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Facts and misconceptions on the Palaearctic existence of the striped ground squirrel

https://doi.org/10.1515/mammalia-2017-0060
Received May 26, 2017; accepted July 27, 2017

Abstract: The striped ground squirrel has a wide distribution in the Ethiopian region but is restricted to a small isolated area in Palaearctic Africa. This fragment was first recorded in the late 1940s in the Souss Valley (Morocco), however, not a single new observation has been published in the following decades. In September 2016 we surveyed the Souss Valley and found squirrels at 43 sites within the triangle between Agadir–Taroudant–Tiznit. Occupied sites were not distributed at random but occurred between an altitude of 45–254 m and on a substrate with coarse texture containing >65% sand. The vast majority of the sites with squirrels (69%) were classified as suburban, cultivated or both. Habitat suitability was estimated by applying geographically weighted logistic regression analysis. The influence of local predictor variables varied across the study area indicating the heterogeneous effects on the determination of the occurrence of the species. The modelled highly suitable habitat area for the striped ground squirrel in Morocco covers almost 690 km^2 and only marginally overlaps the range for the species reported in the literature.

Keywords: *Euxerus erythropus*; habitat modelling; habitat suitability; Morocco; Sciuridae.

Introduction

Species are unique by definition and this also holds for their patterns of spatial occupancy. Distributional ranges echo the exclusive ecological requirements of species and their evolutionary history in response to past ecological and geological processes (Lomolino et al. 2006). Species' ranges can be studied at various temporal and spatial scales provided they are already documented. Before a distributional map can be produced, data on spatial occurrence must be collected in the field. Despite its obvious simplicity, field work constitutes a crucial step and affects the consistency of analyses which may depend upon sophisticated tools and concepts. Incomplete or misleading distributional data will unavoidably compromise subsequent analyses and assessments.

In this study we have addressed the only Palaearctic occurrence of the striped ground squirrel *Euxerus erythropus* (Geoffroy Saint-Hilaire 1803) (formerly *Xerus erythropus*). This is a moderately large (average length of head and body is 249 mm) and long-tailed (relative tail length is 80% of the head and body) member of the African bristly ground squirrels (subtribe Xerini) (Kryštufek et al. 2016). The squirrel is strictly diurnal and terrestrial, seeking shelter in self-dug burrows, crevices and termite mounds. It does not hibernate. It occupies a wide variety of environments, most typically open woodland and savannah. Cultivation creates suitable habitats and facilitates the range expansion into the forest zone (Herron and Waterman 2004, Waterman 2013).

The striped ground squirrel occupies a wide subtropical and tropical belt between the equator and the transition of the Sahelian zone and Sahara (Figure 1A). In addition to this range, which contiguously extends from Guinea, Mauritania and Senegal in the west to Eritrea, western Ethiopia and north-western Kenya in the east, an isolated occurrence is known from the Atlantic coast of Morocco between the cities of Agadir and Taroudant (Kryštufek et al. 2016). The Moroccan population was discovered in 1946–1950 during a small mammal campaign implemented by local authorities for the Pasteur Institute of Morocco. Results were published by Blanc and Petter (1959) who also mapped the borders of the trapping area (Figure 1). These borders were subsequently accepted as indicative of the range of the species in Morocco (e.g. Saint Girons and Petter 1965, Aulagnier and Thevenot 1986). Blanc and Petter (1959) did not report the actual records and not a single observation of the striped ground squirrel was published the decades that followed. It is difficult to

