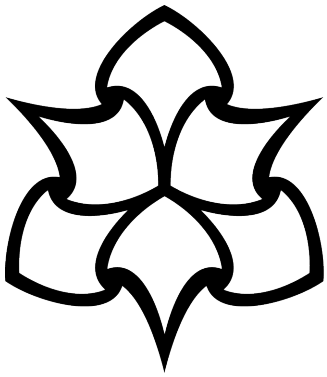

Age-stratified interview campaigns suggest ongoing decline of a threatened tortoise species in the West African Sahel

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ABSTRACT

Face-to-face interviews with local populations are often used to determine the distribution and population trends of elusive threatened species. Although interviewee responses may suffer from some bias, historical trends in the status of a species can be investigated from age-structured questionnaires. In this paper, we tested this idea by analysing separately answers given by older (> 60 years age) and younger respondents (25-44 years old) on the status of the African spurred tortoise, (*Centrochelys sulcata*), a charismatic large reptile listed as Vulnerable in the IUCN Red List. We interviewed 619 persons (hunters/farmers/cattle farmers) of different ages in three of the species' habitat countries (Burkina Faso, Niger and Nigeria). Interviewees were asked whether in their experience the tortoise was common, rare or absent. By using Generalized Linear Models we showed that the probability to answer "common" increased with age in Nigeria and Burkina Faso, whereas the probability of responding "absent" declined with age in Nigeria and Niger. There were no significant effects of age for the answer 'rare' in any country and no differences were found between villages in any of the studied countries. From our data we conclude that spurred tortoises have been extirpated in 16.7% of study sites. We argue that if statistical differences emerge between answers given by respondents of various age classes on the population status of a target species, it is possible to conclude that the species' situation may have significantly changed during the last 30-40 years.

KEYWORDS

Face-to-face interviews; threatened species; traditional ecological knowledge; tortoise; Sahel; conservation

Introduction

Global population trends may be determined using indirect evidence for rare/elusive taxa, especially in tropical and/or difficult-to-access regions (Hellier et al. 1999; Wang et al. 2004; Akani et al. 2013; Turvey et al. 2015; Pham et al. 2019). Face-to-face interviews with local inhabitants have been widely used to explore the likely presence, local distribution and apparent population trends (declining, stable, increasing) of several species of conservation concern (Charnley et al. 2007; Padmanaba et al. 2013; Demaya et al. 2019). However, this use of traditional knowledge can be affected by the difficulty of verifying the trustworthiness of answers given by informants (e.g., Knapp et al. 2010; St. John et al. 2010; Keane et al. 2011; Jenkins et al. 2011; Luiselli et al. 2017).

Our study focussed on the African spurred tortoise (*Centrochelys sulcata*), the second largest tortoise in the world (male weight > 100 kg; Branch 2008). The species has a wide distribution throughout much of the African Sahel (Branch 2008), with scattered populations due to the impact of anthropogenic factors such as cattle grazing and fires (Branch 2008; Petrozzi et al. 2016, 2017a, 2017b) and habitat-determined natural gaps in its distribution (Petrozzi et al. 2017c). Thus, although strongly suspected (Branch 2008), it is not known whether population sizes of this species have actually declined. In this paper, we use a large number of interviews to ascertain whether the species was more/less common now than in the past, by stratifying responses with respect to interviewee age. We argue that answers given by older respondents (> 60 years age) would indicate the population status of the target species 30-40 years ago, whereas answers provided by younger respondents (25-44 years old) would reflect the species' current population status.

Materials and methods

Protocol

Our study was based on 2015-2017 structured interview data, building on a previous study from 1994 to 2007 that provided indirect information on the abundance of tortoises within the

known range of the African spurred tortoise (Vetter 2005; Chirio 2009; Trape et al. 2012), including four West and Central African Sahel countries, Central African Republic, Cameroon, Niger and Burkina Faso (Table 1). We also confirmed the status of the species from ad-hoc field surveys at each site. Using the results of these first surveys we developed more targeted questionnaires for a second phase of work e.g. we decided to only interview men because men hunt and women rarely spend time in the field. We applied the resulting questionnaire during 2015-2017 in a total of 30 villages (Fig. 1) in Nigeria (n = 13), Niger (n = 10) and Burkina Faso (n = 7). Villages were selected on the basis of historical records for the presence of the species in their surroundings and on their relative accessibility. CAR and Cameroon were not included in the surveys for security reasons. A total of 619 adult men were interviewed, Nigeria (n = 233), Niger (n = 209), and Burkina Faso (n = 177).

