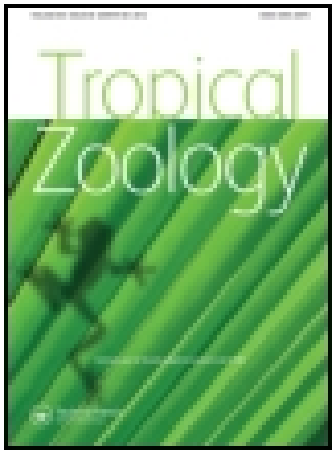

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Aspects of the ecology of the tortoise Kinixys nogueyi (Lataste, 1886) in Togo and Nigeria (West Africa)

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Aspects of the ecology of the tortoise *Kinixys nogueyi* (Lataste, 1886) in Togo and Nigeria (West Africa)

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In this study, the sex ratio, habitat use, and diet of free-ranging *Kinixys nogueyi* are examined. Sex ratio and habitat use were examined in Togo and Nigeria (West Africa), and food habits only in Nigeria. Sex ratios were equal in both populations. Tortoises had clear habitat preferences in both countries, and the Nigerian population exhibited seasonal but not inter-sexual differences in habitat selection. The present study demonstrated that this species inhabits not only Guinea savannahs and relatively wet savannahs, as already reported in the literature, but also rainforest patches and hilly forests, especially in Togo. Food remains in the feces of Nigerian specimens belonged to plants and fungi as well as to animals, with inter-seasonal but not inter-sexual differences in dietary composition. In particular, there was a significant shift from a diet based mostly on animal food in the dry season towards a mainly vegetarian diet in the wet season.

Keywords: tortoise; habitat selection; food habits; West Africa

Introduction

Tortoises of the genus *Kinixys* Bell, 1827 are endemic to Africa (Branch 2007) and are declining rapidly throughout the continent (Mifsud and Stapleton 2014), particularly in West Africa (e.g., Luiselli and Diagne 2013). As a consequence, urgent management is required to conserve these species, especially those that are most endangered (Luiselli and Diagne 2013; Mifsud and Stapleton 2014). Unfortunately, however, the ecology of very few species has been studied in depth under natural conditions (e.g., *Kinixys homeana* Bell, 1827, *Kinixys erosa* (Schweigger, 1812), and *Kinixys spekii* Gray, 1863; see, e.g., Hailey and Coulson 1995; Luiselli 2003; Lawson 2006; Luiselli and Diagne 2013). The West African endemic *Kinixys nogueyi* (Figure 1) is among the *Kinixys* species whose wild populations have never been studied, with scanty natural history data being available only in general books (Chirio and LeBreton 2007). This species has a continuous distribution across the Guinea savannah regions of West Africa (Branch 2007; Mifsud and Stapleton 2014) and appears to be declining (Mifsud and Stapleton 2014). Indeed, it was listed as Vulnerable by the IUCN Red List Assessment meeting held in Lomé (Togo) in

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Figure 1. Adult male of *Kinixys nogueyi* (photo: F. Petrozzi).

August 2013. Here, we focus on the main habitats where the tortoises were encountered in two West African countries (Togo and Nigeria), plus feces analyses performed in Nigeria.

Materials and methods

The Nigerian portion of the field study was conducted during 60-day surveys from May to June 2012 and February to March 2014 in the vicinity of Ibadan (Oyo State, Western Nigeria). Data were collected in the same study area also used for ecological research on monitor lizards (Eniang et al. 2014). Each field day consisted of visual encounter surveys, done simultaneously by at least three independent walking experienced researchers, that lasted for approximately 08:00–18:00 h (Lagos time), with an effort to regularly cover the entire study area during different parts of the day. The surveyed appropriate habitat was 230 ha.

In Togo, data on tortoises were collected opportunistically during random surveys of potentially suitable habitat (forests, forest–savannah mosaics, and Guinea savannahs; Segniagbeto et al. 2014). Field data were collected during the Ph.D. research project of the first author and during other specific research projects as follows. From August to October 2010, field surveys were conducted in forested areas of Togo, specifically the Aboudoulye Reserve and Alibi community forest, as part of research and conservation projects on herpetofauna and general biodiversity (Leapfrog Conservation Fund and AE2D/FFEM). Other field surveys were conducted in Tododo National Park from June to July 2009 (AGBO-ZEGUE NGO/IUCN-NL project). Individuals in these latter surveys were found by overturning leaves and stones in the forest. Field research in the above-mentioned areas was conducted by at least two experienced researchers moving independently across the suitable habitats. We also recorded data from individuals that were captured for domestic consumption by local people.

