Biogeografía de Sistemas Litorales

Dinámica y conservación

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REALIZED NICHE MODELLING OF FOUR SAND-DWELLING LIZARD SPECIES IN QATAR

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Abstract: Qatar is a small country with desert climate and marine influence where only few studies have been done on reptiles and their distribution. These data are basic for the correct conservation and management of the species and their habitats. In this work we present ecological niche models (ENMs) for four sand-dwelling lizards in Qatar, using as predictors remote sensing and climatic data. Although both sets of predictors provided similar outputs, predicting the southern sandy areas of Qatar as suitable habitat for the four species, differences were detected, and they have been corrected using distance to sand layer on the raw remote sensing model. These models were considered at least “good” (AUC>0.8), and provide a useful species distribution predictive tool, despite their limitations. Future advances in the knowledge of the environment, higher resolution habitats and climate maps, will improve these and other ecological niche models in Qatar.

Key words: MaxEnt, reptiles, distribution, biodiversity, desert

Resumen (Modelización del nicho realizado de cuatro especies de saurios arenícolas en Catar): Catar es un pequeño país de clima desértico con influencia marina donde apenas se han realizado estudios sobre reptiles y su distribución hasta ahora, siendo estos datos básicos para la correcta gestión y conservación de las especies y espacios. Por ello, se han realizado modelos de nicho ecológico (ENMs) para cuatro especies de saurios arenícolas en Catar utilizando datos satelitales y climáticos. Si bien los resultados de ambos tipos de modelos son similares, prediciendo como aptas las áreas arenosas del sur, se han detectado algunas diferencias que se han corregido añadiendo una capa de distancia a arenas al modelo de datos satelitales. Los modelos realizados, que se consideran al menos “buenos” (AUC>0.8), son una útil herramienta predictiva de la distribución de las especies, a pesar de sus limitaciones. Futuros avances en el conocimiento del entorno, hábitats y clima a alta resolución permitirán mejorar los modelos de nicho ecológico en Catar.

Palabras clave: MaxEnt, reptiles, distribución, biodiversidad, desierto

INTRODUCTION

Qatar is a small country consisting in small islands in the Arabian Gulf and a peninsula bordered by Saudi Arabia in the south. This peninsula covers 11.571 km^2 with maximum distances of 186 km from North to South and 90 km from East to West. The maximum altitude is 103 m above sea level, so the orography is generally flat.

Climate is arid with high temperatures (the average temperature is 32.8ºC, ranging between 11- 45ºC) and low precipitations (58 mm/year distributed between November and May, with maximums in November and December), but with a marine influence which allows a high relative air humidity (minimum relative humidity, 34% in June) (QSA, 2013).

There are currently at least 21 species of lizards in Qatar, based only on a small number of studies on reptile distribution (Mohammed, 1988; Castilla et al., 2013; Valdeón et al. 2013; Cogălniceanu et al., 2014).Knowing the distribution of lizards in Qatar is our main objective, since it is important for both conservation and management. The current distribution can be assumed as the realized niche of the studied species, which can be forecasted by ecological niche models (ENMs) (Sillero, 2011).

These models require environmental data, which usually are bioclimatic data, but in areas with low density of climatic observatories, ENMs can be done taking advantage of satellite imagery data (Sillero et al. 2012).
One of the problems we observed in Qatar is the loss of sandy habitats due to human alterations, so we prioritized our study by focusing on four lizard species associated with sands.

METHODOLOGY

Occurrence data were obtained during our field work in Qatar in October 2012 and March-May 2013 (92.1%) and from other sources (2008-2014) like geolocated references in scientific papers (1.3%), geotagged photos on the Internet (5.3%) and reliable records from other collaborators (1.3%) (Cogălniceanu et al., 2014), covering almost all the peninsula (Figure 1). We registered in all 18 observations of *Acanthodactylus schmidti* (AS), 27 of *Phrynocephalus arabicus* (PA), 22 of *Stenodactylus arabicus* (SA) and 8 of *Scincus mitranus* (SM).

We used MaxEnt 3.3.3k software (Phillips et al. 2006), which uses the Maximum Entropy method, to create ENMs. This software is considered powerful to create ENMs even with low sample sizes (Hernandez et al., 2006; Pearson et al., 2007). It needs occurrence data (geotagged points) and environmental data (raster layers) to run.

