# Evaluating methods for surveying the Endangered Cuvier's gazelle *Gazella cuvieri* in arid landscapes

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**Abstract** The Endangered Cuvier's gazelle *Gazella cuvieri* is an endemic ungulate of north-western Africa. Information on the species has been based primarily on non-systematic surveys, and the corresponding status estimates are of unknown quality. We evaluate the effectiveness and efficiency of two field methods for systematic surveys of populations of Cuvier's gazelle in arid environments: distance sampling (based on sightings) and sampling indirect sign (tracks and scats). The work was carried out in the north-western Sahara Desert, in Morocco, where what is possibly the largest population of Cuvier´s gazelle persists. A logistically viable survey was conducted over a total area of c. 20.000 km² in 10 expeditions during 2011–2014. A total of 67 sites were surveyed, with 194 walking surveys (2,169 km in total). Gazelle signs were detected at 50 sites, and gazelles were sighted at 21 sites (61 individuals). We found a relationship between sightings and abundance indices based on indirect sign, which could be useful for population monitoring or ecological studies. Additionally, the data could be used in occupancy modelling. Density estimates based on distance sampling required considerable effort; however, it is possible to survey large areas during relatively short campaigns, and this proved to be the most useful approach to obtain data on the demographic structure of the population.

**Keywords** Distance sampling, endemic species, *Gazella cuvieri*, Morocco, occupancy, Sahara Desert, ungulate

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## Introduction

Cuvier's gazelle *Gazella cuvieri* is categorized as Endangered on the IUCN Red List (Mallon & Cuzin, 2008), with a distributional range restricted to portions of three countries of north-west Africa: Morocco, Algeria and Tunisia (Huffman, 2011; Beudels et al., 2013). The most recent population estimate for the species is 1,750–2,950 individuals (Beudels-Jamar et al., 2006), in a few scattered and largely fragmented populations, with the majority in Morocco (900–2,000 individuals). However, these estimates should be viewed with caution, as no description is provided of how data were collected in most areas (but see Abáigar et al., 2005b). Most information on the distribution and status of Cuvier's gazelle has been based on opportunistic records and/or non-systematic surveys (Sellami et al., 1990; de Smet, 1991; Loggers et al., 1992; Cuzin, 1996, 2003; Cuzin et al., 2008).

Cuvier's gazelle was previously known to inhabit both open areas and Mediterranean forests of the Atlas Mountains, from sea level to 2,600 m (Beudels et al., 2013). However, in the mid 20th century a population was discovered inhabiting a true desert environment in the extreme north-western Sahara Desert (Morales Agacino, 1950). This was described as being the largest population of the species (Beudels-Jamar et al., 2006), with subjective estimates of 200–500 individuals based on anecdotes and non-systematic surveys (Cuzin, 2003). However, more recent information suggested the species had declined (Cuzin et al., 2008) and could soon, if not already, be extirpated from the region (Huffman, 2011).

Implementation of appropriate conservation strategies for Cuvier's gazelle is essential and urgent action may be needed to secure a viable future for the species. The first step is to obtain current, scientifically robust information on its distribution and abundance. Thus we present standardized surveys of the north-western Sahara, using systematic sampling methods. We report on the viability, in terms of effort required and accuracy of results, of distance sampling and indirect sign sampling techniques. These findings provide the first analytical data on the species, and a foundation for further studies on the distribution, abundance and demographics of this Endangered gazelle in a harsh desert environment.