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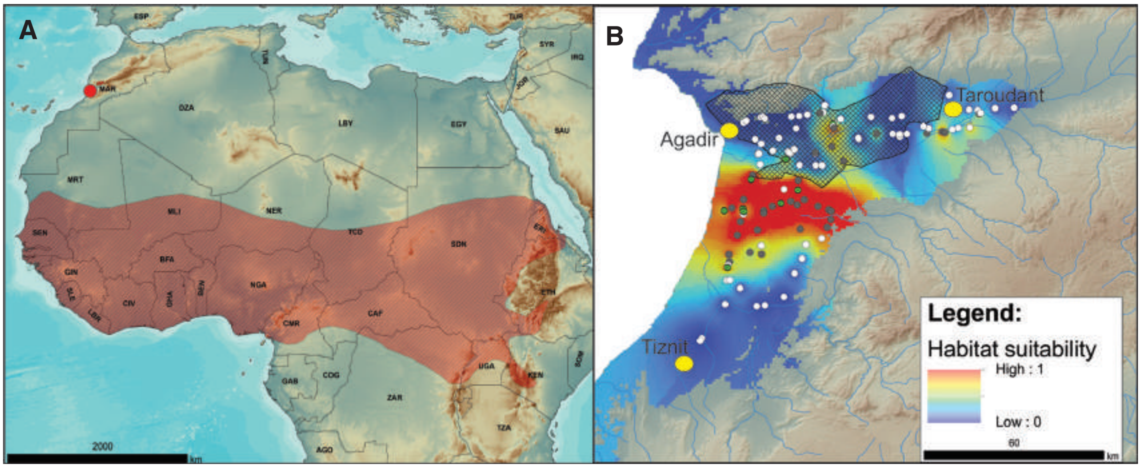

Figure 1: Range map of the striped ground squirrel (*Euxerus erythropus*; from Cassola 2016) and position of the study area (red dot) in Morocco (A). Habitat suitability map is based on the spatial logistic GWR model (B).
Circles indicate sampling sites: white, striped ground squirrel not found; grey, presence of squirrel burrows; green, squirrels observed. Yellow circles denote major cities. The range mapped in Blanc and Petter (1959) is shaded black. Habitat suitability scale (left bottom inset in B) ranges from low suitability (bottom) to high suitability (top) for the target species.

comprehend how a diurnal squirrel widely known inside its sub-Saharan range (Rosevear 1969) escaped any notice in Morocco for more than half a century.

We collected field data on the occurrence of the species, estimated the range of occupancy and defined the environmental factors which indicate the presence of the squirrel. Our results retrieved significant incongruity compared to the map made by Blanc and Petter (1959) which is hardly comprehensible for an obvious diurnal animal. The scarcity of information heavily hindered comparisons between the two maps produced more than half a century apart.

Materials and methods

Data collection

Our study is based on the examination of museum vouchers and on a field survey conducted in 2016. We searched for vouchers in data files and research collections of various European museums and through the VetNet database (http://portal.vertnet.org/search) and the Global Biodiversity Information Facilities (http://www.gbif.org/).

The first field survey was performed in May 2015 in the Souss Valley between Agadir and Taroudant. Following published information (Blanc and Petter 1959, Aulagnier and Thevenot 1986), we searched for squirrels in the argan (*Argania spinosa*) plantations, cultivations and accumulations of rocks, which are reportedly a suitable habitat. The survey was futile. We unexpectedly encountered the species in April 2016 around Sidi Bibi, south of Agadir, and promptly realised that rows of opuntia (*Opuntia fragilis*) provide good shelter (Figure 2C). In September 2016 we conducted a systematic survey of opuntia rows inside the borders set by Blanc and Petter (1959). The initial geographic scope was modified daily in accordance with observations from the field.

For the duration of the survey we slowly drove the car and stopped every c. 5 km provided there was opuntia or some other suitable habitat. The area was first screened using binoculars and subsequently inspected for holes. Three observers dispersed and searched the area for the presence of burrows for a minimum of 30 min. To avoid confusion with jird holes, we used burrow dimensions and photographs obtained previously during small mammal trapping in different parts of Morocco which yielded three species of *Meriones* Illiger 1811 (*Meriones lybicus* Lichtenstein 1823, *Meriones crassus* Sundevall 1842, *Meriones grandis* Cabrera 1907). The Barbary ground squirrel [*Atlantoxerus getulus* (Linnaeus 1758)] is widely sympatric with the striped ground squirrel but seeks shelter among rocks where burrows are also excavated (Aulagnier 2013).

We collected nutshells gnawed by rodents under the argan trees. The tooth marks were subsequently compared against incisors from *Euxerus* Thomas 1909, *Atlantoxerus* Forsyth Major 1893, various species of *Meriones* (see above) and large *Gerbillus* Desmarest 1804 (*Gerbillus campestris* Levaillant 1857 and *Gerbillus tarabuli* Thomas 1902). Comparative museum vouchers were from the collections of Zoologisches Forschungsmuseum Alexander Koenig (Bonn, Germany) and Slovenian Museum of Natural History (Ljubljana, Slovenia). We interviewed local people in the field for the presence of "sinjab"

Figure 2: Striped ground squirrels and their habitat in Morocco.
(A) Adult individual photographed at Ville Tadouarte Ida Ou Mhand near Biogra; (B) striped ground squirrel in its habitat at Sidi Bibi south of Agadir; (C) habitat at Ihchach, south of Ait Melloul; (D) entrance to a burrow under a thorny acacia. Photo: Cătălin Stanciu.

