecko, being the adults more commonly found on medium rocks and juveniles on smaller rocks. This can be explained by interspecific competition, where the bigger adult males expel the smaller juveniles out of the better refuge rocks, the medium ones. These rocks, because they have greater mass, heat slower than the smaller ones that reach much higher temperatures, less favourable for the metabolism of the animals. On the other hand there is independence of the age factor on the refuge choice of rock number, presence of vegetation and soil type, being both adults and juveniles more significantly found under groups of rocks (more than 5) without bushes and in compact soils (see table 8). This can be explained with the extremely low bush density and habitat availability in the study site and in the entire island in general. We also can affirm with the Chi squared test that the choice of rock size, rock number, presence of vegetation and soil type is independent of the sex of the animals both in adults and juveniles.

Table 8. Number and percentage of individuals on each refuge type (characterized by the rock size, rock number, presence of bushes and soil type) in each category of age and sex (males, females, juveniles) and in the total.

	ADULTS				JUVENILES					TOTAL	
REFUGE TYPE	**Males**	**Females**	**All**	**%**	**Males**	**Females**	**Und.**	**All**	**%**	**All**	**%**
Small rock	12	12	24	19.20	13	10	16	39	57.35	63	32.64
Medium rock	40	45	85	68.00	8	7	9	24	35.29	109	56.48
Large rock	6	10	16	12.80	1	3	1	5	7.35	21	10.88
1 rock	16	20	36	28.80	4	4	8	16	23.53	52	26.94
2 rocks	8	10	18	14.40	1	1	6	8	11.76	26	13.47
3 rocks	7	3	10	8.00	3	1	0	4	5.88	14	7.25
4 rocks	1	1	2	1.60	0	1	0	1	1.47	3	1.55
>5 rocks	26	33	59	47.20	14	13	12	39	57.35	98	50.78
No bushes	52	57	109	87.20	19	17	21	57	83.82	166	86.01
With bushes	6	10	16	12.80	3	3	5	11	16.18	27	13.99
Compact soil	42	52	94	75.20	19	17	21	57	83.82	151	78.24
Fine grain soil	12	12	24	19.20	2	2	3	7	10.29	31	16.06
Sandy soil	4	3	7	5.60	1	1	2	4	5.88	11	5.70

On the opposite there is independence of age group for the refuge choice, rock number, presence of vegetation and soil type, being both adults and juveniles significantly more found in a group of rocks (more than 5) with no bushes and in compact soils (see table 8). This can be explained with the extremely low bush density and habitat availability in the study site and in the entire island in general. We also can affirm that the choice of rock size, rock number, presence of vegetation and soil type is independent of the gender of the animals both in adults and juveniles.

4. Conclusions

4.1. Main Conclusions

The studied gecko, *Tarentola caboverdiana substituta*, presented body size differences between sexes only in adults, being males significantly larger than females.

The analysis of pitfall traps showed the existence of local differences in the arthropod composition. So, in the plain area, with no vegetation, we found a high abundance of true bugs and spiders, while in the other analysed habitats (water line, altitude and vegetation areas), beetles were, by far, the most abundant arthropod captured. There was also a daily variation in the arthropod abundance, considering the capture probability observed in the biocenometers. So, arthropods were probably moving more during the morning whereas they were more sedentary during the rest of the day, and most of the groups were more active during the day. An interesting result was the finding of Pseudoscorpions in some of the biocenometers analysed. The existence of this group in the island of S. Vicente had not been previously reported (Báez & Oromí, 2005).

The results regarding the diet of *T. caboverdiana substituta* showed that this species is basically insectivorous, with a quite specialized diet based on Hymenoptera, Lepidoptera and Hemiptera. It seems to be a sit-and-wait forager feeding on moving prey. So, it seems that geckos choose actively the prey, as more abundant prey are not always the more consumed (for example beetles and ants). However, males, females and juveniles had some differences in their diet. Females had a higher consumption of “jumping” arthropods (mainly Hemiptera), while adult males and juveniles feed on flying prey, basically Hymenoptera. Interestingly, we found consumption of Pseudoscorpions in all classes of age and sex.