Tortoises were neither killed nor injured upon capture. Morphological data were recorded and the animals were released unharmed in the same habitats near the point of capture. A few already dead individuals were collected and preserved. Our morphological data were supplemented by including individuals from reptile farms in Lomé, observations that were carried out under the auspices of the Office in charge of the Wildlife (Direction de la Faune et de la Chasse). However, these latter specimens were not used for habitat use data.

Tortoises were collected by random searches among suitable micro-habitats and by using drift fences and pitfall traps that were checked daily. Drift fences were placed along line transects, each 100 m long, with one pitfall trap every 10 m. Each pitfall trap was 80 cm deep. Pitfall traps were kept active for 7 consecutive days at each study area. Daily checking of the pitfall traps was necessary to avoid the death of tortoises eventually captured. Indeed, no tortoise died because of our sampling protocol. Tortoises were measured for curved carapace length, plastron length, and body weight (see Luiselli 2003, for handling procedures). The tortoise individuals were measured with regard to curved carapace length with a tape, and to plastron length with a caliper (precision to the nearest 1 mm). Weight was measured by an electronic precision balance (to the nearest 1 g). Sex was determined by examination of the plastron shape (plastral concavity in males), and the tail size and shape (much larger tail in males, and a tail spine much larger in males; Branch 2007), and individuals were permanently marked by filing a unique sequence of notches into the marginal scutes (Luiselli 2006b). Each individual was assigned to a precise habitat category within the range of habitats available at the study sites.

Dietary data were collected only in Nigeria. Food habits of tortoises were determined by fecal analysis. Fecal samples were obtained from animals that defecated upon handling, and feces were stored in 10% formalin. Feces analysis was done by microscopic examination of samples. Each fecal sample was placed in a shallow dish of water, and the presence of different food items was noted. The percentage of tortoises that ate a given food type compared to the total number of fecal samples was used for the analysis because it was not possible to quantify food items in feces by number or volume. The frequency of utilization of the various habitat types and of the various food types, both by season and sex, was compared by a χ^2 test. The software PAST was used to calculate χ^2 values.

Results

Habitat selection

Nigeria. Overall, we collected 81 tortoises (42 males and 39 females) across seasons (60 individuals in the wet period and 21 individuals in the dry period) and habitat types. We observed an equal overall sex ratio (1.08 M:F), a pattern that was consistent across seasons (Figure 2). Overall and seasonal habitat preferences were evident (total: $\chi^2 = 46.5$; df = 5; $P < 0.0001$ – wet season: $\chi^2 = 23.8$; df = 5; $P < 0.001$ – dry season: $\chi^2 = 31.1$; df = 5; $P < 0.0001$), with no differences in habitat selection by sex (total: $\chi^2 = 4.2$; df = 5; $P = 0.518$ – wet season: $\chi^2 = 3.3$; df = 5; $P = 0.649$ – dry season: $\chi^2 = 2.0$; df = 5; $P = 0.849$). Both males and females behaved differently across seasons, as they did with regard to habitat selection (males: $\chi^2 = 16.6$; df = 5; $P < 0.01$ – females: $\chi^2 = 37.1$; df = 5; $P < 0.0001$).

Togo. We recorded habitat use by 141 individuals (Table 1), which is probably the largest sample size ever studied in the wild for this species. Overall, habitat selection was not even (χ^2; df = 2; $P < 0.001$), and preference for wet savannah was clear, although there was also a remarkable number of individuals captured inside mature forest ($n = 62$), thus showing that these records cannot be claimed as unusual occurrences (Figure 3). Dry savannah records were very rare (Figure 3).

Diet

Food remains in the feces of these tortoises belonged to six categories (three ascribed to plant and fungi, and three to animal taxa; Figure 4). *K. nogueyi* exhibited inter-seasonal

