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Research, part of a Special Feature on Why does hunting in tropical regions matter?

Wild meat consumption on São Tomé Island, West Africa: implications for conservation and local livelihoods

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ABSTRACT. The importance of wild meats for rural people is well documented in tropical forests worldwide. However, the case of oceanic islands remains relatively poorly studied. We assess the contribution made by wild meats to the diets of rural inhabitants in the Island of São Tomé, characterize the relative importance of native and introduced fauna, and discuss the implications of wild meat consumption on rural livelihoods and on the conservation of the resident fauna. Using semistructured interviews, we assessed animal protein consumption in 10 communities (716 household-weeks), around the vicinity of the island's main protected area, Obô Natural Park. Fish and the introduced West African giant snail (*Archachatina marginata*) are the most important sources of protein for rural inhabitants, with wild terrestrial vertebrates being consumed by only a small fraction of sampled households. Significantly higher amounts of wild snail and wild mammal meat are consumed in more remote areas with poorer families depending more on snails, and richer households on fruit bats or introduced mammals. Although eaten in relatively small numbers per household, consumption of wild birds is widespread, thus when extrapolated to the island's entire rural population, this practice is likely to be unsustainable, particularly for endemic pigeons that are also commercially hunted. Our results suggest that rural populations in São Tomé largely depend on protein from introduced wild species, with native and endemic fauna constituting less important sources. However, endemic birds and native fruit bats are extensively harvested for household consumption and constitute a commonly used resource that urgently needs to be regulated.

Key Words: *biodiversity; bushmeat; islands; protein intake; rural demand; wealth*

INTRODUCTION

Wild meat, or bushmeat, provides a major source of protein for tropical forest people around the world (Wilkie and Carpenter 1999, Milner-Gulland et al. 2003, Bennett et al. 2007). In the Congo Basin, wild meat has been estimated to contribute between 30 to 80% of the protein intake for forest-dwelling people (Koppert et al. 1996). In rural areas with poor access to markets, wild animals often constitute the cheapest and sometimes the only type of animal protein available (e.g., Starkey 2004). However, overharvesting can affect the survival of some species, especially large-bodied, slow-reproducing taxa (Bakarr et al. 2001, Fa et al. 2002, Milner-Gulland et al. 2003).

Patterns of species extinctions have been well documented across a wide variety of islands and for a number of taxonomic groups (Sax et al. 2002). Islands have also lost many native species; among vertebrates, extinctions have been greatest for bird species, largely because most other vertebrate groups are relatively depauperate on islands (Myers et al. 2000, Evans and Fishpool 2001, Henderson and Whittaker 2003, Burgess et al. 2006). Although most island extinctions have been attributed to threats such as predation by exotic species (Blackburn et al. 2004, Sax and Gaines 2008), hunting is known to have caused the extinction of native fauna on oceanic islands worldwide (Brooke and Tschapka 2002, Duncan et al. 2002, Fitzpatrick and Keegan 2007).

Recent research on the impact of hunting on the wildlife of large continental islands, such as Bioko and Madagascar, demonstrate that sustained overexploitation can affect the long-term survival of native and vulnerable species (Fa et al. 2000, Jenkins et al. 2011). However, few studies have documented the importance and impact of wild meat consumption on oceanic island faunas. Understanding such patterns, as well as the drivers affecting the use of wild species for food, is an important first step for designing approaches to redress threats to endemic biodiversity (Bowen-Jones et al. 2002).

São Tomé, the largest oceanic island in the Gulf of Guinea off the west coast of Africa, is considered of critical conservation importance because of the numbers of restricted range sympatric bird species (Bibby et al. 1992, Stattersfield et al. 1998, Buchanan et al. 2011) and high rates of endemism in a large number of taxonomic groups. Throughout most of the island, habitat modification is still the single most important threat affecting the island's endemics but uncontrolled hunting also has a heavy impact on some taxa (Peet and Atkinson 1994, ENPAB 2004, Carvalho et al. 2015*a*). Hunting for commercial and subsistence purposes is known to affect introduced species, such as feral pigs, monkeys, and civets, as well as native species, mainly fruit bats and birds, particularly pigeons and doves (Rainho et al. 2010, Carvalho et al. 2015*a*, *b*). However, no studies have monitored levels of wild-meat consumption or its impact in São Tomé.