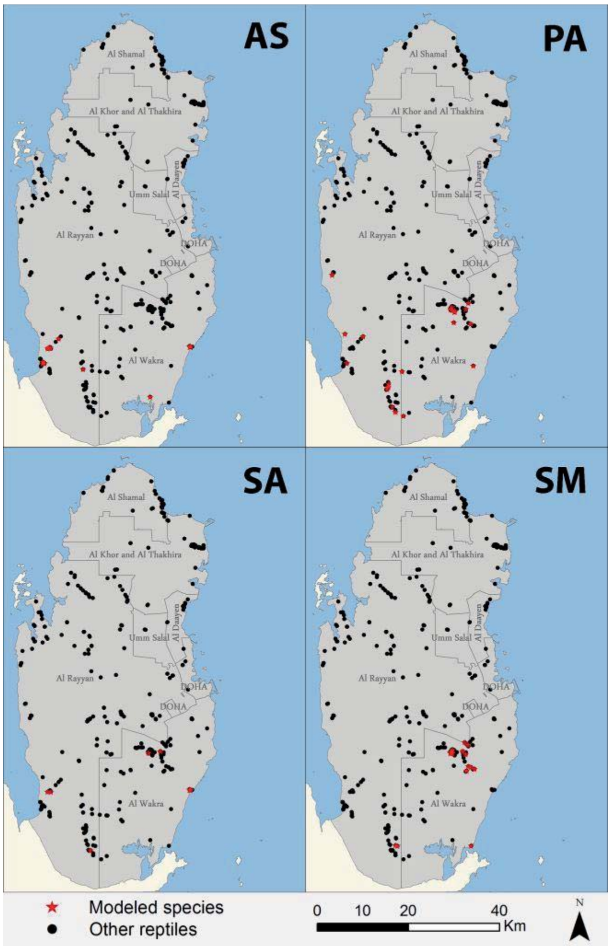

Fig. 1: Distribution of the occurrences of the four lizard species in Qatar.

We used two sets of environmental layers: one obtained from remote sensing, using cloud-free Landsat 8 image (registered on 20 May 2013, consistent with our fieldwork dates) and a DEM provided by ASTER (ASTER GDEM V.2) at 30 m resolution, and another consisting in bioclimatic variables from WorldClim database (Bioclim dataset) (Hijmans et al., 2005) provided at 30 arc-second resolution (approx. 1 km). After re-projecting these data to UTM the layout was obtained at 500 m resolution. Some observations were erased to avoid the presence of two occurrence points for the same species into the same pixel of 30 m or 500 m depending on the environmental dataset used.

From the blue, green, red, near IR, SWIR 1 and SWIR 2 layers, a new image was generated. An atmospheric correction was made by Dark Object method, and then a Principal Component Analysis was done in ERDAS Imagine 2011, saving the first three axes, and a Tasseled-Cap transformation was done, obtaining the brightness, humidity and greenness. Raw layer 11 of the Landsat 8 image was used considering it as temperature layer. We obtained altitude and slope from the GDEM.

A correlation analysis was done in ArcGIS, and the final layers were selected avoiding a correlation higher than 70%. Altitude was discarded because of the low variability in the country, and PC1 and all the layers obtained from the Tasseled-Cap were discarded because there were correlated with other layers. The remaining layers were temperature, PC2, PC3 and slope.

Furthermore, a soil supervised classification was made using ERDAS Imagine 2011 software, to extract a binary layer of sands (presence/absence) in ArcGIS 10 software. This soil classification was evaluated with a map of soils of Qatar (QSA, 2013), having a sand classification accuracy of 97.05%, with an omission error of 9.98 % and a commission error of 6.12%. Moreover, the Euclidean distance to sands was calculated to be used as environmental layer because although our target species are supposed to be associated with sands, lizards can move away and can be temporarily in other habitats if they are close to sands.

To make the models, ten repetitions per model were made, using 80% of occurrences as training and 20% as test, changing the training/test points in each repetition randomly. A consensus model was then made using the average model of the ten repetitions, and it was binarized as presence/absence model using the 10 percentile threshold.

Each average model´s accuracy was tested with the AUC (Area Under the ROC Curve) value. If this value is over 0.8 the model is considered good, or excellent if it is over 0.9.

To compare these final models among species and environmental predictors, we used the Relative Rank (RR) similitude statistic (Warren and Seifert, 2011), implemented in ENMTools 1.4. These values were compared using Mann-Whitney test among methods and among species using Past 3.01 software (Hammer et al. 2001).

DATA

ENM models had an average AUC of 0.90 (0.81-0.94) (Figure 2), so all the models can be considered at least "good" according to this criterion. Nevertheless, for SA and PA, SDA models seem to be sensibly worse than CDA and Bioclim, while for SA both remote sensing based models perform better than Bioclim.. Binary models can be seen in Figure 3.