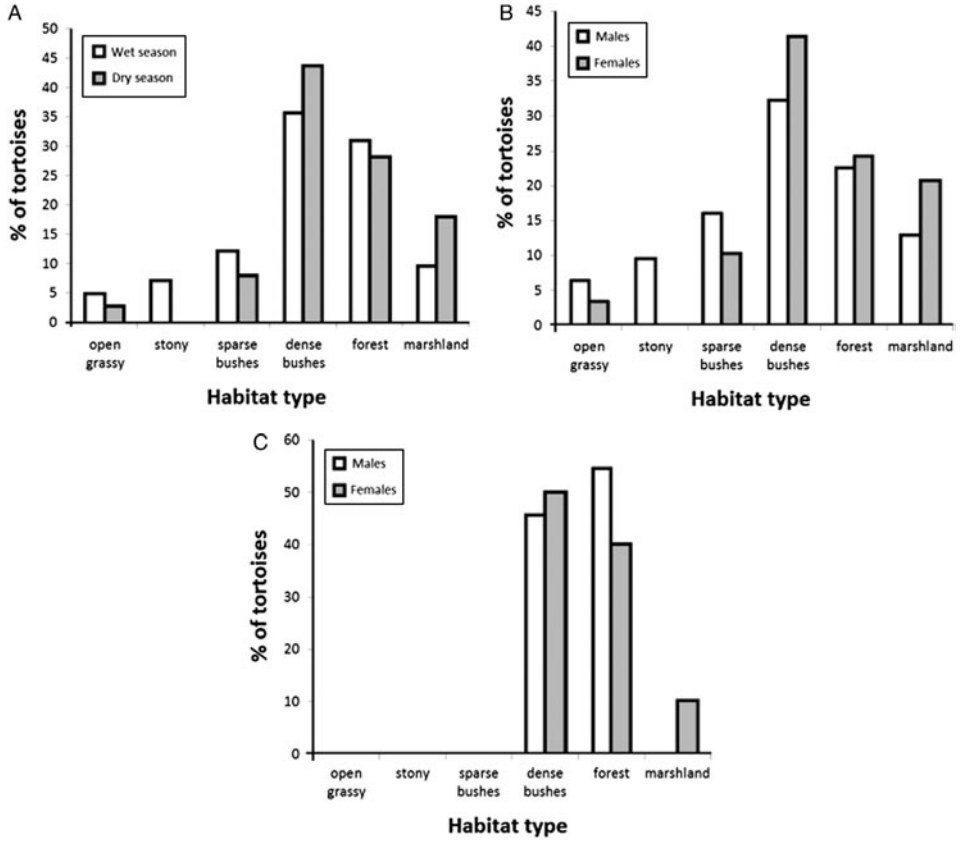

Figure 2. Occurrence (expressed as the percentage of the individuals collected) of *Kinixys nogueyi* in Nigeria (males and females pooled) in the selected habitat types during wet and dry seasons (A). Occurrence of males and females in the selected habitats during the wet (B) and the dry (C) seasons.

differences in its diet spectrum ($\chi^2 = 32.2$; df = 5; $P < 0.0001$), and this pattern was consistent by sex when analyzed separately (males: $\chi^2 = 20.3$; df = 5; $P < 0.01$ – females: $\chi^2 = 12.2$; df = 5; $P < 0.05$). There was a significant shift from a diet based mostly on animal food in the dry season towards a mainly vegetarian diet in the wet season

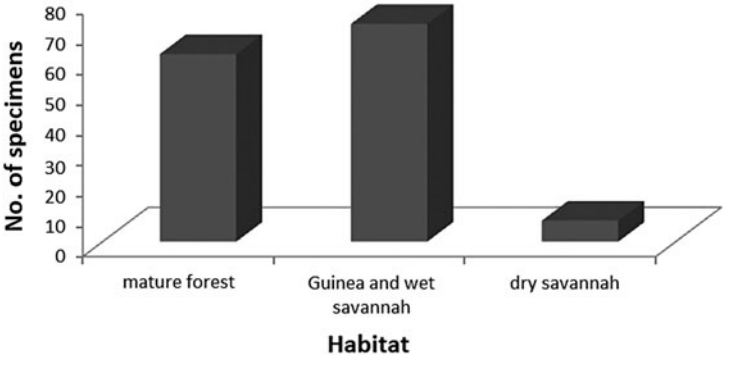

Figure 3. Macrohabitat of captured individuals of *Kinixys nogueyi* in Togo.

Table 1. Summarized data on macrohabitat selection by *Kinixys nogueyi* in Togo.