We recorded the age of each interviewee. All interviewees were classified into one of three groups: (i) >60 years age, (ii) 45-59 years old, and (iii) 21-44 years old. No person < 21 years old was interviewed. We obtained informed consent from all interviewees and their identity was kept anonymous in order to respect their privacy and minimize the risk of untrustworthy answers. All interviewees were informed that our study was merely for research purposes and had no social or political implications.

Interviewees were asked the following two questions:

(1) Have you ever encountered very large tortoises during your hunting/shepherding activities? We explained to older interviewees that we were interested in their comments even if the information provided was historical (as most older interviewees had not hunted or tended livestock for some years at the time of the interviews).

(2) If yes, did you meet them frequently (i.e. at least 4-5 times a year) or rarely (i.e. no more than 1-2 times in each year)?

We also asked interviewees whether the amount of time spent hunting and herding livestock by them each year had declined so as to indirectly measure frequency of encounter

with tortoises. Since many interviewees did not want to answer personal lifestyle questions, answers were only informally recorded, though they had no issues responding questions on the status of our study species. A total of 153 interviewees (25% of all respondents) answered this question; Nigeria (n = 41), Niger (n = 59) and Burkina Faso (n = 53).

If the interviewee answered affirmatively to questions (1) and (2), we also asked him to show us the approximate size of shells of tortoises he had found in the field. This information was crucial because adult African spurred tortoises (up to 100 kg in males) are readily identified by their relatively large size and cannot be confused with any other sympatric species (Branch 2008). When interviewees were clearly speaking of the wrong species, we did not include any of their responses in our dataset. Interviewees were not asked whether they thought the species was declining nor about the "current" status of the species. However, we extrapolated this information by performing statistical comparisons between the frequency of 'yes frequently' answers to the question (2) among age classes, under the assumption that, in a given village a lesser frequency of 'yes frequently' answers in younger interviewees compared to the older respondents would indicate a decline in the population size of the species. To minimize the probability of obtaining untrue answers from respondents, local assistants using the native language performed all interviews. In addition, we interviewed each person separately and independently from other interviews conducted in the same village. Since these tortoises are popular pet animals in the Sahel region, it was explicitly explained to the interviewees that we referred exclusively to specimens encountered in the wild. We kept the length of each interview to 3-5 minutes to reduce inconveniencing the interviewee as much as possible. As indirect evidence of the reliability of the interviewees' answers, (i) we observed wild spurred tortoises in some sites where the respondents claimed that these reptiles were still found (e.g., Baraboulé and Medjoari village (in Arly) in Burkina Faso; see Petrozzi et al., 2016, 2017a, 2017b), and (ii) examined shells of dead animals shown to us in sites where the older respondents claimed they were common (e.g., Daura and Babura in Nigeria).

Assumptions

To interpret the answers given by our respondents, we used two main assumptions:

(1.i) Localities of occurrence of spurred tortoises were considered as highly reliable when more than 65% of interviewees, of any age group, described them as 'common' in the wild. This is of course just an arbitrary threshold, however indicating that most of the interviewed people were consistent in their opinion about the abundance of the tortoise, thus making highly unlikely that all of them were wrong or just lied to us.

(1.ii) Extirpation of spurred tortoises from a given locality was assumed when, in a given locality, more than 65% of the interviewees in the 45-59 and >60 years groups combined reported that the tortoises were as common whereas 0% of the 25-44 years old people reported them as still present (either rare or common) in the wild. We considered in this case the different age categories because people older than 60 do not shepherd anymore as a general trend, being replaced in this task by younger persons.

Statistical analyses

To analyze the potential effect of 'level of hunting and shepherding' on the probability of encounter with tortoises, we performed a Spearman's rank correlation analysis by country (n =41 in Nigeria, n = 59 in Niger, n = 53 in Burkina Faso). In this analysis, the independent variable was the 'level of hunting and shepherding' and the dependent variable was the 'frequency of meeting with the tortoises'. For the independent variable, we attributed a relative score for the various types of interviewees' answers. When the interviewee answered that his 'level of shepherding' was 'stable' throughout the years, we attributed score =0, 'decreasing' (score = -1) and 'increasing' (score=1). For the dependent variable, we scored the answer 'absent' = 0, 'rare' =1, 'common' =2.

