

# A preliminary report on the distribution of lizards in Qatar

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## Abstract

We have updated the list of the lizard species present in Qatar and produced the first distribution maps based on two field surveys in 2012 and 2013. We used the QND95/Qatar National Grid with a grid of 10 × 10 km squares for mapping. Our results show the occurrence of 21 lizard species in Qatar, from the 15 species indicated in the last biodiversity report conducted in 2004. The most abundant family found in Qatar is Gekkonidae with nine species (*Bunopus tuberculatus*, *Cyrtopodion scabrum*, *Hemidactylus robustus*, *H. flaviviridis*, *H. persicus*, *Stenodactylus arabicus*, *S. slevini*, *S. doriae*, *Pseudoceramodactylus khobarensis*), followed by Lacertidae with four species (*Acanthodactylus schmidti*, *A. ophodurus*, *Mesalina brevirostris*, *M. adramitana*), Agamidae with three species (*Trapelus flavimaculatus*, *Uromastix aegyptia*, *Phrynocephalus arabicus*), Scincidae with two species (*Scincus mitranus*, *Trachylepis septemtaeniata*), and Varanidae (*Varanus griseus*), Sphaerodactylidae

(*Pristurus rupestris*) and Trogonophiidae (*Diplometopon zarudnyi*) with one species each. The species richness fluctuated largely across Qatar between one and eleven species per grid square. We believe that the lizard fauna records in Qatar are still incomplete and that additional studies are required. However, our study here fills a gap concerning lizard biodiversity knowledge in the Gulf Region.

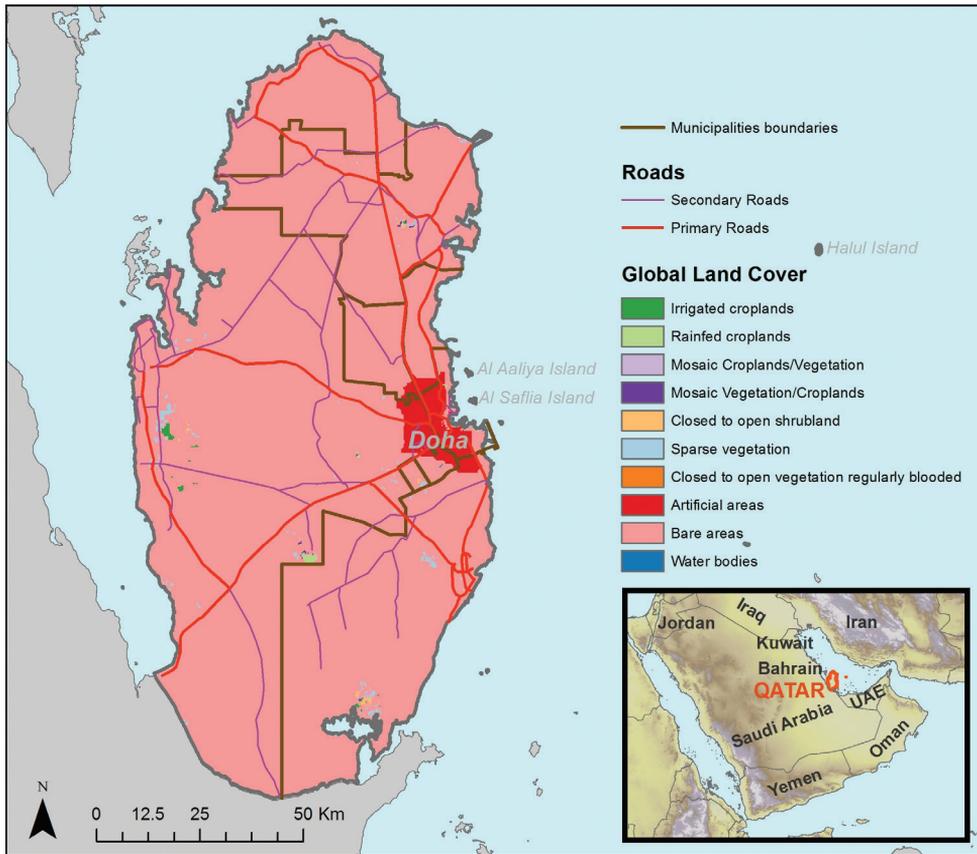
### Keywords

Reptilia, geographic distribution, species richness, inventory, maps, biodiversity, atlas

## Introduction

The rapid worldwide decline of reptiles has raised concerns about their conservation and the urgent need for action (Gibbons et al. 2000). A recent survey of the status of reptiles has shown that nearly one of five reptilian species are threatened with extinction and one of five classified as Data Deficient (Böhm et al. 2013). The decline of reptiles has been influenced by a variety of threats such as habitat loss, degradation and fragmentation, pet trade, invasive species, pollution, diseases and climate change (Böhm et al. 2013, Cox and Temple 2009, Gibbons et al. 2000). For the management and conservation of reptiles, quality species and population data is required to understand and predict the potential impacts caused by human activities. Because the lack of occurrence data is limiting both our understanding of the species needs and the management options (Primack 2010), several global scale initiatives were initiated to compile the vast biodiversity datasets (e.g. Global Biodiversity Information Facility – GBIF, Encyclopedia Of Life – EOL). Such databases accompanied by the advances in computation and advanced analysis allow for the proper management of data based on scientific knowledge (Matin et al. 2012, Reese et al. 2005). Unfortunately, the data available in these global databases is spatially biased, mainly because only few countries are contributing the majority of data.

The state of Qatar is a peninsula with an area of 11,571 km<sup>2</sup> that lies between 24–27°N and 50–52°E (Figure 1). The peninsula projects 186 km north from Saudi Arabia and varies in width between 55 and 90 km. Much of the country is flat with a highest elevation of 103m. Global Land Cover v2.3 identifies 10 coverage categories in Qatar (Figure 1, ESA 2010). The soil consists of a low barren plain covered with rocks, sand or small dunes, arable land representing only 1.6% (Hutchinson Encyclopedia 2011). Qatar's climate is hot and arid with an average annual mean temperature of 27 °C and 75 mm rainfall/year. There are no forests in Qatar and vegetation coverage is scarce with bushes and grasses of sporadic species and some *Acacia* trees (Batanouny 1981). Date palms and exotic vegetation is concentrated in farms across the country. Qatar has the highest density of camels in the Middle East (Richer 2008), however conservation measurements related to livestock management have been only recently implemented by the Ministry of the Environment (MOE) in Qatar. Qatar's population has been increasing rapidly throughout the last decades, reaching currently 1.8 million inhabitants mainly concentrated (80%) in



**Figure 1.** Location of Qatar within the Arabian Peninsula, and general map of Qatar. Global Land Cover was obtained from GlobCover 2.3 (ESA 2010)

the capital of the country (Doha) (Qatar Statistics Authority 2013). The economic growth of Qatar is closely related to ongoing increases of hydrocarbon extraction, since Qatar lies in a strategic location with major petroleum and gas deposits (Qatar Statistics Authority 2013). Human impact, including oil and gas extraction, population growth and infrastructure development represent major threats for the survival of the sparsely and locally disseminated lizard populations, usually with low densities. As a Party of the Convention of Biological Diversity (CBD), Qatar has prepared a National Biodiversity Strategy and Action Plan clearly indicating the commitment to give priority to environmental issues towards sustainable development and preservation of biodiversity (MOE 2004).