In relation to the study area we have concluded that the vegetation density is very low (<9% cover). On the other hand, rock density, especially small rocks, is quite high. We also saw that different habitats reach different temperatures, ranging between 21.5 and 44.0 ºC, which can explain the species choice of refuge type. This is true for all different habitats except between small and medium rocks, where the geckos are usually found.

About the activity pattern we conclude that this gecko is strictly nocturnal, with an active period between the 19:00 and 06:12 hours. We found approximately 25 percent of active animals from total encountered animals during transects of all age and sex classes with no significant differences between them. Active animals presented body temperatures ranging between 21.4 and 27.8 ºC, although this value could reach around 45 ºC in inactive ones.

We found a positive correlation between the body temperature of the animal and the air, soil and rock temperatures. No differences were found in the body temperature of the different sex or age groups, being all closer to thermoconformity than to active thermoregulation.

Finally we found that there is a strong refuge selection of rocks as opposed to vegetation, where no animals were found. Within the rock habitat we found that the geckos are usually under medium or small rocks, depending significantly on age class, being adults more commonly found under bigger rocks than juveniles. This fact can be explained by inter-specific competition based on strong territoriality and interference for a better refugee in terms of thermoregulation and shelter. The presence in all the other refuge characteristics was more related with the habitat availability itself than with the species preferences (rock with no bushes in compact soil and with many rocks around).

4.2. Impact Assessment

The possible impacts of the construction of the Wind Farm and the new road on the *Tarentola caboverdiana substituta* are:

A) Habitat alteration and destruction

The road construction will lead to the alteration and destruction of the habitat of this gecko due to the removal of its preferred refuges that are the rocks.

B) Direct mortality of individuals and eggs due to road construction

Heavy machinery used for road construction and transportation of wind farm equipment will certainly cause the death of many animals and eggs by direct crush or indirectly through rock displacements.

C) Increase of future mortality by increasing facilitation of human presence in the area

Enlarging the narrow dirt road and possibly converting it into a hard-surfaced road will allow an easier access to these valleys for people who will possibly contribute to an increase of habitat alteration or destruction, and ultimately to a decreased fitness of the specimens living in the area.

D) Potential introduction of alien competitor and predator species

Carrying materials with foreign provenience from the city port, where the presence of *H. angulatus* (Mertens, 1955; Schleich, 1996) and *H. mabouia* (Jesus *et al*., 2001; Carranza and Arnold, 2006) have been already confirmed will increase the probability of dispersion of these and even other alien reptiles in the island. These geckos might compete with the native one, reducing its fitness, similarly with what is occurring in Boavista Island with another endemic gecko, *H. boavistensis* (López-

Jurado *et al*., 1999). If rubbish and artificial building is left on the construction site, there will be rats. If they are artificial perches avian predation (corvids and raptors) could increase.

4.3. Mitigation Measures

We propose some measurements to reduce or eliminate each possible impact above referred.

A) Habitat alteration and destruction

To enlarge an existent earth road located easterly to the wind farm site (Selada do Flamengo), which crosses a humanized area (acacia plantation and Ribeira da Vinha) instead of the selected one, located in a preserved valley (see figure 15). This alternative road is only 6.6 km long until Mindelo (4.2 Km of earth road and 5.4 of paved road) in comparison with the projected one that is 10Km long (4.3 Km of earth road and 5.7 Km of paved road). In this way possibly the construction cost of the alternative road will be lower than the projected one.

Considering the high densities of *Tarentola caboverdiana substituta* in the projected area (see table 9 in appendix), if this first option not achievable it will be important to ensure the minimal viable width for truck passage for the future road in order to minimize the habitat destruction.

To construct artificial shelters, to allow a more rapid re-colonization of the animals affected by the referred habitat destruction, with the rocks removed for the road construction by leaving them scattered on the side of the road.