(Arabian for squirrel) and showed them photographs of both squirrel species occupying Morocco (*Euxerus* and *Atlantoxers*). The replies were frequently consistent with our survey of the site, but were unreliable or even misleading in other cases. We therefore accepted such statements cautiously and only as an auxiliary source of information.

The geographic position for each locality (with min = 1, max = 9, average = 2.85, median = 2 holes) was recorded using a Garmin GPSmap 62s device (GARMIN, Kansas, USA).

Environmental datasets

In order to identify and model the ecological niche of the striped ground squirrel in the study area we created a database of environmental variables (30 arc seconds horizontal resolution, WGS84 coordinate system) which were obtained from freely available geospatial databases: WorldClim (19 bioclimatic variables) (http://www.worldclim.org/current), elevation (Jarvis et al. 2008; http://srtm.csi.cgiar.org), land cover (Food and Agriculture Organization of the United Nations, FAO GEONETWORK, Land cover of Morocco; http://data.fao.org/ref/fad3f475-8973-463f-b56ae6b6535c1db5.html?version = 1.0), soil type [FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (HWSD) (version 1.2), available at http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/], and roads and rivers (http://www.diva-gis.org/gdata).

Data analysis

Habitat variables

Differences in environmental variables between occupied and vacant sites were tested using the univariate t-test and the Mann-Whitney U-test. Heterogeneity between the two classes of data was further assessed from a matrix of Euclidean distances using a multiple response permutation procedure (MRPP) (R Development Core Team, Vienna, Austria) with 999 permutations. Tests were conducted in R implementation of the vegan package (Oksanen et al. 2017). The MRPP function calculates the change-corrected within-group agreement A (effect-size parameter). The parameter A describes within-group homogeneity compared to the random expectation, where a value significantly greater than 0 suggests more similarity than expected by chance (McCune and Grace 2002).

Habitat modelling – spatial logistic regression

Habitat suitability for the striped ground squirrel in Morocco was estimated by applying geographically weighted logistic regression analysis with the GWR4 software (Nakaya et al. 2014). This statistical approach captures both spatial dependency and spatial non-stationarity in the modelling process (Brunsdon et al. 1996). The GPS coordinates of both the presence and absence of the striped ground squirrel served as the dependent variable. Predictors were further processed in order to meet the preconditions for logistic GWR modelling (GWR4 version 4.0.80, Ritsumeikan University, Japan). Bioclimatic variables were PCA transformed, resulting in three components explaining 95% of the variance. Land cover data were transformed to continuous distance variables by applying the Euclidian distance algorithm found in TerrSet 18.2 software (TerrSet, Clark University, Worcester, UK) (Eastman 2015). The river and road networks in the study area were considered distance variables as well. The elevation variable was expressed in the form of slope and topographic position index (proxy for topography features) variables (Jenness et al. 2013) by using the Land Facet Corridor Tools (Jenness Enterprises, Flagstaff, USA) within ArcGIS (Environmental Systems Research Institute, Redlands, USA) (ESRI 2010). Several top soil properties from the HWSD vector database were attributed to recorded GPS points (see Supplemental Tables S2–S4) where only reference bulk density (t_Ref_Bulk_Dens) and total exchangeable bases (t_TAB) were added to the logistic GWR habitat suitability model. In order to avoid multi-collinearities among the predictors, the variance inflation factor (VIF) and tolerance (TOL) for each explanatory variable were calculated by using the CAR package (Fox and Weisberg 2011, Fox et al. 2014) in R software (R development core 2008). According to Bai et al. (2010) VIF values over 10 and TOL values below 0.1 indicate serious multi-collinearities between predictor variables. Thus, the logistic GWR model was calibrated with explanatory variables that met those conditions.