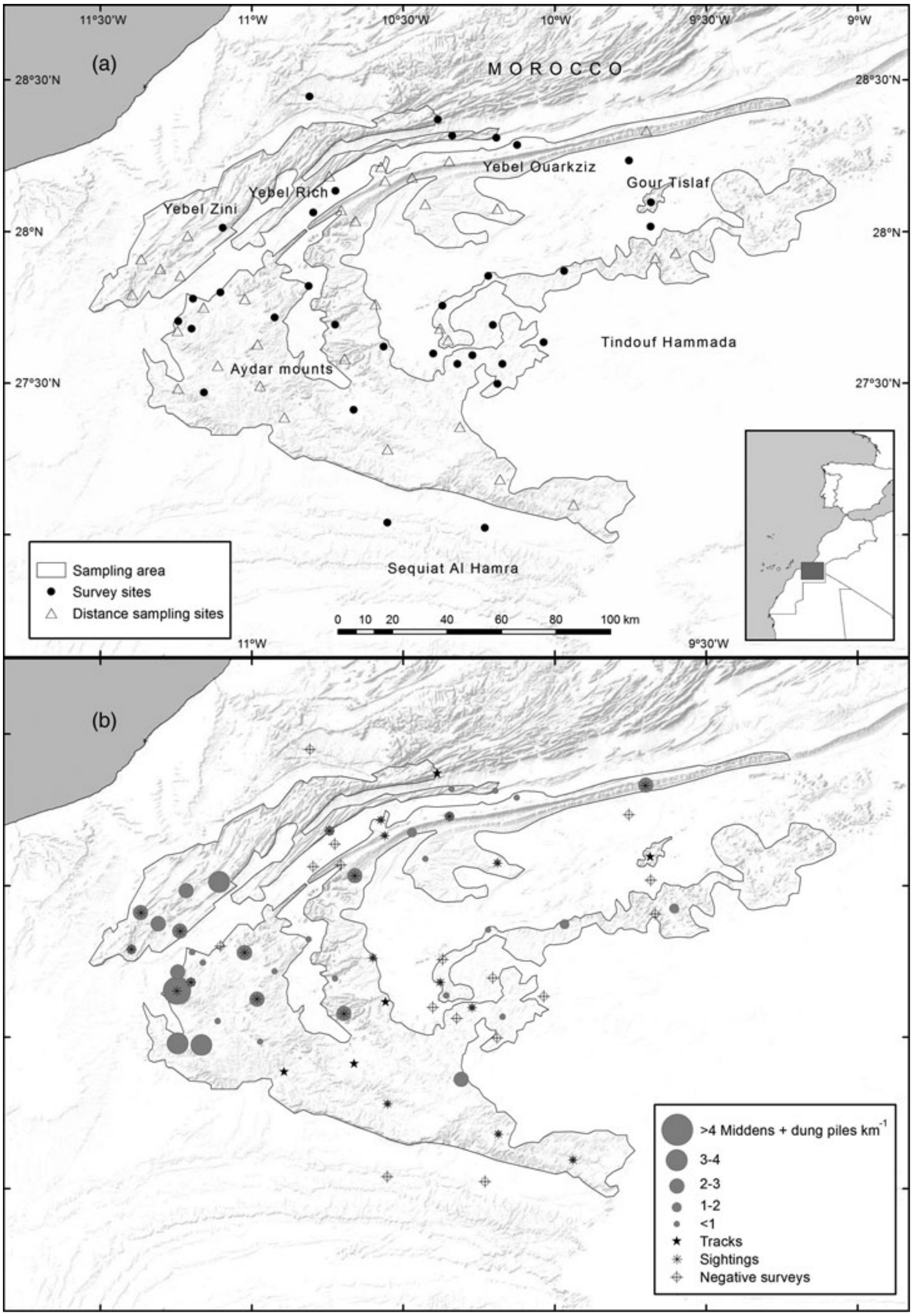


FIG. 1 (a) The study area in the north-western Sahara Desert, Morocco. (b) The distribution of Cuvier's gazelle *Gazella cuvieri* in the study area.

## Study area

The study area comprised the region between the lower Draa River and the upper basin of the Sequiat Al Hamra, Morocco (c. 20,000 km$^2$; Fig. 1). It is a typical Saharan landscape, with a subtropical desert and low-latitude hot, arid climate (Köppen–Geiger classification, Kottek et al., 2006). The mean, minimum and maximum temperatures are 22.7, 8.0 and 39.0°C in the western zones (closer to the Atlantic Ocean), 23.2, 0.0 and 43.0°C in the eastern zones, and 19.1, 10.7 and 29.0°C at the northern limit. Total annual precipitation (with large annual variability) is 138, 59 and 190 mm, respectively (recorded at climate stations at Smara, 26°46′N, 11°31′W; Tindouf, 27°40′N, 8°7′W; and Tan Tan, 28°26′N, 11° 06′W). The terrain is a mix of rough and hilly areas (*yebels*), flat areas with saline depressions (*sebjas*), plateaux (*hammadas*), clay plains (*dayas*), stony plains (*regs*) and some small dune areas (*ergs*). The altitude is 290–770 m. Ancient rivers spread throughout the region in a complex network, some collecting seasonal waters. The main rivers, the Draa and the Chebeika, hold permanent waters called *gueltas*. Vegetation is scarce except in the dry river basins, where important open savannah-like forests of thorn trees *Acacia raddiana* still survive, sometimes together with *Acacia* *ehrenbergiana, Balanites aegyptiaca, Calotropis procera* and *Panicum turgidum*, and along the *gueltas*, where there are abundant *Tamarix africana* bushes. The argan tree *Argania spinosa*, endemic to Morocco, reaches its southernmost limit here, with scattered individuals sheltered in the valleys of the *yebels*. The region is home to key threatened ungulates of north-west Africa, such as Cuvier's gazelle, the western dorcas gazelle *Gazella dorcas neglecta* and the Saharan Barbary sheep *Ammotragus lervia sahariensis* (Cuzin, 1996). There are six human settlements in the region, each with fewer than 100 inhabitants. The region is also used by traditional nomads, who move their temporary camps and herds of goats, sheep and dromedaries across the desert landscape in search of seasonally available forage. There is an extensive network of 4 × 4 vehicle trails and unpaved roads across the region, facilitating easy access for wildlife poachers, usually coming from the nearby cities of Tan Tan and Guelmin.