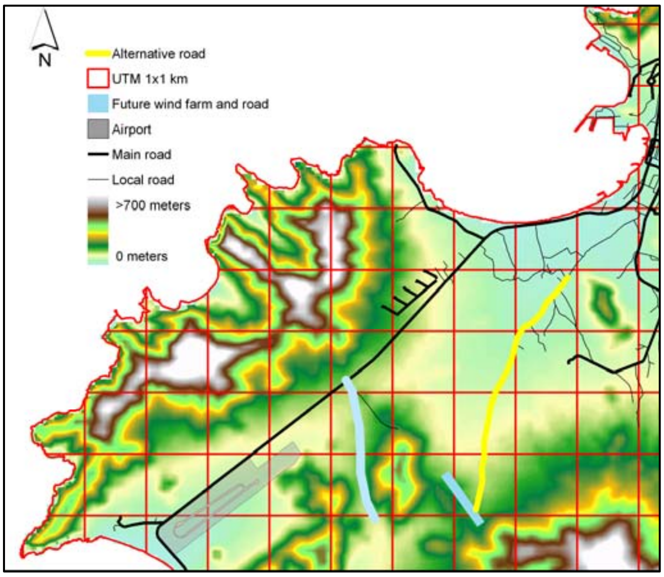


Figure 15. Projected and alternative road to the windmill farm. Projected road: total distance to Mindelo= 10 Km, non-paved road= 4.3 km; alternative road: total distance to Mindelo= 6.6 Km, non-paved road= 4.2 km.

Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), ICETA, Universidade do Porto
Campus Agrário de Vairão • Rua Padre Armando Quintas, Crasto • 4485-661 Vairão
Tel.: (351) 252 660 416 • Fax. (351) 252 661 780
ICETA - Universidade do Porto

B) Direct mortality of individuals and eggs under road construction

To remove the maximum number of individuals before the road and wind farm construction (see appendix on how to catch and manipulate them) and keeping them away of the construction area by implementing a barrier around the construction area (see appendix figure 18).

To choose the best period for undergoing construction in the area, preferentially out of the reproductive period (for now known to be around May to July).

C) Increase of future mortality by increasing facilities to human presence in the area

To implement environmental campaigns about this endemic subspecies of S. Vicente in schools to make local populations aware about its protection.

D) Potential introduction of alien competitor and predator species

To check the constructions materials for alien species and eggs before entering the construction area, e.g. filtering the sand and earth or leaving Mindelo.

To periodically monitor the wind farm for alien species.

To recollect all the rubbish and debris resulted from the construction in order to minimise the chance of colonization of the area by more rats and to avoid the increment of avian predation by the introduction of more perches for prey searching.

Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), ICETA, Universidade do Porto
Campus Agrário de Vairão • Rua Padre Armando Quintas, Crasto • 4485-661 Vairão
Tel.: (351) 252 660 416 • Fax. (351) 252 661 780
ICETA - Universidade do Porto

BIBLIOGRAPHY

Scientific References

Báez M. & Oromí P. (2005). Artrópodos. In: Lista preliminar de especies silvestres de Cabo Verde (hongos, plantas y animals terrestres). Arechavaleta, M.; Zurita, N.; Marrero, M.C. & Martín, J.L. (eds). Consejería de Medio Ambiente y Ordenación Territorial, Gobierno de Canarias, pp. 60-109.

Butterfield B.P., Meshaka W.E. & Guyer C. (1997). Non-indigenous amphibians and reptiles. In: Simberlo M.D., Schmitz D.C., Brown T.C. (Eds.), Strangers in Paradise. Island Press, Washington, DC, pp. 123–138.

Carranza S. & Arnold E.N. (2006). Systematics, biogeography, and evolution of *Hemidactylus* geckos (Reptilia: Gekkonidae) elucidated using mitochondrial DNA sequences. Molecular Phylogenetics and Evolution, 38, 531–545.

Carranza S., Arnold E.N., Mateo J.A. & López-Jurado L.F. (2000). Long-distance colonization and radiation in gekkonid lizards, *Tarentola* (Reptilia: Gekkonidae), revealed by mitochondrial DNA sequences. Proc. R. Soc. London B, 267: 637-649.

Hurlbert S.H. (1978). The measurement of niche overlap and some relatives. Ecology, 59:67-77.

Jacobs J. (1974). Quantitative measurements of food selection. Oecologia (Berlin) 14: 413-417.