In order to validate the model several diagnostic parameters were calculated: the Akaike Information Criterion (AIC), the corrected Akaike Information Criterion (AICc), the percentatge of deviance explained (pseudo R^2), and the area under the receiver operating characteristics (ROC) curve (AUC) values. Parallel to this the striped ground squirrel presence data were used to build a maximum entropy model (Maxent, Princeton University, USA) (Maxent; version 3.3.3 – see http://www.cs.princeton.edu/~schapire/maxent) by applying the same explanatory variables with the purpose of comparing the performance of the GWR produced habitat suitability map. Seventy-five percent of the presence data was used to construct the model and form the functional relationships between the actual presence and the environmental variables. The remaining 25% was used to test the predictive ability of the model. The subsampling technique was used to assess model fit (15 replications in total) and selection of the convergence threshold and regularisation values was carried out using default rules. The number of iterations was chosen such that all models converged. In order to overcome the spatial bias problem of occurrence data, the target-group background data was used as recommended by Phillips et al. (2009). In addition, the Jackknife test of variable importance was carried out within Maxent to evaluate the contribution of explanatory variables to the resulting suitability map (Table S4). Finally, both suitability maps were compared with ROC statistical analysis (Figure 3B).

For the habitat suitability map, a floating raster surface showing probability values ranging from 0 to 1 was developed by applying the inverse distance weighted (IDW) interpolation method (ESRI 2010) based on predicted estimates (coefficient) values for the presence and absence data. In the final habitat suitability map (Figure 1B) we also considered the vertical span (mean ± 3 SD) of the collected data and extracted the probability surface with the corresponding mask.

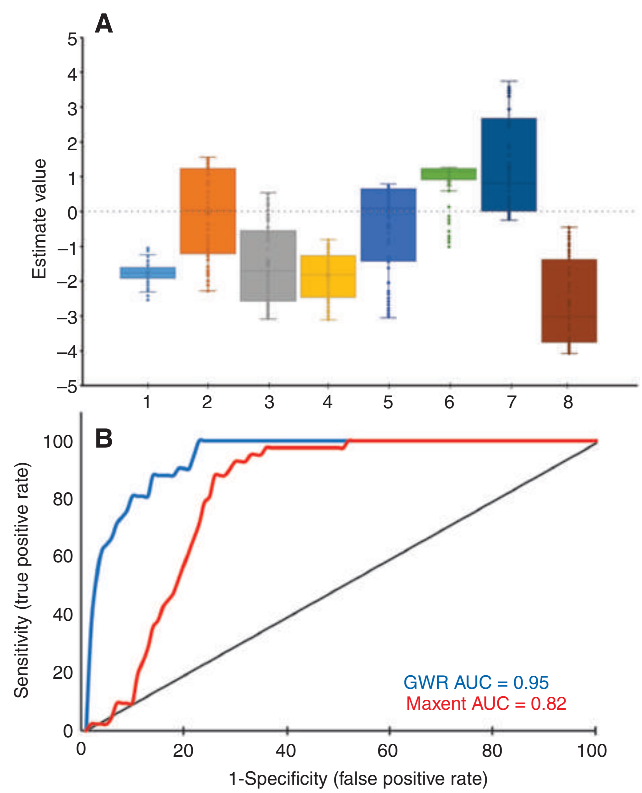

Figure 3: Variation of estimates over the study area by applying spatial logistic GWR model (A) and receiver operating characteristics (ROC) curves of the logistic GWR (blue line) and Maxent (red line) models (B). Inset (A): model estimates 1 – Slope, 2 – CPC 1, 3 – CPC 2, 4 – CPC 3, 5 – distance to bare areas, 6 – distance to mosaic vegetation, 7 – distance to sparse (<15%) vegetation, 8 – distance to artificial surfaces and associated areas (urban area >50%).

Results

Museum specimens

We identified eight museum vouchers of striped ground squirrels from Morocco which were deposited in the Museum national d'Histoire naturelle, Paris (MNHN) and the Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt (SMF). The MNHN holds seven specimens. Three vouchers were obtained from the Pasteur Institute of Morocco, and the only one properly labelled (collection no. 1959-202) was captured in the Souss Valley. The remaining specimens (1971-725 to 1971-728) were from Taroudant. The SMF voucher (no. 49,746) was obtained in 1975 near Ameskroud. All these sites fit into the borders drawn by Blanc and Petter (1959). Because these records could not be georeferenced with the desired degree of accuracy, they were not used in habitat analyses.