Locality	Latitude	Longitude	Number of specimens	Type of vegetation
Agbandji	08°13′5.79″N	01°8′14.70″E	1	Guinean wood savannahs, wood savannahs, gallery forest, degraded Guinean wood savannahs
Gando	10°19′32.30″N	00°44′54.99″E	1	Soudan savannahs, gallery forest, degraded Soudan savannahs
Gerin-Kouka	09°13′58.80″N	00°46′01.20″E	2	Savannahs, wood savannahs, Soudan savannahs
Bassar	09°40′58.80″N	00°28′58.80″E	3	Savannahs, wood savannahs, Soudan savannahs, dry forest
Tomety-Kondji	06°39′56.15″N	01°31′33.77″E	13	Guinean wood savannahs, wood savannahs, gallery forest, dry forest
Kuma Konda	06°57′12.10″N	00°34′43.40″E	5	Hilly forest, tropical wet forests or semi-deciduous forests, degraded forest areas
Danyi Elavagno	07°12′08.26″N	00°42′41.22″E	8	Hilly forest, tropical wet forests or semi-deciduous forests, degraded forest areas
Agbanon	07°16′05.50″N	00°47′55.70″E	12	Hilly forest, tropical wet forests or semi-deciduous forests, wood savannahs, degraded forest areas
Badou	07°34′60.00″N	00°36′00.00″E	6	Hilly forest, tropical wet forests or semi-deciduous forests, degraded forest areas
Tabligbo	06°34′50.92″N	01°30′0.17″E	20	Guinean wood savannahs, Wood savannahs, gallery forest, dry forest, degraded zone
Kouve	06°39′00.00″N	01°24′00.0″E	21	Guinean wood savannahs, Wood savannahs, gallery forest, dry forest
Kpadape	06°50′13.82″N	00°35′31.68″E	8	Hilly forest, tropical wet forests or semi-deciduous forests, degraded forest areas
Agou	06°50′60.00″N	00°43′01.20″E	18	Hilly forest, tropical wet forests or semi-deciduous forests, wood savannahs
Kolokope	07°47′48.10″N	01°17′30.71″E	3	Guinean wood savannahs, wood savannahs, gallery forest, dry forest
Badja	06°22′20.95″N	00°58′50.86″E	2	Guinean wood savannahs, wood savannahs, gallery forest
Kpalimé	06°54′08.16″N	00°37′57.23″E	5	Hilly forest, tropical wet forests or semi-deciduous forests, degraded forest areas
Agave	07°14′02.80″N	00°47′25.70″E	2	Guinean wood savannahs, wood savannahs, gallery forest, degraded Guinean wood savannahs
Tovegan	06°33′56.77″N	00°53′05.98″E	2	Guinean wood savannahs, wood savannahs, gallery forest, degraded Guinean wood savannahs
Yaokope	07°31′00.00″N	01°01′60.00″E	2	Guinean wood savannahs, wood savannahs, gallery forest, degraded Guinean wood savannahs
Tsévié	06°25′11.18″N	01°12′39.49″E	7	Guinean wood savannahs, wood savannahs, gallery forest, degraded Guinean wood savannahs