## Methods

### Overall survey design

Ten expeditions of 7–10 days each were conducted by 2–11 persons in 1–3 4 × 4 vehicles. Five expeditions were carried out in spring (March, April and May), three in winter (December and January) and two in autumn (October). We avoided conducting field work during summer months because of the extreme weather conditions in the area at this time. We logged a total of 50 effective survey days (5 days per expedition over 10 expeditions), with a mean of seven persons per expedition, amounting to 350 person-days of effort in the field.

Our sampling unit was the survey site, defined as an area where a set of walking surveys was carried out. The number and distribution of survey sites were influenced by logistics and accessibility; however, we attempted to achieve a large sample size of spatially independent surveys and regular distribution of sampling effort across the various habitats within the study area. During the two first expeditions we observed that gazelles were absent from flat areas (*sebjas, hammadas, dayas, regs* and *ergs*), and therefore we concentrated subsequent efforts within rugged hilly terrain (*yebels*; Fig. 1). We surveyed 67 study sites during April 2011–April 2014 (Fig. 1). Within each study site 1–4 walking surveys were carried out simultaneously by teams of 2–4 observers. We conducted a total of 194 walking surveys, each with a specific route designed according to local terrain conditions. The mean distance covered in a walking survey was 12.08 ± SE 0.72 km (range 3.8–22.5 km; accumulated distance 2,169 km); survey length varied according to time and logistical limitations. We did not use vehicle surveys to detect gazelles (Attum et al., 2014) because of the rugged terrain and poor preliminary results (only six gazelles were sighted from a vehicle during the entire study).

Cuvier's gazelles were detected exclusively within or close to rugged areas (< 1,000 m), and therefore we excluded flat areas (< 5% slope) from our estimated sampling area by deleting these areas from our relief shapefile of the terrain (*ASTER GDEM v. 2*, NASA, Washington, DC, USA, & METI, Tokyo, Japan) in *ArcGIS v. 9.3* (ESRI, Redlands, USA). The estimated sampling area was 12,176.8 km², in four patches: Yebel Zini–Yebel Rich: 2,153.1 km²; Gour Tislaf: 46.5 km²; Yebel Ouarkziz–Aydar Mountains–Upper Sequiat Al Hamra: 8,323.4 km²; northern slope of the Tindouf Hamada: 1,653.6 km² (Fig. 1).