Field survey

Our survey covered the flat lowlands and gently undulating regions inside the triangle Agadir–Taroudant–Tiznit (Figure 1B). We surveyed 115 localities and found evidence of the presence of striped ground squirrels at 43 sites (hereafter occupied/positive sites); the remaining localities were subsequently referred to as vacant (negative) sites (Supplemental Table S1). Squirrels were observed at nine sites (Figure 2A,B) and the remaining records were based on the presence of burrows. The vast majority of positive sites (63%) were classified as suburban (19 sites), cultivated (eight sites) or both (two sites). Only at one site did we observe striped ground squirrels in an argan plantation on hard rocky ground. *Atlantoxerus* squirrels were observed only at seven sites, and three of these also had striped ground squirrels.

Holes dug by squirrels were larger (diameter 9.0–15.0 cm, mean = 11.8 cm) than those of jirds (*Meriones*) which measured 5.0–9.0 cm (mean = 7.3 cm). Entrances to holes dug by squirrels were always sheltered by vegetation. The majority of burrow entrances (40 sites or 93% of all occupied sites) were deeply inside the rows of opuntia or thorny acacia and therefore well shielded and protected (Figure 2D). At 11 sites squirrels also dug under jujube (*Zyzyphys jujuba*) shrubs. The holes we saw were invariably excavated in soil and never among rocks. In our observations, the Barbary ground squirrels invariably escaped into spaces among rocks where we never found holes dug out into soil.

We frequently found excrement in the vicinity of burrows. That of striped ground squirrels was of similar length (10–20 mm, mean = 13.1 mm) to goat droppings (11–14.5 mm, mean = 11.6 mm), however, they were less thick, both absolutely (4.6–5.5 mm; mean = 5.0 mm) and relative to length (27.5–46.0%, mean = 38.9%); corresponding values for goat excrement were 7.0–8.5 mm (mean = 7.7 mm) and 53.8–72.7% (59.6%).

We examined 173 gnawed nuts collected at 10 sites. A comparison of the abrasions on the shell with the reference material retrieved showed that all the nuts had been opened by rodents of a gerbil (*Gerbillus*) size (body mass <50 g). No evidence that the nuts had been opened by squirrels was found even on sites where *Atlantoxerus* had been observed.

Habitat analysis

Extreme coordinates of occupied sites were W-9°40′32.484″ to W-8°40′47.28″ degrees western longitude and N29°45′52.56″ to N30°30′9.24″ degrees northern latitude. The elevation of the surveyed sites was 19–333 m (134.9 ± 70.3 m) and squirrels were present at the elevations of 45–254 m (118 ± 54 m) (Supplemental Tables S1 and S2). Annual mean temperature of the occupied sites was 19.4 ± 0.47°C and annual precipitation was 213.5 ± 19.95 mm. Sites occupied by squirrels differed significantly from vacant sites in altitude, latitude and in four climatic variables out of 19 analysed (Supplemental Table S2). Specifically, the positive sites had higher temperature of the coldest quarter (bio_11) and received less precipitation (bio_17, 18). The rainfall was also more seasonal (bio_15). Thirteen top-soil variables out of 19 analysed and 16 sub-soil variables out of 17 differed significantly between the two classes of sites (Supplemental Tables S2 and S3).

The MRPP analysis of three types of habitat data (top-soil, sub-soil and bioclimatic variables) revealed significant differences between the occupied and the vacant sites in soil data (top-soil: $A = 0.175$, $p = 0.001$; sub-soil: $A = 0.153$, $p = 0.001$) but not in bioclimatic data ($A = 0.009$, $p = 0.121$). In general the squirrels were more likely present on a substrate with coarse texture, i.e. on sands, loamy sands and sandy loams with <18% clay and >65% sand.