The lizard fauna of Qatar is poorly known. Apart from the study of Mohammed (1988) who reports the presence of 16 lizard species in Qatar, there is no comprehensive study available for the country. Additional information reporting the presence of lizards in the country is dispersed in several scientific publications (e.g., Arnold 1980a, 1980b, Leviton et al. 1992, Castilla et al. 2011a, Metallinou et al. 2012) or the data

is scattered in grey literature (Anonymous 2010, Nasher et al. 2009). To date there is not a single distribution map for any lizard species in Qatar, and very little is known about the biology and ecology of any of the Qatar lizard species except for some recent studies (Castilla et al. 2011a, b, Castilla et al. 2013, Martín et al. 2012, Herrel et al. 2013, Valdeón et al. 2013a). The aim of the present study is (i) to provide an inventory of the lizard species present in Qatar, (ii) to map their distribution, and (iii) to conduct a preliminary analysis of spatial lizard richness.

## Methods

### Mapping species occurrences

The inventory of lizard species present in Qatar was conducted during 45 days of field work in October 2012 (15 days) and in March–May 2013 (30 days), with an average time of 6 hours per day spent searching for lizards (range 3–10 hours/day). The surveys were conducted in the mainland and in three islands. Halul Island (25.67N, 52.40E) is in the E of Qatar at 81.5 km from the nearest coast in Al-Khor. Al Aaliya Island (25.41N, 51.56E) is situated at 2.5 km from the Eastern coast near Doha city. Al Saffia Island (25.34N, 51.58E) is also in the Eastern coast at a distance of 3.1 km from Doha. Al Aaliya and Al Saffia islands are separated by 5.5 km. The methods used for the inventory varied according to the habitat and time of the day, and are consistent with McDiarmid et al. (2012). The most used methods were active search during the day and night-torch surveys along transects. Most types of habitats were inventoried and special focus was given to searching under natural cover (rock-flipping) and artificial (i.e. litter) cover that often provided shelter to reptiles. On low traffic roads we conducted road surveys, both during the day and night. We occasionally also used pitfall traps and artificial cover (i.e. cardboard) for short periods of time of less than 48 hrs. The geographic location of each individual was taken on a Global Positioning System (GPS). When several individuals of the same species occurred within a short distance of one another, only one spatial data point for that given species was considered. This explains the difference between the number of species sightings and the higher number of lizards observed.

The majority of the data included in the final distribution maps come from our own surveys. However, we have also added three records from publications of Qatar University (Anonymous 2010, Nasher et al. 2009), and 41 records from local volunteers and photographers that accompanied their observations with clear photographs, GPS coordinates or grid square locations. The lizard species were identified based on morphological traits described in Arnold (1986) and Leviton et al. (1992). The most current changes in the nomenclature of the species were according to Fujita and Papenfuss (2011), Moravec et al. (2006), Pyron et al. (2013) and Bauer et al. (2013). Lizard voucher specimens are deposited in the scientific collections of the Ministry of Environment in Qatar. The distribution data belongs to the Ministry of Environment of the State of Qatar and will be uploaded to GBIF in the future.

## Data management and analysis

To make the distribution maps we proceeded as follows. The GPS geocoordinates were exported to ArcGIS 10 (ESRI) to create a shapefile, which was projected to the official reference system in the country, QND95/Qatar National Grid (UPDA 2009). A regular grid with squares of  $10 \times 10$  km was made following the Qatar National Grid, while adapting the traditional nomenclature of UTM (Universal Transversal Mercator) or MGRS (Military Grid Reference System) squares (NGA 2013) to the Qatar National Grid (Valdeón et al. 2013b). A similar spatial resolution of  $100 \text{ km}^2$  was previously used in several national and regional herpetological atlases (e.g. Arnold 1995; Godinho et al. 1999; Gosá and Bergerandi 1994; Oldham and Weller 2000; Pickard and Towns 1988; Pleguezuelos et al. 2002).

Species richness per square was calculated as the number of species detected in each  $10 \times 10$  km square. We used two relative measures as estimators of species abundance: (i) The percentage of daily sightings, measured as the number of days a certain species was observed from the total number of fieldwork days ( $n = 45$ ), so we did not consider multiple sightings of the same species. (ii) The percentage of overall sightings. This was calculated as the number of times a species was observed from the total number of sightings ( $n = 617$ ). We used presence-absence data for computing a species accumulation curve (SAC) and five non-parametric estimators of species richness (ICE, Chao 2, Jackknife 1, Bootstrap and Michaelis-Menten) using EstimateS 9 (Colwell 2013).

## Results

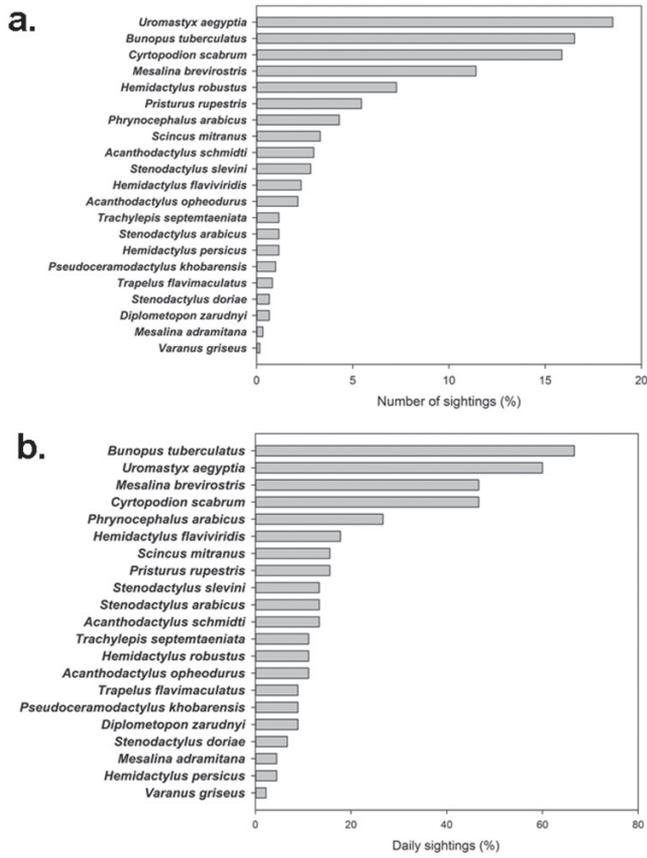
During the 45 days of field surveys we observed a total of 865 individual lizards ranging from 5 to 35 per day (average of 19 individuals/day). The total number of species sightings is lower (617), since for some species several individuals were located close together, usually under the same shelter.