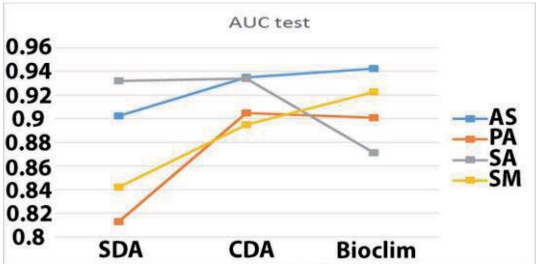

Fig. 2: AUCs of the ENMs constructed for each species and with different environmental predictors (SDA: Using only Landsat 8 data and slope as environmental layers; CDA: Using Distance to sands, Landsat 8 data and slope as environmental layers; Bioclim: Using Bioclim dataset as environmental layers).

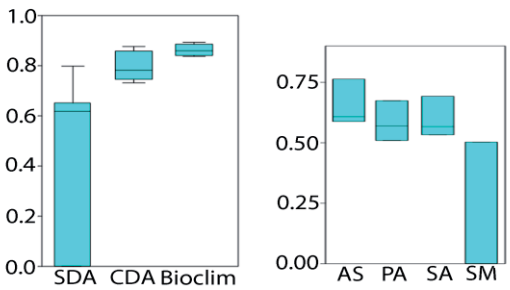

Fig. 4: Similitude among the species´ models created from each set of predictors (left), and similitude between the different outputs generated by the different set of predictors for each species (right)

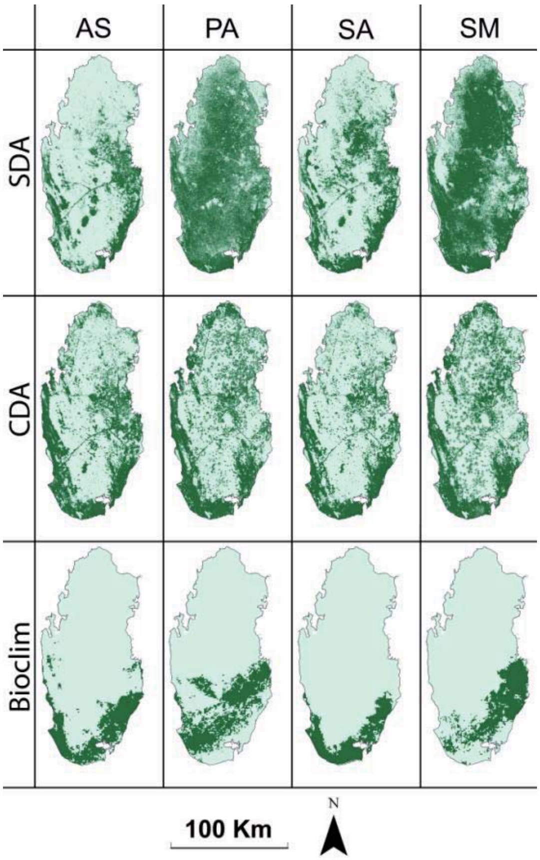

Fig. 3: ENMs constructed for each species and with different methodologies.

Our results show significant differences between the SDA and CDA models ($p<0.05$), and between the SDA and Bioclim models ($p<0.005$). However, no significant differences were found between the CDA and Bioclim models ($p > 0.05$).

When comparing intraspecific correlations between pairs of methods no significant differences were found among species, although *Scincus mitranus* SDA model is very different to the CDA (RR=0.00078) and Bioclim (RR=0.00083) models.

CONCLUSIONS

We obtained similar SDA distribution models for the species *Phrynocephalus arabicus* and *Scincus mitranus*, considering suitable almost all the peninsula. This may be explained because both species have been observed mainly in patched habitats where siliceous sand dunes are surrounded by limestone landscapes and mixed spectral signatures can be assigned to limestones in these models, or some animals were found on limestones, but always near sands.

The distance to sands layer plays a great role, correcting at least partially this error, as can be seen in the CDA models, where similar ENMs are shown for the four species (Figures 3 and 4). Since these species are distributed in the southern sandy areas of Qatar, this indicates that they are sand-dependent species, a fact confirmed by our own observations and bibliography (e.g. Arnold, 1984).

Although bioclimatic maps appear more accurate, according to AUC-test results, they can be less reliable due to the low number of climatic observatories in the area used to build the climatic database (Hijmans et al. 2005), and because we only modelled partial ranges of these species. More effort to build a robust climatic database in the country is necessary for ecological modelling and other research fields.

Although current maps can be very useful to predict the occurrence of species in areas not sampled of Qatar, future approximations made with larger sample sizes and new layers of predictors with higher spatial resolution climatic data, and higher resolution imagery or others, will improve these models, providing an essential biodiversity management tool.

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