We explore the following: (1) the contribution wild meat makes to protein intake in rural communities in São Tomé; (2) the importance of introduced versus native wild species; and (3) factors that determine bushmeat consumption patterns. We achieve this through interviews with stakeholders in rural households. We discuss the results within the scope of sustained livelihoods and the conservation of the island's unique fauna.

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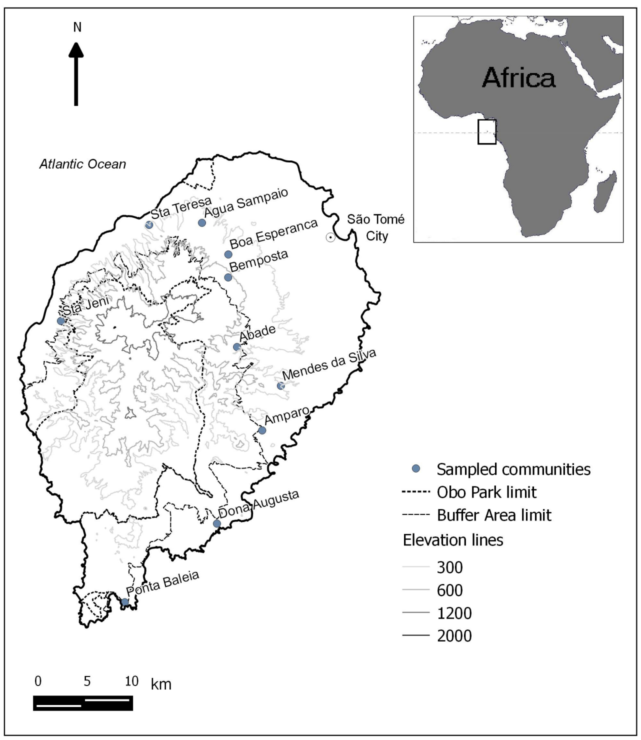
METHODS

Study area

São Tomé, 857 km², is the larger of the two oceanic islands that constitute the Democratic Republic of São Tomé and Príncipe (Fig. 1). It is located just north of the equator, about 250 km west of mainland central Africa. The island is characterized by rugged terrain with numerous steep mountains, reaching up to 2024 m at the Pico de São Tomé. This strong relief creates a marked precipitation shadow effect, with average annual rainfall ranging from less than 600 mm in the northeast, to over 6000 mm in the southwest (J. T. Bredero, W. Heemskerk, and H. Toxopeus, 1977, *unpublished manuscript*). Altitude also creates a strong temperature gradient, with annual averages ranging from 25.5 °C at sea level to less than 13.5 °C above 1500 m (Silva 1958). Humidity is high throughout the year in most of the island with little seasonal variation (Carvalho et al. 2014). Rain is concentrated during the wet season, September to May, and a dry season, "gravana," extends from June to August. There is also a less demarcated dry period of a few weeks, "gravanito," around December and March (Jones and Tye 2005).

Fig. 1. Location of sampled communities on São Tomé Island. The rectangle on the inset shows the location of the island off the west coast of Africa.