We inventoried 21 species of lizards belonging to seven families: Gekkonidae with nine species, Lacertidae with four species, Agamidae with three, Scincidae with two and Varanidae, Trogonophiidae and Sphaerodactylidae with one species each (Table 1). The number of lizard species observed per day ranged between 1 to 10 (average of  $4.1 \pm 2.1$ ). In the island Al Saffia we only found two species (*Pseudoceramodactylus khobarensis* and *Mesalina brevirostris*), in Al Aaliya island we found three species (*Pseudoceramodactylus khobarensis*, *Mesalina brevirostris* and *Hemidactylus robustus*), and in Halul island we found five species (*Hemidactylus persicus*, *H. flaviviridis*, *Cyrtopodion scabrum*, *Pristurus rupestris* and *Trachylepis septemtaeniata*). Based on our measurements of relative abundance, we found that four species of lizards appear to be the most abundant: *Bunopus tuberculatus*, *Cyrtopodion scabrum*, *Uromastyx aegyptia* and *Mesalina brevirostris* (Figure 2). The species accumulation curve approaches a plateau, suggesting that the majority of species present has been inventoried (Figure 3). The

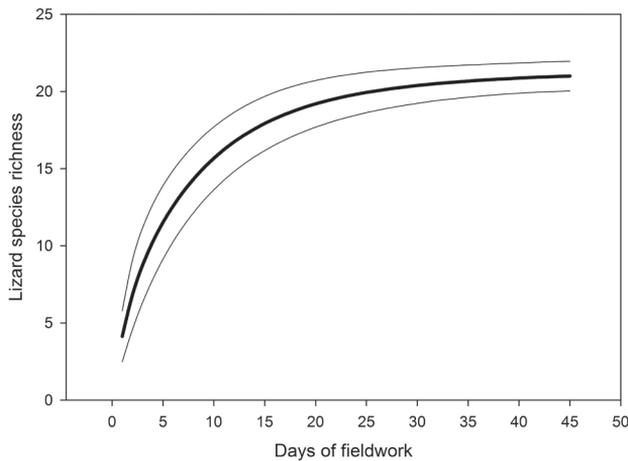
**Table 1.** Lizard species inventoried in Qatar during the surveys conducted in 2012–2013, and publications where the species (or other species probably mistaken with correct species) are recorded for the first time in Qatar.

Species	Family	First record in Qatar
<i>Pristurus rupestris</i> Blanford, 1874 (a)	Sphaerodactylidae	Ministry of Environment 2004
<i>Pseudoceramodactylus khobarensis</i> Haas, 1957	Gekkonidae	Valdeón et al. 2013a
<i>Senodactylus arabicus</i> (Haas, 1957)	Gekkonidae	Metallinou et al. 2012
<i>Senodactylus doriae</i> (Blanford, 1874) (a)	Gekkonidae	Metallinou et al. 2012
<i>Senodactylus slevini</i> Haas, 1957	Gekkonidae	Arnold 1980b
<i>Bunopus tuberculatus</i> Blanford, 1874 (a)	Gekkonidae	Mohammed 1988
<i>Cyrtopodion scabrum</i> (Heyden, 1827)	Gekkonidae	Mohammed 1988 (cited as <i>Gymnodactylus scaber</i> )
<i>Hemidactylus flaviviridis</i> Rüppell, 1835	Gekkonidae	Mohammed 1988
<i>Hemidactylus persicus</i> Anderson, 1872	Gekkonidae	Castilla et al. 2013
<i>Hemidactylus robustus</i> Heyden, 1827	Gekkonidae	Mohammed 1988 (cited as <i>H. turcicus</i> )
<i>Scincus mitranus</i> Anderson, 1871	Scincidae	Mohammed 1988 (cited <i>S. scincus</i> , probably mistaken with <i>S. mitranus</i> )
<i>Trachylepis septemtaeniata</i> (Reuss, 1834)	Scincidae	Mohammed 1988 (cited as <i>Mabuya aurata</i> )
<i>Diplometopon zarudnyi</i> Nikolsky, 1907	Trogonophiidae	Mohammed 1988
<i>Mesalina adramitana</i> (Boulenger, 1917)	Lacertidae	Arnold 1980a
<i>Mesalina brevirostris</i> Blanford, 1874 (b)	Lacertidae	Mohammed 1988 (cited as <i>Eremias brevirostris</i> )
<i>Acanthodactylus schmidti</i> Haas, 1957	Lacertidae	Mohammed 1988 (cited <i>A. scutellatus</i> , probably mistaken with <i>A. schmidti</i> )
<i>Acanthodactylus ophiodurus</i> Arnold, 1980	Lacertidae	Mohammed 1988 (cited <i>A. boskianus</i> , probably mistaken with <i>A. ophiodurus</i> )
<i>Varanus griseus</i> (Daudin, 1803)	Varanidae	Mohammed 1988
<i>Uromastyx aegyptia</i> (Forskål, 1775)	Agamidae	Mohammed 1988 (cited as <i>U. microlepis</i> )
<i>Phrynocephalus arabicus</i> Anderson, 1894	Agamidae	Mohammed 1988 (cited as <i>P. nejdensis</i> )
<i>Trapelus flavimaculatus</i> Rüppell, 1835	Agamidae	Mohammed 1988 (cited as <i>Agama flavimaculata</i> )

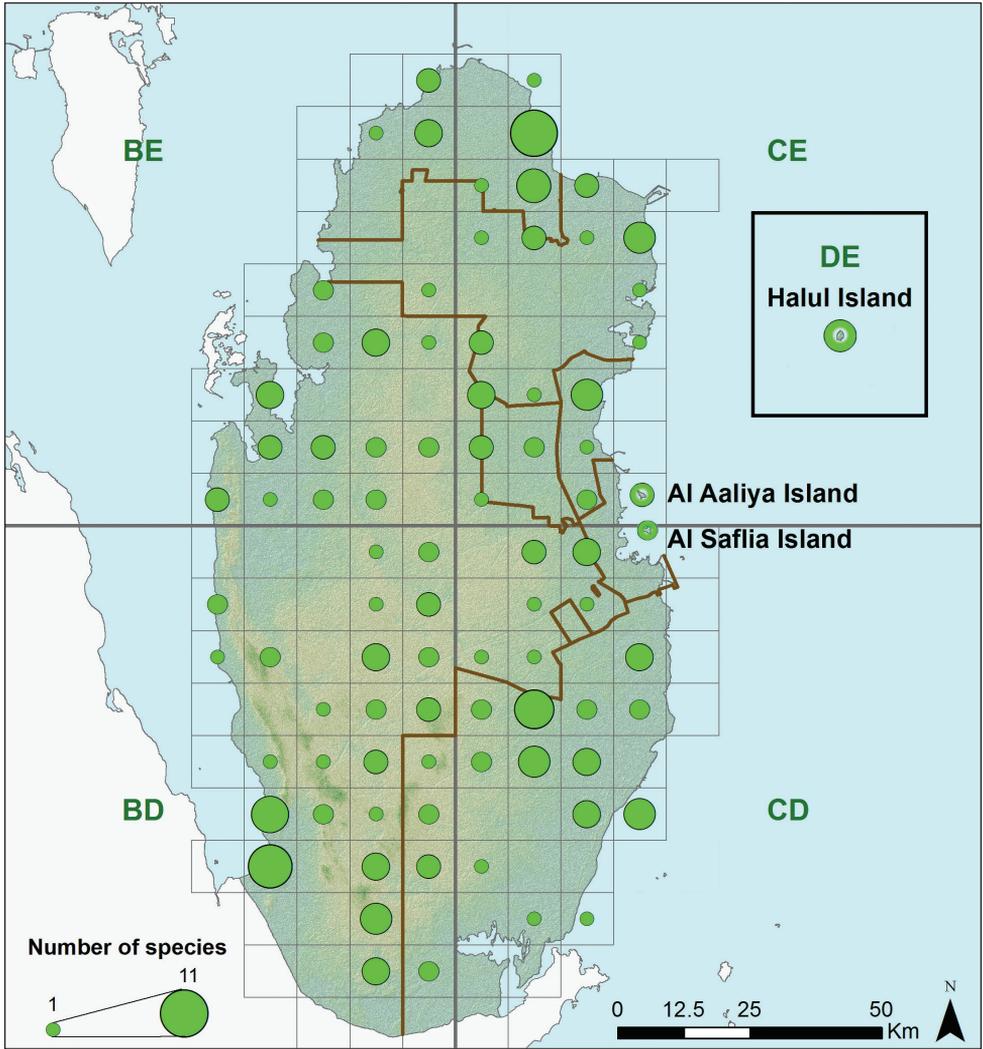
use of non-parametric estimators of species richness supports this statement indicating that only 2–4 species of lizards remain to be discovered (estimator, mean value  $\pm$  standard deviation): ICE 23.61  $\pm$  0.01, Chao 2 25.83  $\pm$  5.86, Jackknife 1 25.83  $\pm$  2.01, Bootstrap 23.11, and Michaelis-Menten 24.63. The preliminary lizard species richness varied largely across Qatar between 1–11 species per grid square (Figure 4). The distribution maps for the 21 lizard species in Qatar are presented in Figures 5–13, and Figure 14 shows the photos of the lizards.