Generalized Linear Models (GLM) were used to model the interview results for the different answer types and to quantify their relationship with site (village) and age classes (three categories) of the interviewees (Hosmer and Lemeshow 2000). A single model was run

for all countries, with country identity as the factor. In the model, the three answer types (i.e. common, rare, or absent) were the dependent variables and country and the three age classes were the independent variables. The identity link function and a Poisson distribution of error were used (McCullagh and Nelder 1989). The significant variables were computed using the 'all effects' (for the age classes) and the best subset procedure using Statistica 6.0 software. Parametric tests were used on normally-distributed variables; otherwise, non-parametric tests were used in our analyses. Normality and homoscedasticity was assessed by Kosmogorov-Smirnov test ($P < 0.05$). Statistica 6.0 software was used for all analyses.

Results

The results from the unstandardized interviews are summarized in the online supplemental materials (Table S1).

Standardized interviews

In Nigeria, the 'level of hunting and shepherding' was positively correlated with the probability of encounter with tortoises ($r_s = 0.529$, $n = 41$, $P < 0.001$), whereas there was no correlation in both Niger ($r_s = -0.075$, $n = 59$, $P = 0.571$) and Burkina Faso ($r_s = -0.123$, $n = 53$, $P = 0.378$).

In most of the 30 localities, only respondents > 60 years age reported spurred tortoises as 'common' (Table 1). The only exception to this rule was Kafin Sarki (Nigeria), where the majority of the 45-50 year age group also reported the species as common (Table 1). However, in 6 out of 8 localities in Nigeria and in all 8 localities in Niger, none of the younger respondents (25-44 years old) considered the spurred tortoise to be common. There was a decrease in numbers of respondents who reported the tortoise as common with age in Niger and Nigeria (Table 2).

GLM model results indicated that probability of common responses increased with age in Nigeria (estimate 1.27, $P = 0.000025$), Niger (estimate = 0.27; $P = 0.000000$) and Burkina Faso (estimate = 0.72; $P = 0.002111$). The probability of the tortoise being absent decreased with age in Nigeria (estimate = -2,31; $P=0.000000$) and Niger (estimate = -0,21; $P = 0.000000$),

but not in Burkina Faso (P = 0.087). Effects of age classes on the answer 'rare' do not get uncovered for any of the three countries (Nigeria: P = 0.403; Niger: P = 0.522; Burkina Faso: P = 0.488). There was no significant effect of village or country as variables in all analyses (Table S2). Extirpation of tortoises may have occurred in 16.7% of the sites (2 in Nigeria, 3 in Niger, and 0 in Burkina Faso) where old-age interviewees reported the species as common and the young interviewees as absent (Table 1).

Discussion

A main result of our study is that 'level of hunting and shepherding effort' did not influence the type of answers on tortoise status in Burkina Faso and Niger, whereas it did in Nigeria. Although based on a relatively low number of interviewees, we attributed these inter-country differences to the rarity of the spurred tortoises in Nigeria (Vetter 2005; Petrozzi et al. 2015).

Older interviewees more frequently reported the tortoise as being common than did younger interviewees. Our GLM models showed that these differences were not by chance, and therefore that these differences really depended on the divergent experience that older and younger interviewees had with the African spurred tortoises in the field. The most plausible explanation for the different answers between older and younger respondents is that the African spurred tortoise has dramatically declined in many parts of its range, and that it may have even disappeared in several sites (over 15% of the surveyed sites) where it was once common. We doubt that other reasons (such us suboptimal 'research searching' by shepherds in some sites compared to others; differential levels of elusive habits of the tortoise by site and by interviewee's age group) can explain the observed pattern, given (i) the high number of interviewees and villages, and (ii) the heterogeneous social, political and cultural background of the various populations inhabiting Burkina Faso, Niger and northern Nigeria. However, it is possible that some of the older interviewees may have exaggerated the abundance of tortoises in their memory (a variant of the 'old times' sake' syndrome). Identification errors can be surely ruled out given the huge size of the species and its role as a 'pet animal' in local contexts.

Using percentage responses in which older interviewees declared the target species' presence, it is possible to suggest that the spurred tortoise was widely distributed (and possibly abundant) in Niger, but scarce in Burkina Faso. These patterns are consistent with the known history of the distribution of this species in West Africa (Boulweydou 2008; Chirio 2009; Trape et al. 2012; Petrozzi et al. 2016, 2017c).