The island's human population, around 180,000 inhabitants, is concentrated around the main city and towns; an average density of 210 inhabitants per km². Population growth rate is estimated to be over 2% per year. About 34.5% of the population lives below the poverty level (Alkire et al. 2011), largely depending on natural resources because most are unable to afford imported goods. Almost one-third of the island's land area has been designated a protected area, the Parque Natural do Obô (Albuquerque and Cesarini 2009). The park encompasses most of the island's remaining old-growth forest as well as large areas of secondary forest. There is, however, little enforcement. Around 40 rural communities are found scattered around the park's outskirts. Most communities have limited access to roads, production and trade of food items, and are therefore precariously poor (FAO 2012). Legislation on hunting has been in preparation since 1995. It was reviewed in 2012 but has yet to be promulgated (M. Carvalho, *personal communication*).

Data collection

We studied 10 rural communities within the island's 5 main rural districts between October 2011 and September 2012 (Fig. 1). Within these, we selected households to sample, stratified by their location, i.e., two per district, and according to the approximate number of inhabitants. The country's 2001 population census (INESTP 2001) was used as a baseline for community selection. The number of people within these communities varied from 100 to 200 inhabitants, 30-50 households. All studied communities were characterized according to (1) their geographical location relative to the natural park, ocean, and capital city, and accessibility from main roads, and (2) general socioeconomic situation, i.e., access to energy, water, sewage, and transportation, as well as the number of hunters, farmers, palm wine collectors, and chainsaw operators in each community (Appendix 1). Because hunting and resource use formal restrictions throughout the island are not enforced and are largely unknown by most island inhabitants including those near the national park, we are confident that our interviewee responses were not affected by any knowledge of hunting restrictions despite living alongside the national park.

Before the start of data collection, the aims of the project were presented to each community. In each community, we mapped and numbered all households from which we randomly selected a number for sampling, depending on their will to participate. If a household was not available or not willing to be interviewed, another number was selected. Information was collected through a semistructured interview with the household head or, if absent, with the person responsible for preparing food. All interviews were conducted by trained local assistants who would overnight in the communities during sampling. During the first interview, we enquired about the household structure and socioeconomic status, including the number of inhabitants, gender, age, occupation, and literacy of head of family; household type, access to energy, water, and sewage; ownership of agricultural fields and/or livestock and family production; total regular income for all family members; possession of 14 family assets, e.g, cellphone, generator, motorbike, stove, television, DVD player, firegun, airgun. We also included questions on the three most preferred protein sources, e.g., sea fish, chicken eggs, different domestic meats, and bushmeat species. We updated information in subsequent interviews if there were any relevant changes.

To compare data among households and communities, occupancy of each household was converted into adult male equivalent (AME), so that a male person aged > 10 years = 1 AME, females aged > 20 years = 0.72 AME, females 10-19 years

= 0.84 AME, and all children aged < 9 years = 0.6 AME (Albrechtsen et al. 2006).

We sampled a total of 195 households, corresponding to a total of 819 inhabitants, between 16 and 21 households per community. Because not all selected households could be sampled in each of the 4 interview periods, our final sampling effort was 716 households-weeks, out of the 780 possible. To cover an annual cycle, we assessed consumption during (1) the main rainy season (October-November); (2) short dry season (February-March); (3) second rainy season (May), and (4) end of main dry season (August-September). All animal food items, i.e., meat, fish, and eggs, eaten during the week (seven days recall) before the interview were quantified in terms of the number of units and weight in kg consumed. All recorded animal products were expressed in terms of protein consumed (kg/AME), as described in Appendix 2. The contribution made by each food type was measured in terms of whether it was present in the household recall or not, as well as the total amount consumed.

Household wealth group

Based on a pilot study, undertaken before the main data collection, we classified household relative wealth using a group of wealth indicators as a proxy for subsequent analysis. A two-step cluster analysis of the interviewed households was first performed based on the following indicators: household type and number of divisions, quantity of possessed assets (each asset as an independent variable), household access to energy and sewage, and the literacy of the household head. The analysis separated two fairly distinct clusters: 65% of interviewees were allocated to a less wealthy group and 35% to a wealthier one, with more possessions and higher living standards, of which the following were the most important featured variables: generator/TV/DVD ownership and quantity, energy supply, type of household and number of divisions. The cluster membership was assigned as a new categorical variable for the household socioeconomic characterization, designed as wealth group.