**Figure 2.** Estimates of lizard species abundance based on **a** the proportion of sightings of a certain species from the total number of sightings ( $n = 617$ ), and **b** the presence of a species per day from the total number of fieldwork days ( $n = 45$ ) (see methods for details).



**Figure 3.** Species accumulation curve (bold line) reflecting lizard species richness based on presence-absence data for the whole country. The thin lines indicate the estimated error margins (95%).



**Figure 4.** Lizard species richness at a resolution of 100 km<sup>2</sup>.

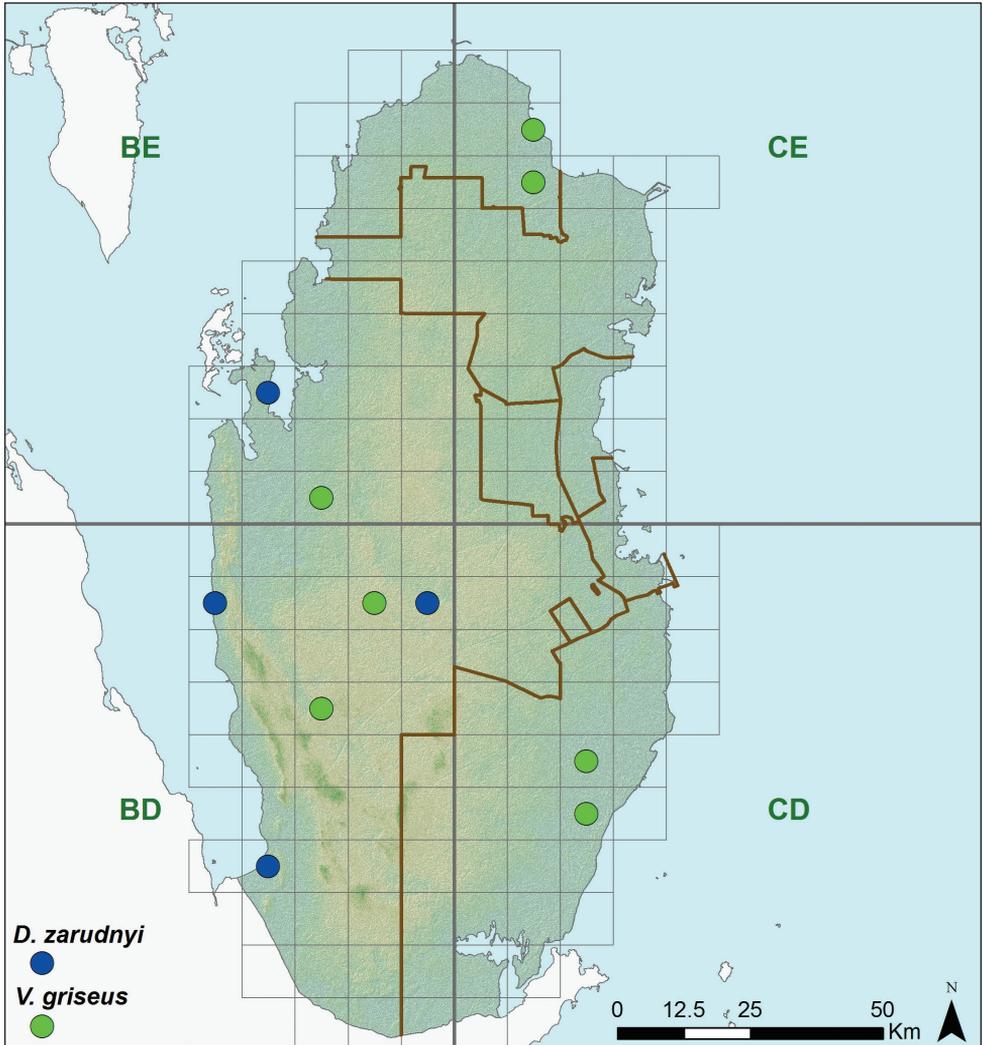
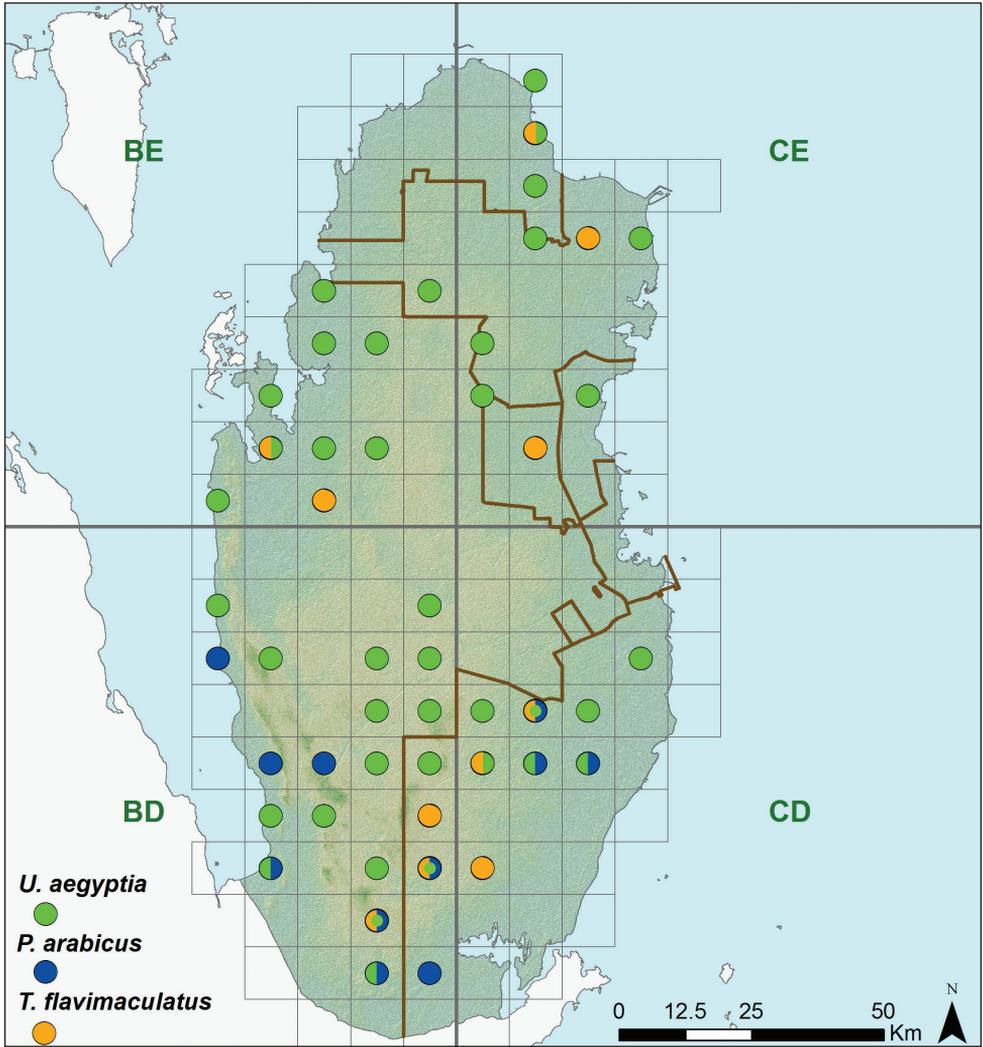


Figure 5. Distribution of *Diplometopon zarudnyi* and *Varanus griseus*.