Habitat suitability analysis

Based on the VIF and TOL values, 16 explanatory variables were included in the logistic GWR habitat suitability model in Morocco. The estimates and Wald χ^2 values (Supplemental Table S4) indicated the independent global variables with the highest predictive power in explaining the spatial pattern of the striped ground squirrel. Here, the distance to sparse (<15%) grassland, topsoil-reference bulk density and distance to rain-fed croplands play an important role. Negative estimates in this case suggest that the striped ground squirrel habitat is generally located closer to sparse grasslands and rain-fed croplands. The Box-and-Whisker plots in Figure 3A, illustrate how the influence of local predictor variables (estimates) vary across the study area. These spatially nonstationary parameters indicate heterogeneous effects on the determination of the dependent variable. The estimates of variables slope, CPC 3 and distance to artificial surface occupy only a wide range of negative values representing a relatively more uniform effect. However, five out of eight selected local predictors significantly vary in estimate value from positive to negative thus assuming different effects on the striped ground squirrel distribution pattern in the geographical space. The most significant spatial non-stationarity was exhibited by the CPC 1 variable, followed by the distance to bare areas and distance to mosaic vegetation (grassland/shrubland/forest) (50–70%) or cropland (20–50%).

The spatial GWR model did perform significantly better than the classic aspatial logistic regression model (Supplemental Table S4). The improvement was measured by a clear decrease in the AICc value (23.064) and a 20% increase in the explained deviance (from 0.44 to 0.64). The accuracy of the resulting habitat suitability map was estimated with the ROC curve (Figure 3B) by considering any given threshold value. The spatial logistic GWR model reached a clearly higher AUC value than the presence-only data based Maxent model, thus indicating better association between the results and the observed distribution pattern of the striped ground squirrel.

The modelled suitable habitat area for the striped ground squirrel in Morocco is mainly located on the extensive plane south from Agadir (Figure 1B). Some allocated suitable areas extend in the northeast direction along the Souss River towards the city of Taroudant. By comparing the striped ground squirrel estimated habitat area in 1960, it is evident that the recent population is concentrated more southwardly. The estimated highly suitable area ($p = 0.75$–1) covers almost 690 km^2 whereas the unsuitable ($p = 0$–0.25) area represents 3619 km^2 of the region below an altitude of 350 m.

Discussion

Our field survey confirmed the presence of the striped ground squirrel in Morocco and defined the geographic scope of its distribution. It is evident at a glance (Figure 1B) that the range is bordered by the Atlantic Ocean in the west and mountain ranges of the atlas (north) and the anti-atlas (south-east). Inside this geographical frame the squirrels were not distributed randomly but congregated to the south of the Souss Valley with scattered observations also inside the valley itself. Several environmental variables were common to occupied sites: sandy substrate, low altitude and a low level of seasonal rainfall. Furthermore, positive sites were closely associated with cultivation and a suburban environment. Habitat suitability analysis additionally revealed the importance of bare land and mosaic habitats for the presence of this squirrel. In general, the habitat occupied by the striped ground squirrel in Morocco corresponds to the situation elsewhere. The species is a habitat generalist (Rosevear 1969) and the only difference between Morocco and the Sudano-Guinean savannah to the south of the Sahara is in the more relaxed habitat selection inside the main range of the species with a wider range of habitats occupied (Herron and Waterman 2004).

The range retrieved in our study differs appreciably from the one outlined by Blanc and Petter (1959). Specifically, Blanc and Petter (1959) entirely missed the major fragment of a highly suitable habitat to the south of the Souss Valley. Instead they mapped the range inside the zone where we found few or no signs of the presence of striped ground squirrels. One can presume with good reason that the Pasteur Institute did not target the striped ground squirrel in particular, and made no attempt to document its range. An alternative explanation for the discrepancy between the two maps would be a shift in distribution during the last half century. Our habitat modelling retrieved variability in predictor variables throughout the study area. Dissimilar effects of the key environmental parameters on the striped ground squirrel distribution pattern in the geographical space make alterations of the range borders more probable. The likelihood of a certain event however, proves little on its own. We could not trace protocols of the campaign of the Pasteur Institute in the Souss region and the information on specimen tags of the few vouchers which were preserved is of no help in this case. The paucity of historic information therefore precludes further discussion.