Site accessibility

The effort necessary to reach each community from populated areas via main roads depended on distance as well as road quality. This combination determined the type of transport that could be used to reach the communities and the time necessary. This ultimately conditions the access of some basic foods, such as fish, which has to be transported from coastal areas because there is no freshwater fish available, and/or domestic meats by some communities. Because of this, we determined the relative consumption of bushmeat, fish, and domestic meat as a function of each community's difficulty of access. We used a categorical measure of the quality of access roads, from good to bad road conditions, ranging from one to four, respectively, which was recorded during interviews. This figure was then multiplied by an index of relative distance of the community to the closest densely populated center along the main road (used as a proxy for trading point of consumption goods). This distance was classified in three categories: < 2.5 km; between 2.5 and 7 km, and > 7 km. An inaccessibility index for each community was then obtained, ranging from 1 to 12, from more accessible to increasingly inaccessible, respectively.

Data analysis

We used univariate tests to understand the correlation between consumption patterns and household wealth, social status, and geographic location. Furthermore, ordination techniques were used to develop an effective visual summary of rural consumption patterns, including all interviewed households in the same ordination space (Borcard et al. 2011). We employed nonmetric multidimensional scaling (NMDS) ordination based on Bray-Curtis dissimilarities, using the mean presence of different food types on the consumption replicates of sampled households. Envfit function was performed to test for the significance of sampled socioeconomic and geographic variables and its relation with the axes of the ordinations (Borcard et al. 2011). All statistical procedures were carried out in R v. 2.10.0 (R Development Core Team 2009).

RESULTS

Consumption data

All sampled households had consumed some animal product during the recall week. Fish and West African snails (*Archachatina marginata*) were the most important components of rural diets (Table 1). Fish was the most widely consumed food, reported in 92% of the sampled households, but consisting only 25% of the total contribution for protein intake.

Wild meats accounted for more than half of total protein foods consumed by the sampled households (Table 1). The greatest contribution was made by the consumption of the introduced West African snail, which accounted for 43.7% of all protein consumed. Despite the relatively high protein contribution represented by giant snails, its consumption was restricted to 62% of the households.

By contrast, wild vertebrates contributed much less to the total protein intake of households. Most vertebrate meat consumed was of introduced mammals, namely feral pigs (*Sus domesticus*), Mona monkeys (*Cercopithecus mona*), and African civets (*Civettictis civetta*); 5.8% of the consumed animal protein. Native fruit bats (*Eidolon helvum*) and birds (11 endemic and 1 native species) contributed only 3.2% and 0.6% of the total protein consumed, respectively. Introduced mammals were also consumed by a small fraction of the sampled households. Fruit bats were the most widely consumed, recorded in 9.6% of sampled households.

Domestic meats were consumed by almost half of the households sampled, but made a relatively low contribution to rural diets. Chicken was the domestic animal with higher protein contribution (11.5%) as well as the most widely consumed (39% of the households). Domestic mammals, i.e., pig, goat, and sheep, constituted only 5.5% of the total consumption in 2.5% of sampled households.