**Figure 6.** Distribution of three agamid species (*Phrynocephalus arabicus*, *Trapelus flavimaculatus*, *Uromastyx aegyptia*).

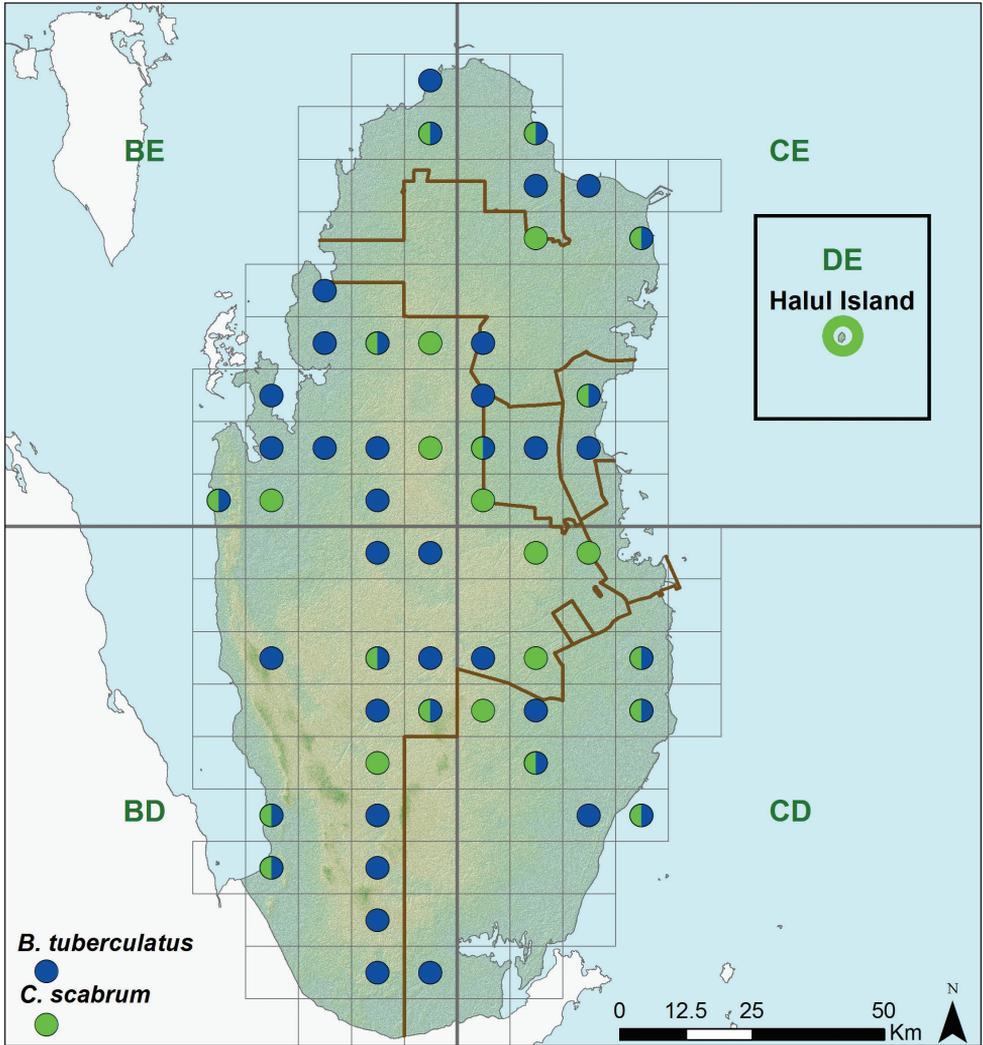


Figure 7. Distribution of *Bunopus tuberculatus* and *Cyrtopodion scabrum*.

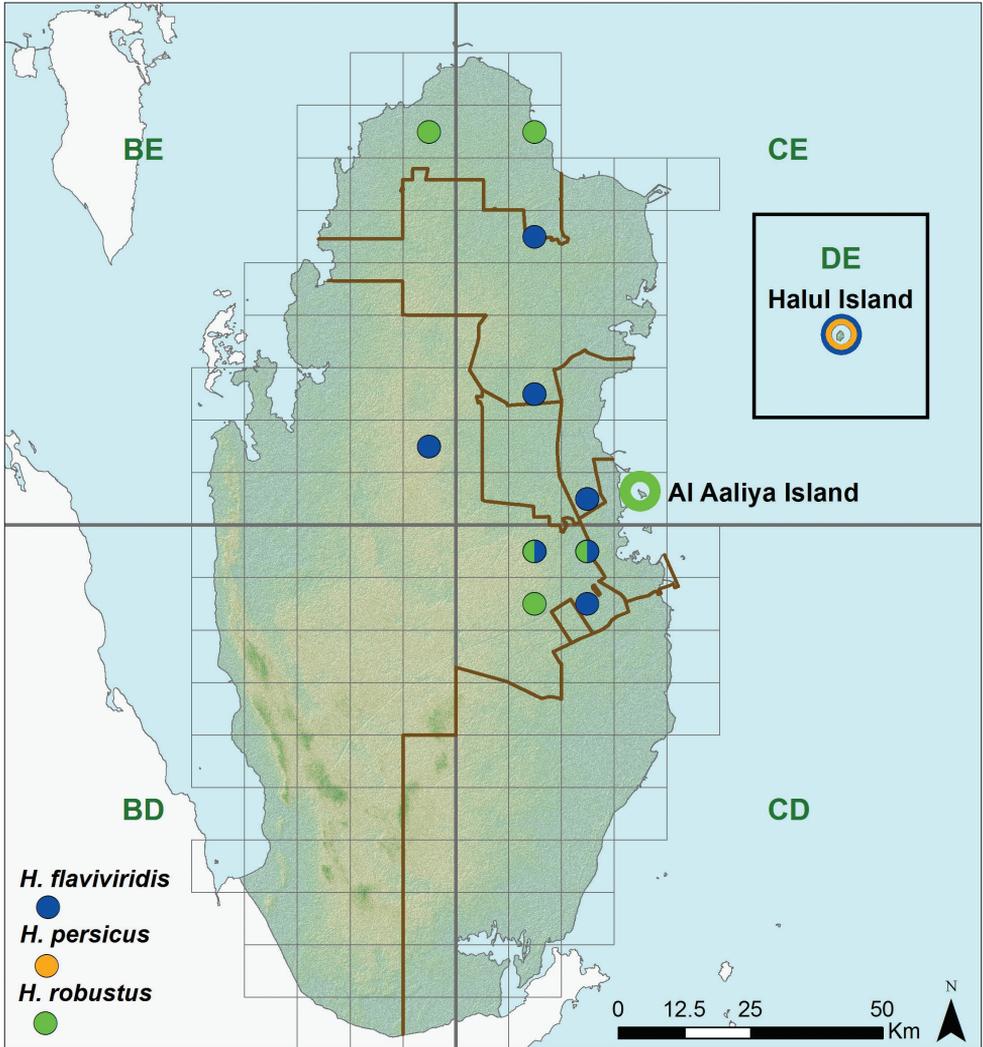


Figure 8. Distribution of the species of the genus *Hemidactylus*.