### Field data collection techniques

We selected two methods of field data collection commonly used for gazelle surveys in arid and semi-arid environments: (1) direct observations or sightings (Lawes & Nanni, 1993; Dunham, 1997; Abáigar et al., 2005b; Chammem et al., 2008; Cunningham & Wronski, 2011; Attum & Mahmoud, 2012), and (2) indirect signs, such as tracks, isolated dung piles and latrines or middens (Abáigar et al., 2005a; Chammem et al., 2008; Wronski & Plath, 2010; Attum et al., 2014). We developed two kinds of walking surveys to sample direct sightings and indirect sign (Fig. 1). The first type was a sighting survey, where 2–3 persons walked the same route, beginning just before sunrise; one person (the guide) walked c. 100 m ahead, scanning the open landscape (with the naked eye and using binoculars) for gazelles (direct sightings), and the other(s) followed, looking for tracks and pellets. Indirect sign surveys were similar to sighting surveys but were conducted at any time of the day, with observers looking only for indirect signs. Indirect sign was sampled at all 67 survey sites, whereas active searches for direct sightings were carried out at only 33 sites. Survey routes were initially determined using *Google Earth* (Google Inc., Mountain View, USA). Subsequently, exact routes were recorded in the field using global positioning systems (GPS). Surveys were stratified in an effort to proportionally cover most of the micro-habitats of each survey site. Therefore, upon arrival at each site the routes were amended to include and properly represent valley bottoms and mid-slope and hill-top sections of rugged terrain. At most sites 2–3 surveys were carried out simultaneously, in different cardinal directions to avoid overlap or interference with gazelle sightings. The sighting surveys were designed as distance sampling surveys (Buckland et al., 2004; Abáigar et al., 2005b), in which the location of gazelles observed far from the survey transect was estimated using the biangulation method (Millspaugh & Marzluff, 2001). For gazelles sighted closer to the transect, their exact GPS location was recorded. Using *ArcGIS* we calculated the perpendicular distances of sightings from the

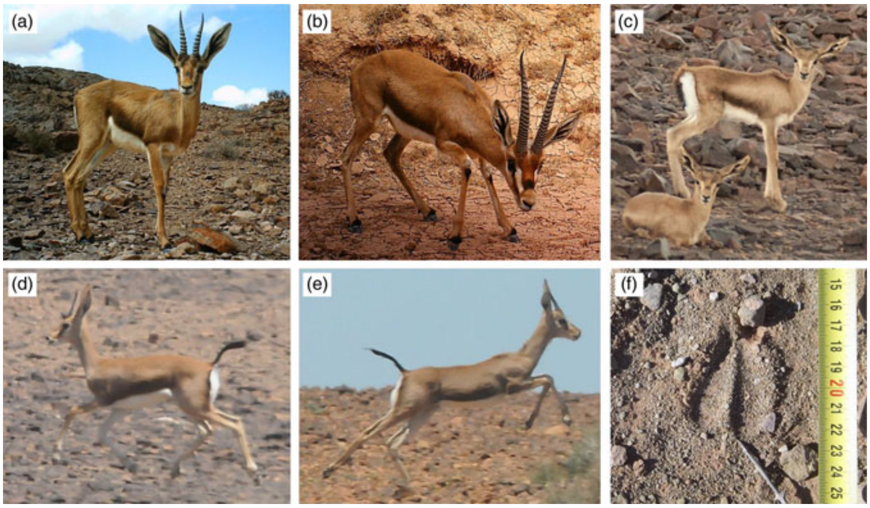


PLATE 1 Photographs of Cuvier's gazelles of various age categories and sex taken during surveys in the study area: (a) subadult male; (b) subadult male; (c) calves; (d) subadult female; (e) adult female; and (f) a typical track left by a Cuvier's gazelle (the heart shape distinguishes Cuvier´s gazelle tracks from those of goats, sheep and Barbary sheep). (a) and (b) were taken by camera traps.

transect. When possible, age and sex of gazelles were recorded, based on body size and shape, and size of horns. Some individuals observed in the distance or moving quickly away from the observers could not be categorized accurately. Age categories were defined as follows: calves (< 6 months old), subadults (7–18 months) and adults (> 18 months) (T. Abáigar, Parque de Rescate de la Fauna Sahariana de la Estación Experimental de Zonas Áridas, Almería, Spain, pers. comm.).

To ensure correct identification of indirect sign we sent 73 faecal samples visually identified as belonging to Cuvier's gazelle to the Research Centre in Biodiversity and Genetic Resources at Porto University, Portugal, for genetic identification following methods described in Silva et al. (2015). Of the 73 samples, 41 were identified to species through genetic analysis (39 to Cuvier's gazelle, one to dorcas gazelle and one to domestic goat). Thus, field identification of dung samples was correct in 95.12% of cases tested. Only fresh and clear tracks were included in the data (Plate 1), specifically to avoid confusion with domestic ungulates (mainly goats) and Barbary sheep. There was a risk of misidentifying the tracks of dorcas gazelles as those of Cuvier´s gazelles, and therefore we only included tracks identified in situ by our team using reference data from Wacher et al. (2011), and rejected tracks < 5 cm long of isolated individuals.