Our study suggests that a stratified-by-age-interview approach may be useful to determine patterns of decline in threatened species inhabiting unstable and/or difficult-to-access regions of the world. Target species should be, as was the case of the African spurred tortoise, (i) easily and non-ambiguously identified by the respondents and (ii) charismatic, in order to minimise potential biases in the patterns of answer by the interviewees. Presently, we do not have any evidence that our method can work well also with non-charismatic species.

The information collected from the interviews was coarse regarding abundance (common, rare, absent) and with no temporal references other than the interviewee age, thus these coarse resolutions could potentially hamper fine analyses of population trends (Turvey et al. 2012, 2015). We intended to use broad categories of "abundance" in order to highlight general population trends with minimizing the eventual lack of reliability by interviewees in a geographic region where local communities are very often suspicious and reluctant in being precise in their answers to scientists (our personal experience).

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Table 1 Raw data distribution of the three types of answer (tortoise is common, rare or absent) by respondents' age in each village of the three countries. Highlighted in bold are those cases where >60 common was coupled with 25-45 absent. Total sample sizes in each village and in each country are also presented.

	> 60 common	> 60 rare	> 60 absent	45-60 common	45-60 rare	45-60 absent	25-45 common	25-45 rare	25-45 absent
	NIGERIA								
Daura	**6**	**2**	**0**	**2**	**2**	**5**	**0**	**1**	**7**
Babura	**4**	**2**	**0**	**1**	**0**	**3**	**0**	**1**	**4**
Medu	**4**	**1**	**0**	**0**	**2**	**6**	**0**	**1**	**4**
Nguru	**3**	**1**	**0**	**0**	**1**	**3**	**0**	**0**	**5**
Auyo	0	1	4	0	0	6	0	0	7
Geidem	0	1	5	0	0	5	0	0	8
Sabon Birni	0	1	3	0	0	5	0	0	8
Gwadabawa	0	0	5	0	0	4	0	0	7
Moriki	5	2	0	2	2	0	0	2	5
Kafin Sarki	**4**	**1**	**0**	**2**	**1**	**0**	**1**	**1**	**6**
Botawa	**3**	**0**	**1**	**2**	**3**	**0**	**0**	**1**	**6**
Isa	**6**	**2**	**0**	**4**	**3**	**0**	**1**	**3**	**7**
Shanga	0	0	4	0	0	5	0	0	8
TOTAL	35	14	22	13	14	42	2	10	82
	NIGER								
Zabori	**6**	**0**	**0**	**2**	**5**	**0**	**0**	**0**	**7**
Niamey	**7**	**0**	**0**	**1**	**6**	**0**	**0**	**0**	**7**
Diney	**7**	**0**	**0**	**1**	**6**	**0**	**0**	**3**	**5**
Safia	**5**	**0**	**0**	**3**	**3**	**0**	**0**	**1**	**8**
Madaoua	**4**	**3**	**0**	**0**	**0**	**8**	**0**	**0**	**7**
Dosso	**6**	**1**	**0**	**0**	**5**	**1**	**0**	**4**	**4**
Matamey	**2**	**5**	**0**	**2**	**3**	**2**	**0**	**0**	**6**
Maradi	**6**	**0**	**0**	**1**	**3**	**2**	**0**	**3**	**5**
Eroupa	6	1	0	1	3	2	0	5	2
Tatori	**8**	**0**	**0**	**3**	**4**	**0**	**0**	**0**	**8**
TOTAL	57	10	0	14	38	15	0	16	59
	BURKINA FASO								
Kantchari	2	1	6	0	3	5	0	0	9
Medjoari	1	3	3	0	3	4	0	1	9
Dori	0	1	8	0	0	9	0	0	10
Baraboulé	0	0	8	0	0	8	0	0	11
Thiou	0	0	9	0	0	11	0	2	7
Dokuy	1	3	1	0	1	9	0	3	5
Tansila	2	5	0	0	4	3	0	3	3
TOTAL	6	13	35	0	11	49	0	9	54

Table 2 Synopsis of the percent distribution of the three types of answer (tortoise is common, rare or absent) by respondents' age in each of the three countries (all sample sizes for each village being cumulated). Standard Deviations are also presented after the means.