Jesus J.; Brehm A. & Harris D.J. (2002). Relationships of *Tarentola* (Reptilia: Gekkonidae) from the Cape Verde Islands estimated from DNA sequence data. Amphibia-Reptilia 23 (1): 47-54.

Joger U. (1984). Die Radiation der Gattung Tarentola in Makaronesien. Courier Forschungsinstitut Senckenberg, 71: 91-111.

Joger U. (1984). Morphologische und biochemisch-immunologische Untensuchungen zur Systematik und Evolution der Gattung *Tarentola* (Reptilia: Gekkonidae). Zoologische Jahrbücher. Abteilung für Anatomie und Ontogenie der Tiere, 112: 137-256.

Joger U. (1993). On two collections of reptiles and amphibians from the Cape Verde Islands, with descriptions of three new taxa. Courier Forschungsinstitut Senckenberg, 159: 437-444.

Krebs C.J. (1999). Ecological Methodology. Addison-Welsey Longman Publishers, New York.

López-Jurado L.F., Mateo J.A. & Geniez P. (1999). Los Reptiles de La Isla de Boavista (Archipiélago de Cabo Verde). Boletín de la Asociación Herpetológica Española, 10, 10–13.

Mertens R. (1955). Die Eidechen der Kapverden. Soc. Sci. fenn. Comment. Biol., 15: 1-16

Jesus J., Brehm A., Pinheiro M. & Harris D.J. (2001). Relationships of Hemidactylus (Reptilia: Gekkonidae) from Cape Verde Islands: what mitochondrial DNA data indicate. Journal of Herpetology 35 (4): 672-675.

Schleich H.H. (1984). Die Geckos der Gattung Tarentola der Kapverden (Reptilia: Sauria: Gekkonidae). Courier Forschungsinstitut Senckenberg, 68: 95-106.

Schleich H.H. (1987). Herpetofauna caboverdiana. Spixiana Suppl. (no. 12) 75 pp.

Schleich H. (1996). Lista Vermelha Para Os Répteis (Reptilia). In T. Leyens & W. Lobin (Eds) Primeira Lista Vermelha de Cabo Verde (122–125). Frankfurt: Courier Forschungsinstitut Senckenberg, 193.

Shine S., Williams N. & Gündling L. (2000). A guide to designing legal institutional frameworks on alien invasive species. Gland, Cambridge and Bonn (IUCN).

Sokal R.R. & Rohlf F.J. (1995). Biometry. Freeman and Company, New York.

Whittaker R.J. (1998). Island biogeography: ecology, evolution and conservation. Oxford University Press. 285 pp.

Other Document

Africa infomarket.org. (eds.) O sector das energias renováveis em Cabo Verde. (2004). http://www.africainfomarket.org/aim/AIM/published/DEFAULT/paginas/55242-Portugus/Energias_Renovables.pdf

Direcção Geral de Indústria e Energia, Ministério da Economia, Crescimento e Competitividade, in "Document Preparé pour la Conference de la Banque Africaine sur le Developpement de L´Energie Eolienne en Afrique – Tunisie 28 et 29 de Octobre de 2004"

ELECTRA (2008). Relatório de Contas: 2007. A Report by Electra, Empresa de Electricidade e Água, S.A. Cabo Verde.

EWEA - European Wind Energy Association - Wind Energy - The Facts *Environment*, Vol. 4., 2008. http://www.ewea.org/fileadmin/ewea_documents/documents/publications/WETF/WETF.pdf

Instituto Nacional de Meteorologia e Geofisca (National Institute of Meteorology and Geophysics). Delegação de S. Vicente.

Plano Nacional de Desenvolvimento, 2002/2005 - Volume II

APPENDIX

Involvement of the local community in the study

We consider very important local community being involved in the study in order to motivate its members to the future conservation of the species and to give an opportunity to local students to learn and apply scientific methodologies directed to herpetology studies. In this way, with the important support of the Prof. Rui Freitas, we have presented two oral communications in UNICV, Mindelo, to the Marine Biology class about our research work and presented to them the possibility to accompanying us during the field work (figure 16).