## Data analysis and evaluation of methods

We analysed the effect of season on gazelle detections. We divided data into two periods: spring (March–May, 40 study sites) and autumn/winter (October–January, 27 study sites). We compared the effect of season on the percentage of study sites with confirmed gazelle presence, and on the abundance of indirect signs and of gazelles sighted, both standardized as kilometric abundance index (sighted gazelles per km; signs per km), using U-Mann Whitney tests. We calculated the effort required (km walked) to detect gazelles, and identified the type of data that first confirmed gazelle presence at each site (pellets, tracks or direct sightings).

An imperfect detection analysis (MacKenzie et al., 2006) was carried out to determine whether the number of surveys per site had any influence on the effectiveness of detection of indirect signs (measured as detection rates, see below). We selected those sites where gazelles were sighted (hereafter, real positive sites) that had three simultaneous surveys of > 5 km each (16 sites and 48 (16 × 3) surveys in total). We used a cut-off of 5 km because our data showed that if no sign was found within 5 km, increasing the search effort did not increase the likelihood of detecting sign. The detection rates (positive surveys/total surveys) and the percentage of false absences ((1 − detection rate) × 100) were calculated simulating one survey per site (48 chances), two surveys per site (48 chances) and three surveys per site (16 chances).

The relationship between the relative abundance (kilometric abundance index) of isolated dung piles and middens (subsequently pooled together) and the abundance of sightings (gazelles per km) was analysed using the Pearson correlation. We excluded tracks from this analysis because the ability to detect tracks depended largely upon substrate type, which varied. Only sites with gazelle presence were considered in this analysis and, to avoid redundancy, the various replicates of each site were pooled together (29 sites).

We tested the utility of the pooled data for occupancy and density approaches. Firstly, we used *PRESENCE v. 6.2* (MacKenzie et al., 2006) to calculate occupancy probability ($\Psi$) using presence/absence site occupancy data analysis, with single-season survey-specific p analysis, applied to the 28 sites containing three replicates (surveys) each. A detection history of 28 rows (number and order of sites) and three columns (number and order of surveys per site) of zeros (0, gazelles not detected) and ones (1, gazelles detected) was built for the occupancy analysis (note that indirect sign was detected for all instances of 1). Secondly, we used *DISTANCE v. 6.0* (Thomas et al., 2010) to calculate the density from the distance sampling surveys (Buckland et al., 2004). The detection function was half-normal, as (1) the data set did not facilitate either uniform or hazard-rate functions, and (2) the half-normal function yielded more conservative results than the negative exponential function. The estimated population size ($N$) was then calculated using the equation $N = A \times D$, where A is the estimated sampling area and $D$ is the density.

## Results

Gazelles were detected at 50 of the 67 study sites (74.63%), and 61 individuals in 28 groups were sighted at 21 locations (Fig. 2). We recorded 48 sightings with sufficient accuracy to determine sex, age class and group size (mean = 2.17 individuals per group) for describing population structure (Fig. 3). Isolated dung piles were the most frequently collected type of data, and sightings were the rarest (Table 1). Middens were always associated with more abundant isolated dung piles nearby. Of the 50 positive sites 10% (n = 5) had gazelle presence confirmed by tracks alone. Twelve of 17 negative surveys (70.59%) were in flat areas.

*Seasonal effects on surveys* No seasonal variation was found for the three variables tested: percentage of sites with gazelles detected (spring 77.5%, autumn/winter 70.3%; $U = 501.0$, $Z = -0.65$, P = 0.51), kilometric abundance index of indirect signs (spring 0.64, autumn/winter 0.49; $U = 490.0$, $Z = -0.49$, P = 0.62), and kilometric abundance index of gazelles sighted (spring 0.028, autumn/winter 0.05; $U = 465.0$, $Z = -1.02$, P = 0.30).

*Effort required to detect Cuvier's gazelles* A mean survey distance of 2.15 ± SD 1.74 km (range 0.02–5.69) was required to detect any sign of gazelle presence. The first sign detected was tracks at 66.66% of sites, dung piles at 30.76% and middens at 2.56%. No gazelles were sighted prior to detection of indirect sign.

*Imperfect detection analysis* The imperfect detection analysis yielded the following estimations of detection rates and false absences within real positive study sites: (1) detection rate = 40/48 = 0.83 and 17% false absences for one survey per site; (2) detection rate = 45/48 = 0.94 and 7% false absences for two surveys per site; and (3) detection rate = 16/16 = 1 for three surveys per site and 0% false absences. At two of the five sites with no detected gazelle presence (Yebel Zini and Yebel Rich, Fig. 1) the survey effort was sufficient (3 transects > 5 km each) to have detected gazelles had they been present, and therefore real absences can be assumed. Surveys at the other three sites were < 5 km, and thus the results could be false negatives.