	> 60 common	> 60 Rare	> 60 absent	45-60 years common	45-60 years rare	45-60 years absent	25-45 years common	25-45 years Rare	25-45 years absent
Nigeria	46 ±38	18.35±11.28	35.6±46.8	20.07±25.31	19.88±21.71	60.05±43.87	1.66±4.11	10.78±11.52	87.55±13.35
Niger	85.71±24.28	14.29±24.27	0	21.21±16.48	57.6±26.12	21.21±31.12	0	20.75±26.3	79.25±26.3
Burkina Faso	12.16±12.11	28.07±29.63	59.93±40.07	0	21.07±24.16	78.93±24.16	0	17.1±20.22	82.9±20.22

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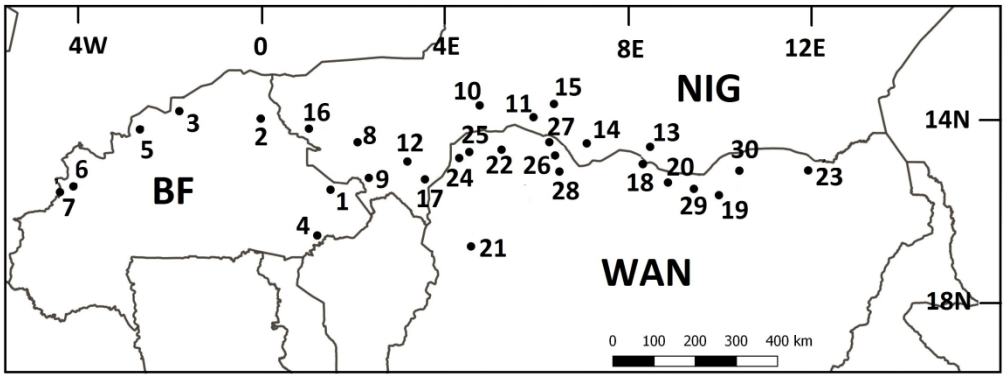
Fig. 1. Map of the study region in the West African Sahel, showing the villages where interviews were carried out. Abbreviations: WAN = Nigeria; NIG = Niger; BF = Burkina Faso; 1: Kantchari; 2: Dori; 3: Baraboulè; 4: Madjoari; 5: Thiou; 6: Dokuy; 7:Tansila; 8: Niamey; 9: Diney; 10: Safia; 11: Madaoua; 12: Dosso; 13: Matamey; 14: Maradi; 15: Eroupa; 16: Tatori; 17: Zabori; 18: Daura; 19: Auyo; 20: Babura; 21: Shanga; 22: Gwadabawa; 23: Geidem; 24: Botawa; 25: Kafin Sarki; 26: Isa; 27: Sabon Birni; 28: Moriki; 29: Medu; 30: Nguru.



295x111mm (299 x 299 DPI)

ONLINE SUPPLEMENTAL MATERIALS

Results from the Unstandardized interviews

A summary of the unstandardized interview campaigns is given in Table S1. These unstandardized interviews provided very valuable information on relative abundance of the species, but also on its natural history within the different sites. Interestingly, part of the information provided by the interviewees was later confirmed by ad-hoc field surveys, thus showing the reliability and feasibility of using these interviews. For instance, the fact that the species was quite abundant in the Termit-Teneré area, as reported in the interviews, was later confirmed by transect surveys using Distance (Petrozzi et al., 2017b), and that above-ground activity and egg hatching occur during rainy season was also confirmed by field surveys (Petrozzi et al., 2017b, 2017c, and unpublished observations).

Table S1 Synopsis of the non-standardized interviews on the population status and natural history of African spurred tortoises. CAR = Central African Republic.

Year	No. Of interviewees	Locality	Coordinates	Declaration
1994	15	Birao (CAR)	10,28N+22,79E ; 500 m	Rather common north of the town
1995	4	Am-Dafok (CAR)	10,46N+23,29E ; 500 m	Uncommon in the bush around the village
2000	3	Bouba Ndjida (Cameroon)	8,72N+14,58E : 330 m	Formerly rather common in the protected area; now most probably extinct
2005	8	Termit (Niger)	16,38N+11,47E ; 550 m	Quite abundant during rainy season
2007	5	La Tapoa (Niger)	12,04N+2,26E ; 250 m	Very abundant hatchlings during rainy season
2007	5	Diapaga (Burkina Faso)	12,07N+1,79E ; 280 m	Formerly rather common around the village; now very rare

Table S2. GLM effect of the village on the probability of answers by interviewees in the three surveyed countries

Type of answer	P-value
Nigeria	
Common	0.917
Rare	0.840
Absent	0.983
Niger	
Common	0.667
Rare	0.633
Absent	0.689
Burkina faso	
Common	0.391
Rare	0.494
Absent	0.852