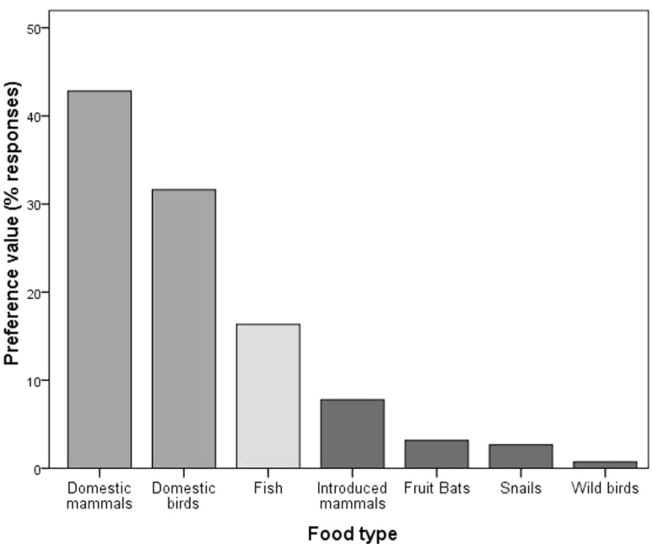
Preferences

Despite their relative low consumption level, most species (72%) preferred by respondents were domestic species (Fig. 2); domestic mammals, especially pig, but also domestic birds, mainly chicken. Wild species were preferred by only 13% of the sampled households and were mostly introduced mammals. Fish was mentioned as preferred by 12% of households and snails by only 3%.

Table 1. Animal food items and their relative consumption in sampled households (N = 195) in rural communities in São Tomé Island, corresponding to a sampling effort of 716 household weeks.

Food items	Species (where applicable)	Introduced/ Native/ Endemic	Units	Total consumption (edible kgs)	Mean consumption (edibkg/AME)	Assessed contribution for total protein intake (%)	Sampled households consuming this food type (%)
Fish		NA	2987	454.6	0.26	22	92
Chicken		NA	277	233.8	0.12	11	39
Duck		NA	12	24.3	0.02	2	2
Domestic pig		NA	3	91.1	0.06	5.3	0.9
Goat and sheep		NA	1	9.5	0.01	0.4	1.6
Eggs		NA	1138	56.9	0.03	2.6	53
Giant snail	*Archachatina marginata*	Int	14,581	819.1	0.54	45.7	62
Obo snail	*Archachatina bicarinata*	End	10	0.5	0	0	0.6
Feral pig	*Sus domesticus*	Int	1	49.5	0.02	1.6	0.16
Civet	*Civettictis civetta*	Int	4	33.5	0.02	1.5	0.6
Mona monkey	*Cercopithecus mona*	Int	14	23.3	0.01	1	4
Fruit bat	*Eidolum helvum*	Nat	307	58.7	0.04	3.1	9.6
Maroon pigeon	*Columba thomensis*	End	8	1.6	0	0.1	0.6
Bronze-naped pigeon	*Columba malherbii*	End	25	2.2	0	0.1	2.2
Green pigeon	*Treron sanctithomae*	End	24	2.9	0	0.2	1.9
Other birds			45	3.8	0	0.3	2.5
Giant weaver	*Ploceus grandis*	End	11				
Olivaceous thrush	*Turdus olivaceofuscus*	End	10				
Forest dove	*Columba simplex*	End	9				
São Tomé prinia	*Prinia molleri*	End	6				
Príncipe seedeater	*Serinus ruffobruneus thomensis*	End	3				
Newton's sunbird	*Anabathmis newtonii*	End	3				
São Tomé weaver	*Ploceus sanctithomae*	End	1				
Black-capped speirops	*Zosterops lugubris*	End	1				
White-tailed tropicbird	*Phaeton lepturus*	Nat	1				

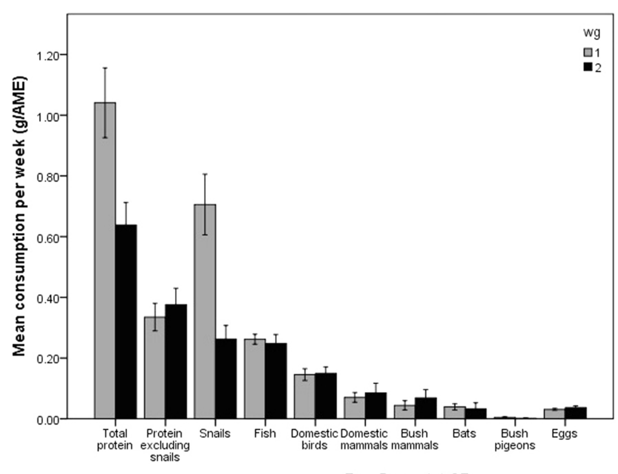
Fig. 2. Preferred type of food named by respondents during first interview.