Figure 16. Marine biology students of UNICV learning and applying scientific methodologies used for herpetological studies. A) Collecting data. B) Setting pitfall traps.

Methodology for capturing and handling Tarentola geckos

Tarentola geckos usually are not very fast-moving animals, so it is easy to catch them by hand if some guide lines are followed:

A) They are usually under medium rocks and in groups of 2 or 3 animals, so it is important when lifting a rock to catch them to count the number of animals present. This will avoid crushing one when attempting to catch another. If possible do not roll the rock but hold it in the air while another person grabs the animals that usually run around it or stay close to the rock site in the soil. They are very mimetic, so watch closely before rolling the rock again or putting it down. Always move the rock gently and in one direction only while another person tries to catch the animals giving indications where it is hiding or has moved to the helper.

B) Grab the animals with bare hands to feel it better and avoid its escape. Do not grab the animal by the tail. It will detach from the body and the animal will escape, leading to reducing its fitness with no need. The better way to grab it is covering its body and head with an open flat hand on it and then using a finger of the other hand to press it down into the soil, in the mid-body area or in a limb (figure 17 A), while the first hand grabs its full body.

C) These animals are very delicate and sensitive to pressure. Once it is grabbed, hold it gently, especially juveniles, by the limbs or in the mid-body area, using in this case the thumb and index fingers (figure 17 B) and put it into a tissue or net bag. Never use plastic bags to put the animals. Hold the bag laterally in the waist in order to avoid it to hit the rocks while moving them or put it in a fresh area in the shadow to ensure that they are sheltered from heat and dehydration.

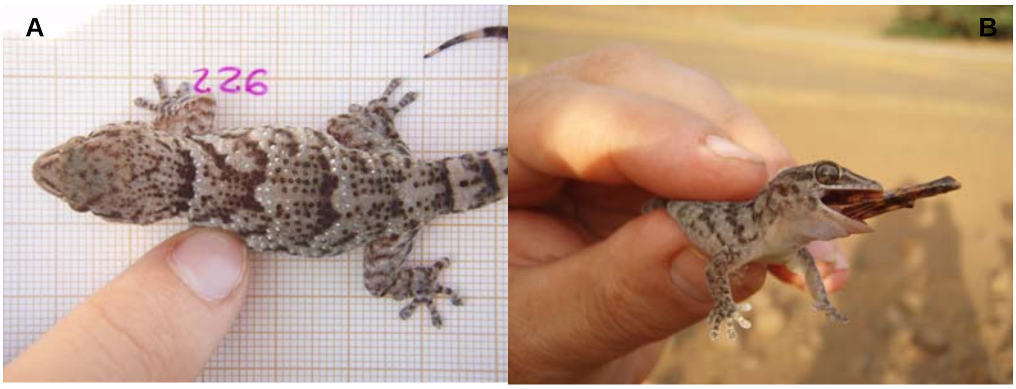


Figure 17. A) How to hold a gecko before grabbing it. B) How to hold a gecko after grabbing it.

Prevention of the re-invasion of the construction area by geckos

After capturing the maximum possible number of geckos in the construction area it is vital to prevent them of re-entering it. One possible way to achieve this is by implementing a barrier around the construction area. A simple one meter high net, with a mesh lower than one squared centimetre and embedded in a ridge into the ground, can barrier the geckos after its release (figure 18).

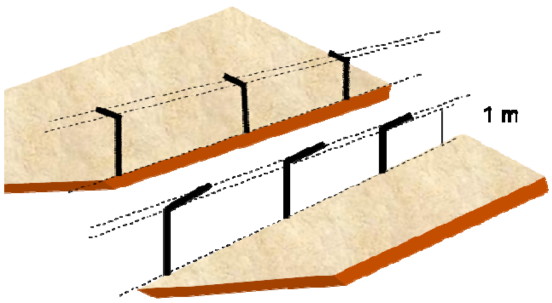


Figure 18. Structure to barrier the re-entrance of geckos in the construction area.