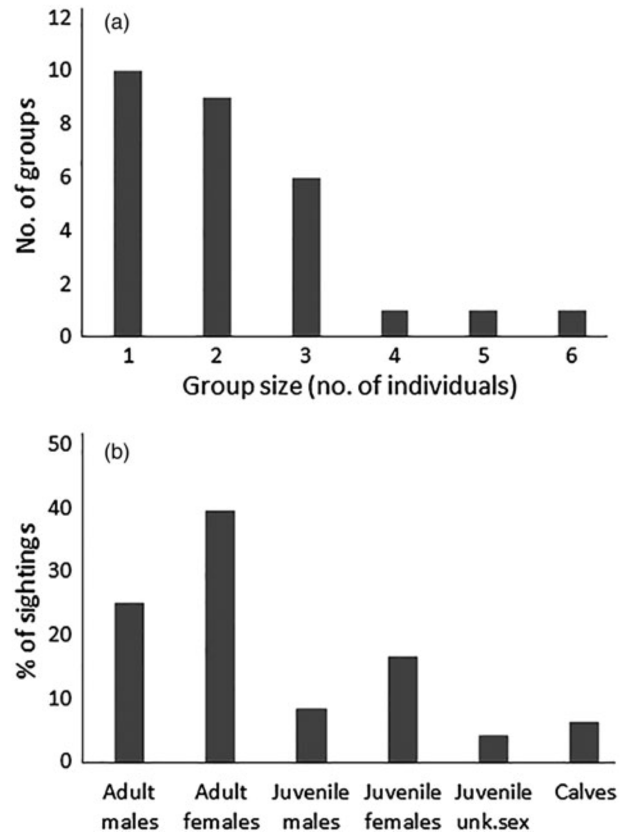


FIG. 2 (a) Sex and age composition of Cuvier's gazelles, from 48 discernible observations (of a total of 61 sightings) and (b) numbers of groups of various sizes observed in the study area (Fig. 1).

*Relationships between indices of abundance* We calculated a mean kilometric abundance index of 0.29 ± SE 0.085 km$^{-1}$ and 0.22 ± SE 0.059 km$^{-1}$ for isolated dung piles and middens, respectively. The abundances of isolated dung piles and middens were positively correlated ($R_s = 0.82$, P < 0.0001; Fig. 4), and therefore they were pooled together (mean kilometric abundance index = 0.52 ± SE 0.13; Kolmogorov–Smirnov (K–S) test for normality: $Z = 1.05$, P = 0.22). We found a positive relationship ($R_p = 0.69$, P = 0.026; Fig. 4) between indirect signs (as dependent variable) and the abundance of sightings (mean kilometric abundance index or encounter rate from distance sampling = 0.081 ± SE 0.019 gazelles km$^{-1}$; K–S test: $Z = 1.10$, P = 0.17).

*Occupancy and density estimates* The estimated value of $\Psi$ was 0.85 ± SE 0.061 (95% CI 0.68–0.94). The effort for the distance calculations was 707.1 km over 64 surveys,

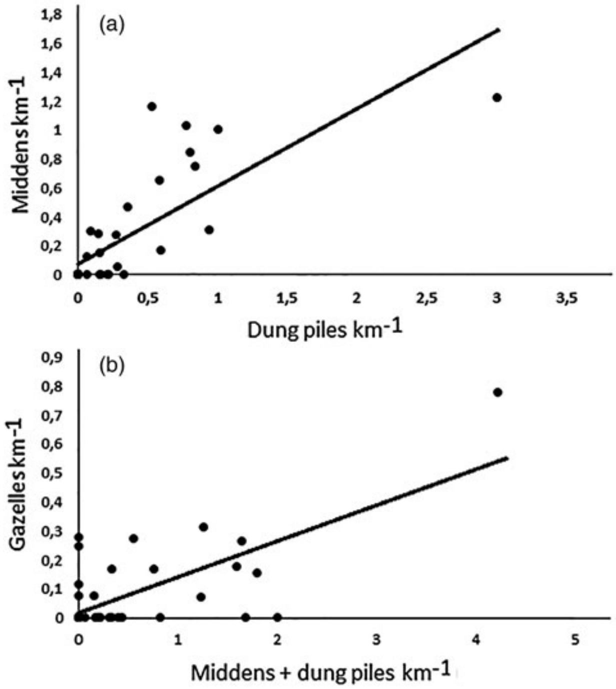


FIG. 3 Relationships between (a) two types of indirect signs (middens and dung piles), and (b) indirect signs and direct sightings of Cuvier´s gazelles in the study area (Fig. 1).