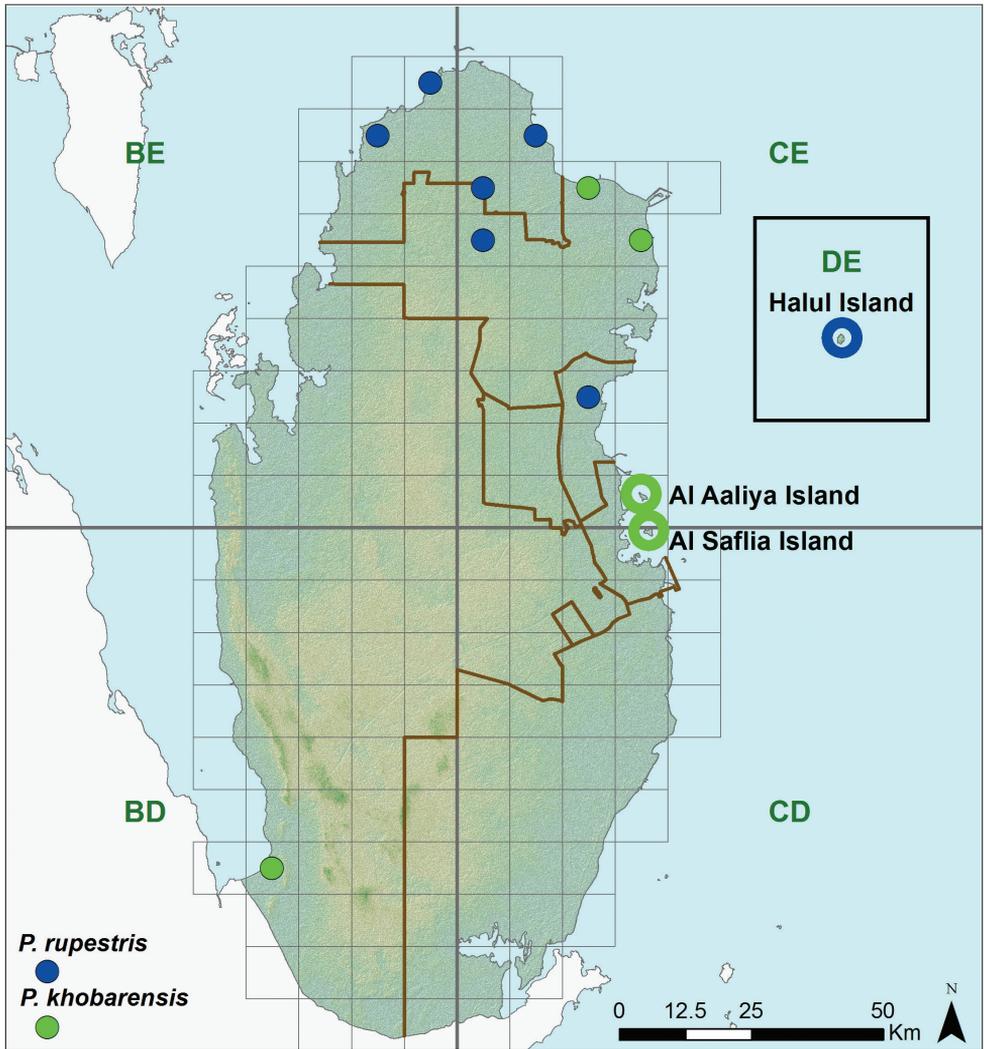


Figure 9. Distribution of *Pseudoceramodactylus khobarensis* and *Pristurus rupestris*.