Estimation of densities of Tarentola geckos in the study area

Even though, due to time constrains, a specific methodology to estimate population densities was not applied (as capture-recapture technique) it is possible to make its rough estimate based on the number of geckos spotted during sampling on transects (table 9). This estimate assumes no variance in the habitat, as density is habitat dependent. It is then possible to establish the number of geckos affected by the construction, knowing its total area of impact.

Table 9. Estimation of densities of *Tarentola* geckos in the study area based on transects sampling.

Transect nr./direction	Duration (min)	Distance (m^2)	Start time (h:min)	End time (h:min)	Nr. of geckos	DENSITY (per Km^2)	DENSITY (per ha)
1 N	00:45	3870	04:15	05:00	3	775	8
1 NE	00:45	1410	03:15	04:00	7	4965	50
1 NW	00:45	2140	05:10	05:55	6	2804	28
1 S	00:45	1530	07:05	07:50	7	4575	46
1 SE	00:45	1810	08:00	08:45	7	3867	39
1 SW	00:45	3460	06:05	06:50	5	1445	14
2 N	00:45	480	09:10	09:55	6	12500	125
2 NE	00:45	1530	11:00	11:45	5	3268	33
2 NW	00:45	1300	13:15	14:00	5	3846	38
2 S	00:45	1550	10:00	10:45	8	5161	52
2 SE	00:45	1150	12:00	12:45	7	6087	61
2 SW	00:45	1510	14:05	14:55	7	4636	46
3 N	00:45	1730	15:20	16:05	7	4046	40
3 NE	00:45	850	20:15	21:00	5	5882	59
3 NW	00:45	1070	18:15	19:00	5	4673	47
3 S	00:45	930	16:15	17:00	6	6452	65
3 SE	00:45	1250	17:15	18:00	8	6400	64
3 SW	00:45	2800	19:15	20:00	6	2143	21
4 N	00:45	2260	21:10	21:55	5	2212	22
4 NE	00:45	980	23:00	23:45	6	6122	61
4 NW	00:45	3210	01:00	01:45	4	1246	12
4 S	00:45	2470	22:05	22:50	3	1215	12
4 SE	00:45	2370	02:00	02:45	4	1688	17
4 SW	00:45	2830	00:00	00:45	6	2120	21
5 N	00:45	5200	20:15	21:00	3	577	6
5 NE	00:45	1510	17:05	17:50	4	2649	26
5 NW	00:45	1230	19:25	20:10	8	6504	65
5 S	00:45	1060	15:00	15:45	8	7547	75
5 SE	00:45	1990	18:30	19:15	9	4523	45
5 SW	00:45	1600	16:00	16:45	8	5000	50
6 N	00:45	2050	03:00	03:45	5	2439	24
6 NE	00:45	4740	05:00	05:45	4	844	8
6 NW	00:45	3430	06:00	06:45	5	1458	15
6 S	00:45	3150	04:00	04:45	4	1270	13
6 SE	00:45	3440	07:00	07:45	4	1163	12
6 SW	00:45	1200	08:05	08:50	7	5833	58
7 N	00:45	1000	21:15	22:00	5	5000	50
7 NE	00:45	2000	02:00	02:45	3	1500	15
7 NW	00:45	920	22:15	23:00	2	2174	22
7 S	00:45	4390	00:10	00:55	2	456	5
7 SE	00:45	2750	01:05	01:50	5	1818	18
7 SW	00:45	4620	23:05	23:50	2	433	4
8 N	00:45	780	09:15	10:00	6	7692	77
8 NE	00:45	1470	10:10	10:55	6	4082	41
8 NW	00:45	1250	14:15	15:00	5	4000	40
8 S	00:45	530	12:05	12:50	6	11321	113
8 SE	00:45	900	11:05	11:50	6	6667	67
8 SW	00:45	1630	13:00	13:45	6	3681	37
SUM	**12:00**	**97330**			**261**		
AVERAGE±STDV		**2030**			**5**	**3891 ± 2672**	**39 ± 27**

Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), ICETA, Universidade do Porto
Campus Agrário de Vairão • Rua Padre Armando Quintas, Crasto • 4485-661 Vairão
Tel.: (351) 252 660 416 • Fax. (351) 252 661 780
ICETA - Universidade do Porto