TABLE 1 The number and percentage of sites at which various types of data on Cuvier´s gazelle *Gazella cuvieri* were recorded in the arid landscapes of the north-western Sahara Desert, Morocco (Fig. 1).

| Type of data | No. of sites | % sampled sites | % positive sampled sites |
|---|---|---|---|
| Sightings | 20 | 29.85 | 41.66 |
| Isolated dung piles | 38 | 56.71 | 75.00 |
| Middens | 28 | 41.79 | 56.25 |
| Tracks | 30 | 44.77 | 60.41 |

resulting in 26 clustered observations (57 gazelles) and a maximum detection width of 1.08 km. The half-normal function without any adjustment term (corrected Akaike's information criterion, AICc = 346.33) was selected over the half-normal function with cosine adjustments of order two (AICc = 348.54) and over the half-normal function with simple polynomial adjustments (AICc = 347.16), offering a good value of adjustment to the observed distribution of sightings (K–S test: $Z = 0.23$, $P = 0.12$; Fig. 4); the half-normal function with hermite polynomial adjustments was not possible with the data set. The results of the distance analysis are in Table 2. The resulting population estimate for Cuvier's gazelle in the study area is 935 individuals (95% CI 597–1607).

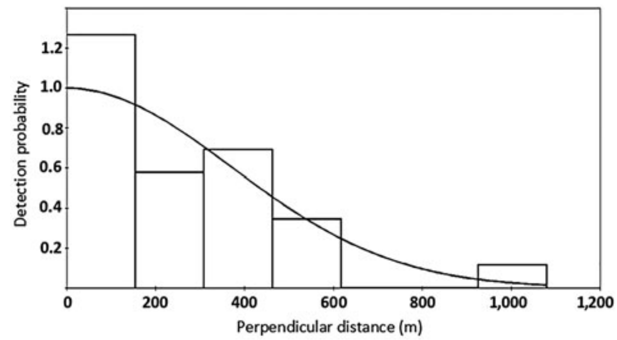


FIG. 4 Detectability function and distance distribution of observed Cuvier´s gazelles in the study area (Fig. 1).

## Discussion

We found that sampling indirect sign can yield optimal results for Cuvier's gazelle, even in situations of low or very low density. Moreover, the species' sign is usually easy to recognize, especially the middens, which are not likely to be confused with those of other species. Similar findings have been reported for the mountain gazelle *Gazella gazella* (Attum et al., 2006; Wronski & Plath, 2010). Our results suggest that it is feasible to obtain sufficient sample sizes for occupancy models or ecological studies (Abáigar et al., 2005a; Attum et al., 2006; Wronski & Plath, 2010) with relatively low effort. In $< 2$ effective sampling months of combined effort we detected gazelles in 74.62% of all surveys and determined that a survey distance of 2.15 km is sufficient to detect gazelles if present. Moreover, imperfect detection (the biases produced by false negative surveys; MacKenzie et al., 2006) was observed in few samplings, and could be avoided by increasing the effort at some sites. Only track surveys produced a low rate of positive detection. This is not surprising, as detecting this type of indirect sign depends not only on effort but also, more importantly, on substrate. The difficulty of detecting tracks in rocky areas, as well as environmental circumstances (e.g. rain, wind) that can quickly destroy this type of sign, could lead to false negative surveys. However, the rate of negative points within the area of Yebel Zini and Yebel Rich (Fig. 1) was low (2 of 52 survey sites), and therefore the effects of this limitation (which could result in underestimation of the population) were negligible. As we found a significant positive relationship between sightings of gazelles and indirect indices of abundance, the latter could also be used for population monitoring, both at spatial and temporal scales.