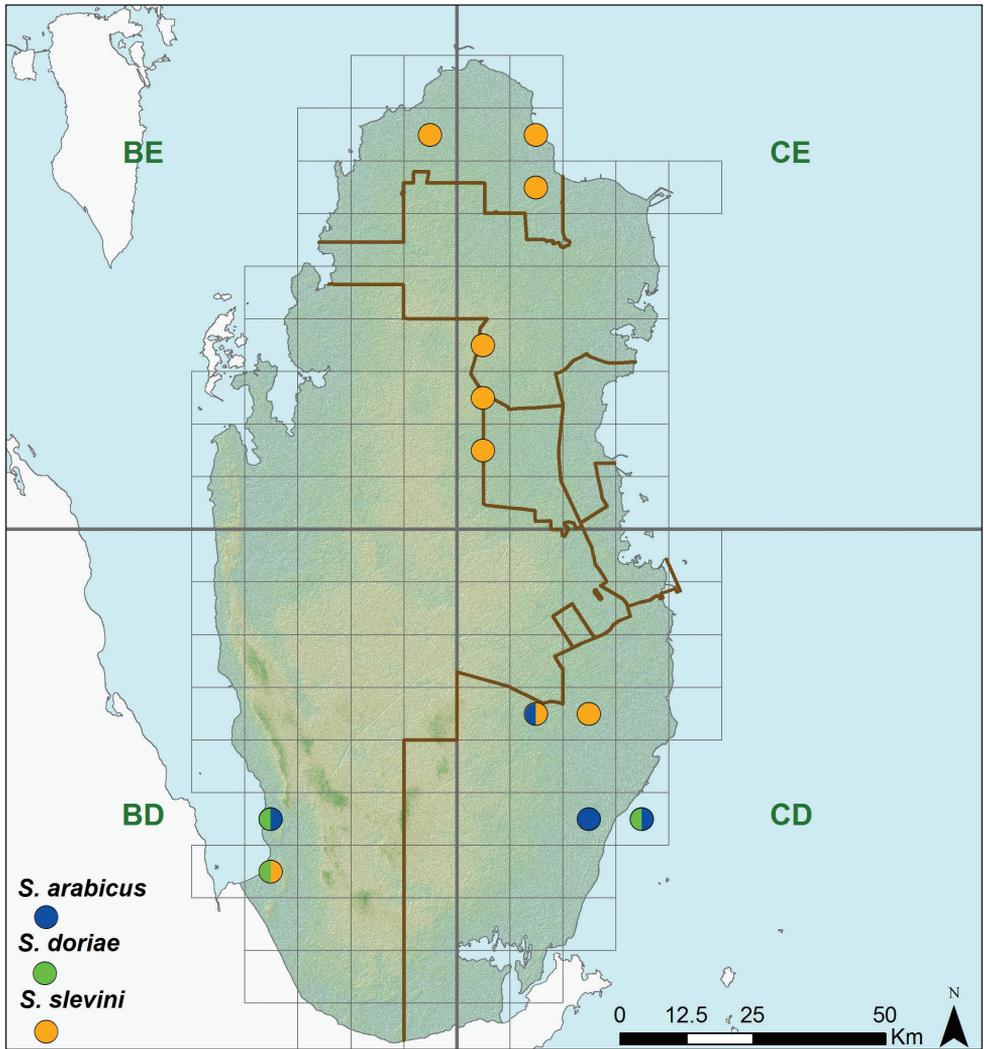
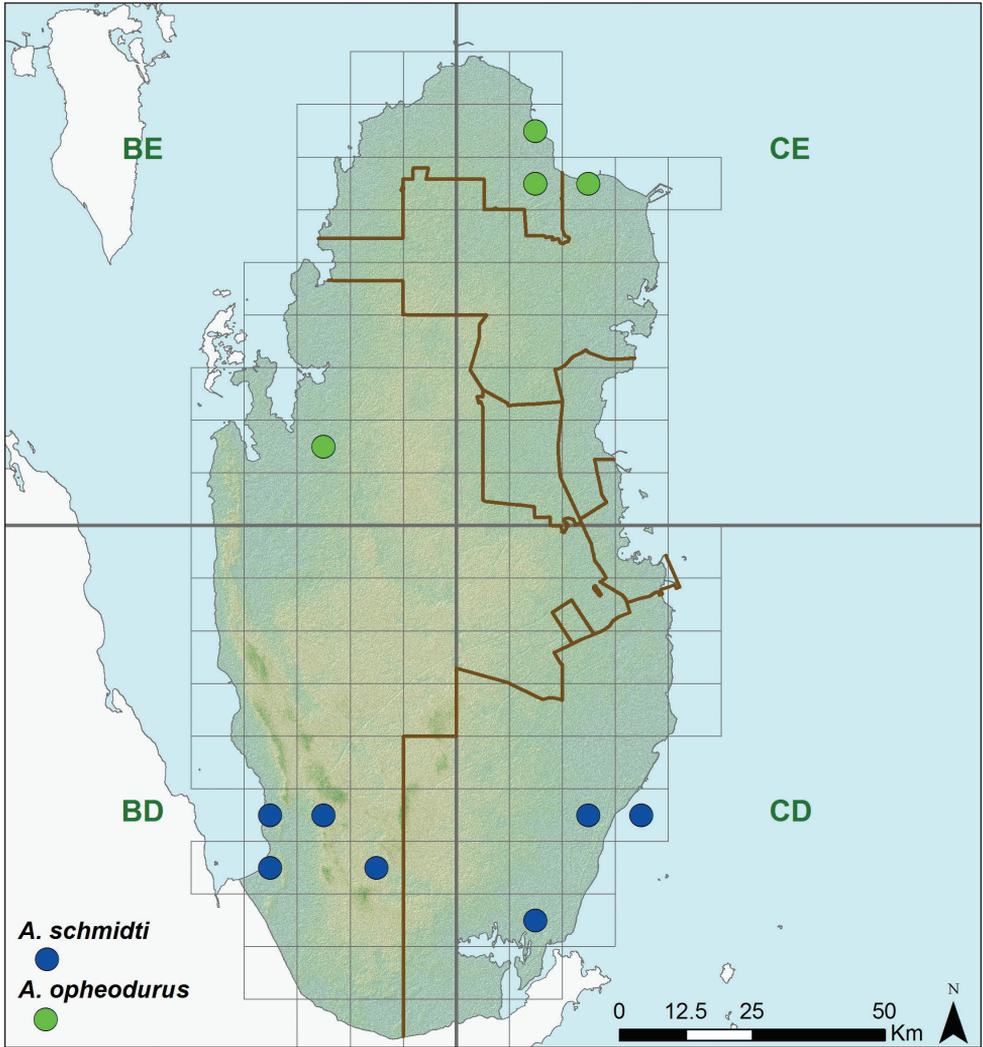
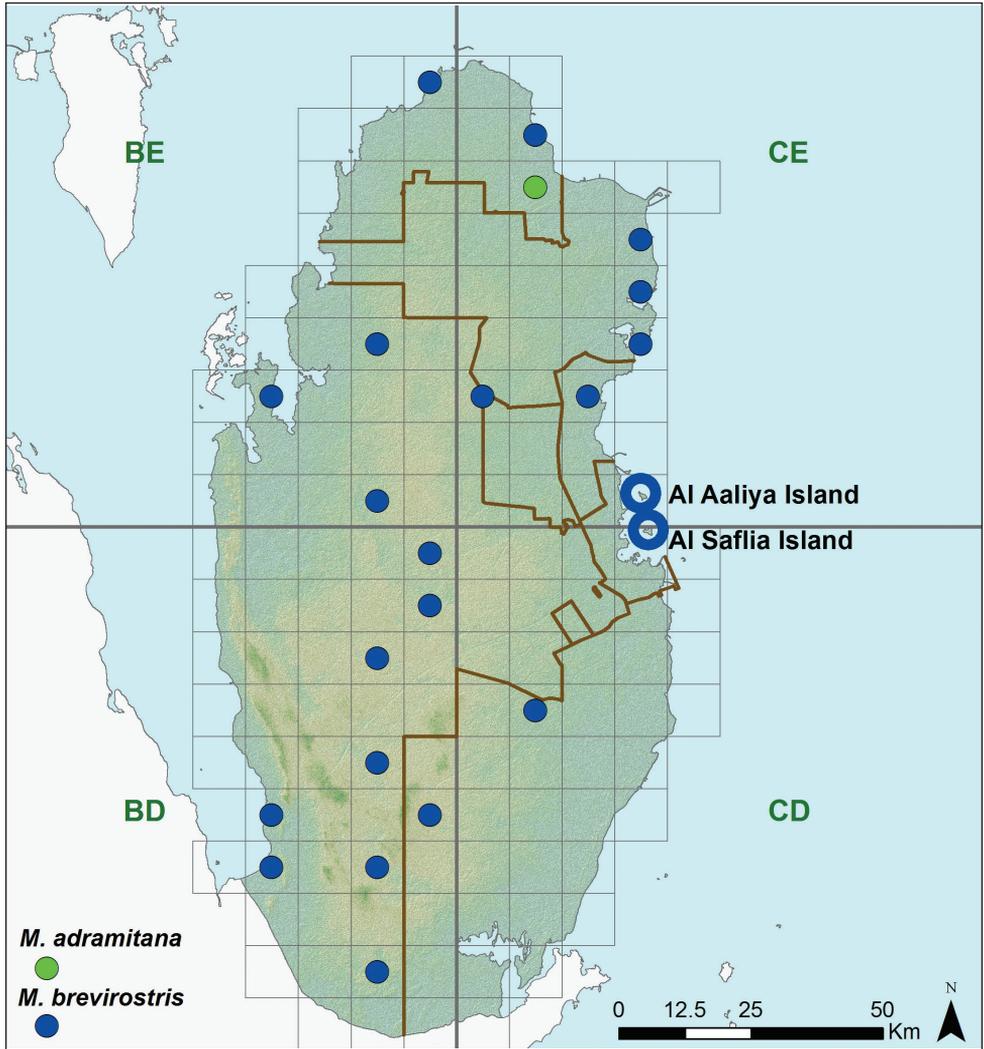


Figure 10. Distribution of the species of the genus *Stenodactylus*.