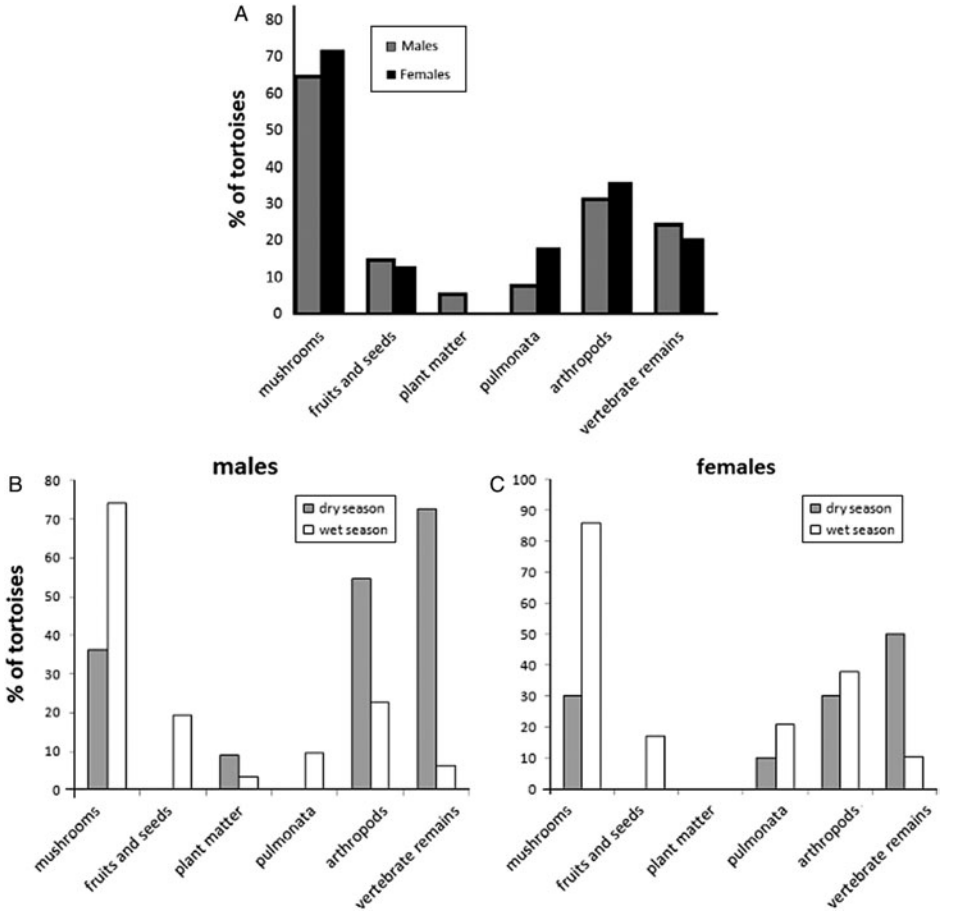

Figure 4. Diet composition (expressed as the percentage of each prey item selected by the tortoises) of *Kinixys nogueyi* in Nigeria: males and females overall (A); males (B) and females (C) across seasons.

(χ^2 test; df = 1; $P < 0.01$). No inter-sexual differences in food selection was found ($\chi^2 = 4.0$; df = 5; $P = 0.555$).

Discussion

Habitat selection

Our study has revealed patterns of habitat use by *K. nogueyi* that were consistent between Togo and Nigeria, but that in part challenge the available published information (e.g., Chirio and Lebreton, 2007). Indeed, we found that, in Togo, most specimens were found in Guinea savannah (see also Branch 2007; Chirio and LeBreton 2007), but also inhabited rainforest patches and hilly forests, which represent the exclusive habitat types of *K. erosa* and *K. homeana* in this country (Segniagbeto et al. 2014, 2015). Nigerian individuals were also often observed inside forest and dense bush patches. Both in Nigeria and in Togo, *K. nogueyi* individuals from forest sites tend to be darker and more uniformly colored in the carapace than savannah specimens (our unpublished observations). Thus, we

documented for the first time that a third *Kinixys*, *K. nogueyi*, also may widely occur inside the forested zones of West Africa, where it co-occurs in sympatry or at least in contiguous parapatry with the two forest species *K. homeana* and *K. erosa* (Segniagbeto et al. 2014). All previously available literature (e.g., Branch 2007) considered *K. nogueyi* to be a typical savannah inhabitant, although most of published data likely referred to the closely related *Kinixys belliana*. Until recently, *K. nogueyi* had been considered conspecific with *K. belliana* (Bour 2006). Kindler et al. (2012) were the first to treat this taxon no longer as a subspecies of *K. belliana* but as a species of its own, on the basis of clear genetic data analyses.

We hypothesize that our data on habitat use may suggest that *K. nogueyi* is presently expanding its range via colonization of previously unavailable forested patches. Range expansion may be enhanced by deforestation and the alteration of mature forest (Segniagbeto et al. 2015), thus possibly challenging the forest niches of *K. homeana* and *K. erosa*. A similar trend has been observed regarding West African cobras, with a wet savannah inhabitant (*Naja nigricollis*) progressively invading the (nowadays altered) rainforest region to the detriment of the forest specialist *Naja melanoleuca* (Luiselli 2006a). It is not unlikely that the same phenomenon is presently happening with tortoises, resulting in increased interspecific competition (Luiselli 2006b) that may represent an additional threat to the remnant populations of the two forest tortoises.

Diet

Prior to this study, the diet of wild *K. nogueyi* was known from only a very few samples collected in the River Niger Delta of Nigeria (Luiselli 2003) and from anecdotal references that likely confused data from *K. nogueyi* with those from *K. belliana* (e.g., Ernst and Barbour 1989; Branch 2007). Our results have shown that both males and females feed essentially on mushrooms, arthropods, and dead vertebrates, with plant matter being of considerably less importance. An omnivorous diet was suggested by previous authors (e.g., Ernst and Barbour 1989; Luiselli 2003; Branch 2007), but our study demonstrates that this tortoise is more carnivorous than previously suspected, although mushrooms remain the most important food item in the percentage of animals feeding on them.

The diet of *K. nogueyi* appeared to be similar to that of *K. homeana* and *K. erosa* in Nigeria, also exhibiting an omnivorous diet both in mature and in altered moist forest patches, with plant matter, seeds, fungi, Oligochaeta, Gastropoda, and a wide range of arthropods being eaten frequently (Luiselli 2003, 2006). Compared to these forest species, however, *K. nogueyi* showed a more pronounced seasonal variation in the diet, probably the result of the more pronounced seasonality in resource availability in Guinea savannah than in rainforest habitats. This hypothesis can be easily tested by comparing the seasonal variation in the diet of Guinea savannah versus rainforest populations of *K. nogueyi*. Our studies on Togolese populations from forest habitats are ongoing and will hopefully provide useful information regarding this question in the next years.

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