The distance surveys did not provide additional information or improve upon the results from the indirect surveys in terms of distribution data and relative abundance. Moreover, distance surveys increased the effort required, as it was necessary to walk longer distances to see gazelles than to find indirect sign. It seems that the distance results were affected not only by the low density of gazelles but also

TABLE 2 Results of the distance analysis of data on Cuvier's gazelle in the study area (Fig. 1).

| Parameter (unit) | Estimate ± SE | %CV | 95% CI |
|---|---|---|---|
| Detection probability | 0.42 ± 0.065 | 11.41 | 0.33–0.54 |
| Effective strip width (m) | 461.76 ± 52.69 | 11.41 | 365.32–583.66 |
| Density of groups (groups km$^{-2}$) | 0.039 ± 0.008 | 22.34 | 0.025–0.061 |
| Expected group size (no. of individuals) | 2.03 ± 0.24 | 12.17 | 1.58–2.60 |
| Density of individuals (individuals km$^{-2}$) | 0.08 ± 0.02 | 25.44 | 0.049–0.132 |

by their shy and vigilant behaviour (authors, pers. obs.; Manor & Saltz, 2003). Although distance sampling (with wide confidence intervals) was the only way to estimate gazelle density, our density estimate must be viewed with caution, as it was based on data from surveys that spanned a long sampling period (2011–2014), during different seasons, and with low sample sizes (see criticisms in Buckland et al., 2004). We have, however, demonstrated that with sufficient effort it is possible to gather enough field data for distance analysis. Furthermore, the distance survey was useful in gathering data on the demographic structure of the population.

Even considering the limitations of our density estimation it is clear that the species is scarce within the study area. Reference densities for comparison are not available; however, the mountain gazelle has been found at densities of 0.64–15.0 individuals km$^{-2}$ in arid but well-protected areas (Dunham, 1997; Cunningham & Wronski, 2011). We assume that the observed abundance of Cuvier's gazelle is not strongly limited by natural factors, as this population lives under optimal conditions for the species in an arid habitat (Cuzin, 2003). Rather, poaching may have a significant impact on population dynamics. Poaching has traditionally been a major factor in the decline and extinction of ungulate species throughout the Sahara Desert (Beudels-Jamar et al., 2006), including in Morocco (Morales Agacino, 1950; Valverde, 1957; Loggers et al., 1992; Cuzin et al., 2008). During our field work we observed three poaching parties, and two more poachers were photographed by a hidden camera trap. Although more information is needed, we fear that poaching may be a significant threat to this population, and further protection may be necessary to secure a viable future for the species.

Our study highlights some limitations of previous estimates of the local populations of Cuvier's gazelle, which were based on subjective estimates. Cuzin et al. (2008) estimated that the studied population comprised only 100–300 individuals, and regarded it as a secondary and less important focus for Morocco´s Wild Ungulates Action Plan. However, our results suggest that this population requires increased attention from managers, as it is the only extant population with an effective population size close to 500 individuals (all other populations are estimated to comprise < 300 individuals; Beudels-Jamar et al., 2006), and is therefore the most genetically viable in the long term (Frankham et al., 2014). Considering a recent prediction that 'Cuvier's gazelle might be soon extirpated from the Western Sahara, if not already' (Huffman, 2011), our population estimate of 600–1,600 individuals is a cause for optimism. Nonetheless, given the potential impact of poaching on the population, there is an urgent need for regular monitoring and conservation action.

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## Author contributions

JMGS, FJHS, BÁ, ÁA, JB, IC, SC, MÁDP, JL, EM, JP, JRS, JMS, JMV and GV carried out the field surveys. JMGS prepared the manuscript. AQ and EV supervised the research.

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## Biographical sketches

Jose María Gil-Sánchez, F. Javier Herrera-Sánchez, Begoña Álvarez, Ángel Arredondo, Jesús Bautista, Inmaculada Cancio, Salvador Castilo, Miguel Ángel Díaz-Portero, Jesús de Lucas, Emil McCain, Joaquín Pérez, Javier Rodríguez-Siles, Juan Manuel Sáez, Jaime Martínez Valderrama and Gerardo Valenzuela have extensive experience in research and management of threatened fauna of the Iberian Peninsula, including the Iberian lynx, the Spanish imperial eagle, Bonelli's eagle and Montagu's harrier. Since 2010 their work has focused on research and conservation of the threatened mammals of the Moroccan Sahara, especially wild ungulates (Cuvier's and dorcas gazelles and Barbary sheep) and carnivores (including the Saharan cheetah, the honey badger, canids, and the striped hyaena). Abdeljebbar Qninba's research interests lie in the wildlife of Moroccan wetlands and the Sahara Desert. Emilio Virgós' research focuses on the ecology of Iberian mammalian carnivores.