**Figure 11.** Distribution of the species of the genus *Acanthodactylus*.



**Figure 12.** Distribution of the species of the genus *Mesalina*.

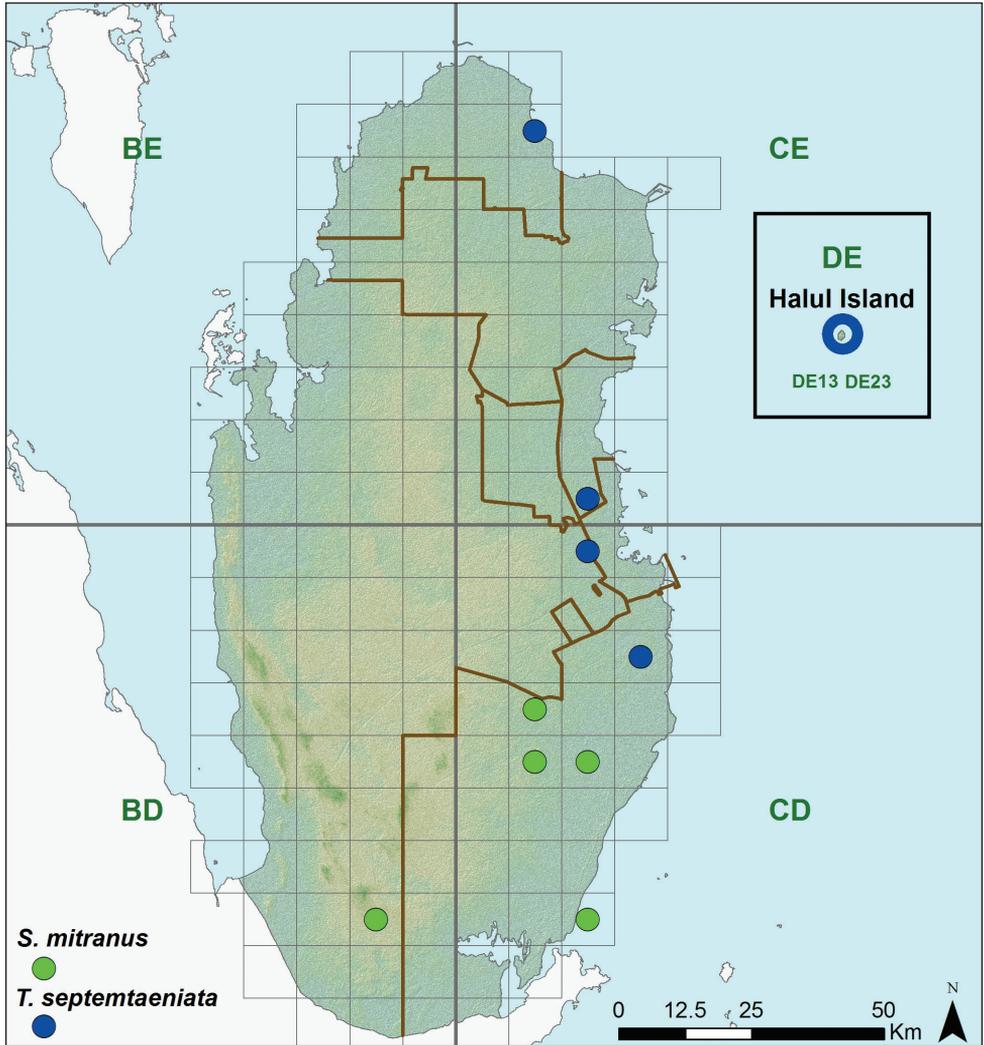


Figure 13. Distribution of Scincidae species (*Scincus mitranus* and *Trachylepis septemtaeniata*).



**Figure 14.** Photos of lizard species inventoried in Qatar (Author: Valdeón A, except for *Diplometopon zarudnyi* (Yamaguchi N)).

## Discussion

In this study we provide the first consistent list of lizard species for Qatar, and the first distribution maps based on field surveys. Our study fills a gap in the knowledge of lizard distributions in the Arabian Peninsula and in Qatar specifically. Except for the study of Mohammed (1988), previous data has not been systematic and only included anecdotal references (Arnold 1980b, Leviton et al. 1992, Metallinou et al. 2012, Sindaco and Jeremčenko 2008).

During our surveys we attempted to collect data throughout the entire country; however this was not possible due to difficulties of accessing certain areas (e.g. industrial and private properties). The SE part of Qatar is difficult to access due to sandy soils and that was not fully sampled either. There are also differences in lizard species detectability due to differences in body size (e.g. maximum snout-vent length in *Uromastyx aegyptia* of 375 mm and only 32 mm in *Pristurus rupestris* (Meiri 2008)), behavior and period of activity (night or day). The lack of past information on the lizard species present in Qatar does not allow identifying allochthonous from native species. We consider species strictly associated with urban areas (e.g., *Hemidactylus flaviviridis*) as probably introduced, but further phylogeographic studies are required to elucidate their status. However, despite such difficulties, our lizard species inventory seems to be nearly completed as indicated by the estimators of species richness and the SAC (Fig. 3). Nevertheless, it could be not surprising to find in Qatar additional lizard species that occur in the vicinity of Qatar. The maps provided in Sindaco and Jeremčenko (2008) show that 13 lizard species are present near Qatar, including *Ptyodactylus hasselquistii*, *Teratoscincus (scincus) keyserlingii*, *Phrynocephalus maculatus*, *Pseudotrapelus* sp., *Trapelus ruderatus*, *T. pallidus*, *Chalcides ocellatus*, *Scincus scincus*, *Acanthodactylus boskianus*, *A. haasi*, *A. gongrorhynchatus*, *A. scutellatus*, and *Mesalina guttulata*.

The preliminary species distribution maps provided in this study allow, nevertheless, for further analysis on distribution patterns of abundance, rarity, richness and assemblage composition at larger spatial scales (Elith et al. 2010, Baselga et al. 2012). The distribution data are also valuable for conservation planning and modeling species distribution at regional and global level (Sillero et al. 2005).

The reptiles of Qatar are threatened by the rapid human population growth that increased from several tens of thousand inhabitants to almost two million in the last century, habitat destruction caused by construction development, gas and oil extraction and transport facilities, and the introduction of alien species (especially cats). The human impact is unevenly distributed, with high human impact in and around Doha, moderate along the coast and low in the interior (WCS 2005). Qatar produces around 2 million tons of solid municipal waste annually, corresponding to a daily generation rate of about 2.5 kg per capita that are disposed mainly through landfill and composting. This increase in solid waste generation not only results in the environmental pollution but also habitat destruction (Al-Maaded et al. 2012). There are 7790 km of roads (0.67 km road/km<sup>2</sup>), of which 90% are paved, and 571 cars per 1,000 people (2002

est) (Hutchinson Encyclopedia 2011). High traffic on roads, particularly in rural areas, can result in high mortality in reptile populations (e.g. Shepard et al. 2008). Road-kills are frequent and while it is difficult to document it in small lizards, carcasses of larger lizards like *Uromastyx* are often found along roads. The response of lizards to the relatively recent human impact in Qatar provides an excellent example of the winner-loser concept (McKinney and Lockwood 1999), with several species benefiting from man-made artificial habitats (e.g. *Cyrtopodion scabrum*, *Hemidactylus flaviviridis*, *H. robustus*). We estimate that human activities will result in changes in the ranges of the lizards of Qatar and stress the urgent need for a complete species inventory and mapping, as a background study for a future monitoring program.

## Conclusion

The distribution maps presented in this paper as visualized occurrence records fill a gap in the knowledge of biodiversity in Qatar, and will help the prioritization of conservation efforts and the identification of important conservation areas for lizards. This study is a first step in updating the Qatar databases of lizards and wildlife, with the goal to make scientific biodiversity data available and useful for the international community.

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