Another enigma is how the population of the striped ground squirrel has continued to be ignored for so long inside the intensively cultivated region and in the vicinity of a busy port. Europeans acquired certain knowledge of Moroccan fauna by the 16th century if not earlier. The most notable example is the Barbary ground squirrel which had been depicted already by the Swiss zoologist Konrad

Gessner (1569) and after him by the Dutch painter Jan Brueghel the elder in his painting done in 1613 and entitled The Entry of the Animals into Noah's Ark (Kryštufek et al. 2016). Cabrera (1932) argues that the shipping port for Gessner's animal was "Santa Cruz de Berberia", the current name of which is Agadir. Agadir remained the major seaport for transfer of animals from the 17th to the 19th centuries (Cabrera 1932). If the striped ground squirrel did occupy the vicinity of Agadir already at that time one would expect that some specimens would reach Europe together with the Barbary ground squirrel. This, however, was not the case as the striped ground squirrel was first mentioned by Geoffroy Saint-Hilaire (1803) who received a specimen from an unknown locality. The striped ground squirrel remained unnoticed by zoologists working in Morocco during the 19th century (e.g. Lataste 1885) and subsequently until the report by Blanc and Petter (1959). However, even carefully conducted surveys which postdate Blanc and Petter (1959) missed the species. For example, the Smithsonian Institution African Mammal Project (1961–1972) in Morocco yielded 6221 rodent vouchers, including 141 Barbary ground squirrels (Schmidt et al. 2008), but not a single striped ground squirrel. Saint Girons and Petter (1965) frankly admitted in their Rodents of Morocco that they had never seen a striped ground squirrel themselves, relying instead entirely upon Blanc and Petter (1959).

The Moroccan isolate of the striped ground squirrel may be a relic from the early Holocene. At about 10.5 ka the rapid arrival of monsoon rains triggered an abrupt northward shift of the tropical precipitation belts and turned the by-then hyperarid Sahara into a habitable savannah (Kuper and Kröpelin 2006, Liu et al. 2006). Habitat change facilitated a northward expansion of a great many mammals which are currently found only to the south of Sahara (Kowalski and Rzebik-Kowalska 1991) and among them was the striped ground squirrel. The presence of this rodent is documented in Bir Kiseiba in southern Egypt during the Neolithic age (Osborn and Osbornová 1998). The 19th century records for Egypt (Jentink 1882) and "Nubia" are less straightforward as they may refer to what is now Sudan (Kryštufek et al. 2016). An abrupt vegetation collapse at 7.5 ka from the green Sahara to its current desert state triggered the extirpation of the striped ground squirrel in what is now Egypt and putatively isolated its presence in Morocco to a small habitat island which is the subject of this study. The hypothesis on the origin of the Moroccan isolate is testable using appropriate genetic markers (cf. Galimberti et al. 2015, Stojak et al. 2016). This would necessitate a new approach with an extensive geographic sampling in the Sahelian zone and beyond, where a putative ancestral population may occur.

The range of the striped ground squirrel in the Sudano-Guinean savannah, between the equator and the transition of the Sahelian zone and the Sahara (Figure 1A), is estimated at 7.8 million km^2 (encyclopaedia of life database: http://eol.org/pages/1178594/data) and the species is, unsurprisingly, classified as Least Concern on the IUCN Red List (Cassola 2016). The Moroccan isolate, which we predicted to cover merely 690 km^2, makes up <0.01% of the total area and is of interest despite its miniscule size. First this is the only occurrence of the striped ground squirrel in the Palaearctic (Kryštufek et al. 2016). Second, the Moroccan population is small and occupies a region densely populated by humans and extensively cultivated for agriculture. Our interviews showed that inhabitants consider striped ground squirrels pests and harass them. As shown above, climate change, which has already extirpated the striped ground squirrel in Egypt and most probably beyond, could pose a threat to the Moroccan outlier as well. With this in mind, our results set forth a solid ground for future monitoring of the species.

Acknowledgements: Travels to Morocco which set the frame for present study were organised by the Oceanographic Research and Marine Environment Protection Society "Oceanic-Club" (Constanţa, Romania) and the "Grigore Antipa" National Museum of Natural History (Bucharest). We are particularly grateful to Dumitru Murariu, Răzvan-Valentin Popescu-Mirceni, Gabriel Chişamera, Costică Adam and Zaharia Răzvan. Cécile Callou (Muséum national d'Histoire naturelle, Paris) provided information on vouchers held in Paris. Access to collections was granted by Irina Ruf and Katrin Krohmann (Senckenberg Museum Frankfurt) and Rainer Hutterer (Zoologisches Forschungsmuseum Alexander Koenig, Bonn). Karolyn Close edited for grammar and style. B.K. acknowledges the financial support from the Slovenian Research Agency (research core funding no. P1-0255).

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Supplemental Material: The online version of this article offers supplementary material (https://doi.org/10.1515/mammalia-2017-0060).