Wealth and consumption of food types

The poorest families (wealth group = 1) consumed significantly more snails than wealthier households (wealth group = 2), representing 54% and 30%, respectively, of the protein intake in the groups' diet (Mann Whitney U-test, $p < 0.001$; Fig. 3). Wealthier families ate significantly more protein other than snails (Mann Whitney U-test, $p = 0.41$), mainly domestic animals and eggs (wealth group = 2; Mann Whitney U-test, $p = 0.47$). For the other food types, including fish and wild vertebrates, there were no significant differences among wealth groups.

Fig. 3. Average protein intake of each food type per wealth group. (1) lower wealth indicators, (2) higher wealth indicators.



Patterns of bushmeat consumption

The bidimensional ordination of sampled household consumption patterns show their distribution within the sample and its relation to assessed variables (Fig. 4). The first axis of the NMDS ordination of the households' consumption patterns (Stress = 0.18) reflects the increase of consumption of chicken and eggs among sampled households. The second NMDS axis represents the gradient between a high consumption of giant snails and an increasing consumption of fish. Other domestic and bushmeat items were positively associated with first axis and negatively with second, and were mainly consumed by a specific group of households (Fig. 5).

Fig. 4. Proportion in diet of each food type for considered wealth group: (1) lower wealth indicators, (2) higher wealth indicators.

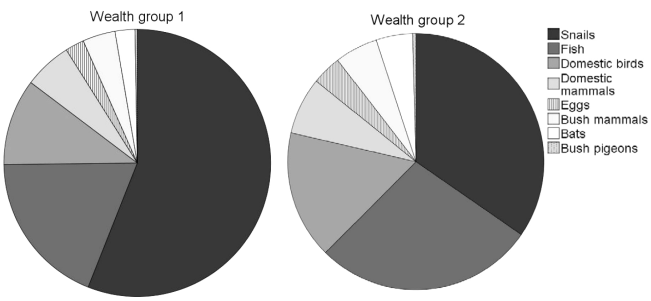
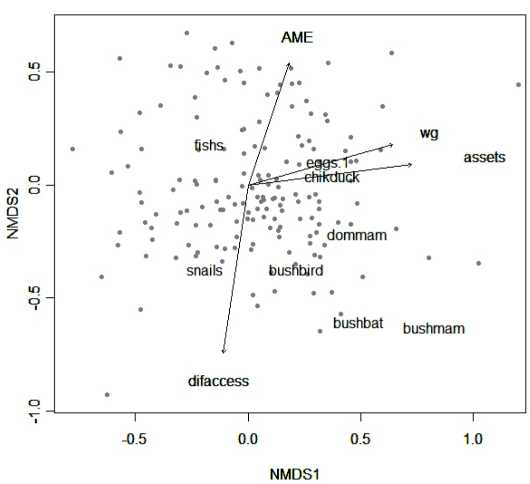


Fig. 5. Nonmetric multidimensional scaling (NMDS) ordination of average consumption frequencies of animal food items per household (Stress = 0.18), with the scores of each species on ordination axes indicated by its position on the diagram. The grey dots on the back are the households, distributed in the diagram based on their average consumption of each food type. The arrows represent the fitted variables for household's socioeconomic characterization: AME (number of adult male equivalents at the household), wg (wealth group), assets (average number of listed assets of the household), and difaccess (inaccessibility index). These were the significant variables (p max = 0.05) identified from a larger introduced group.



Fitting the socioeconomic and geographic variables into the ordinated consumption patterns, the variables, which explained most of the variance along the two axes, are the average quantity of assets and the households' wealth group (NMDS1) and the inaccessibility opposite to the number of adult male equivalents (AME) in the household (NMDS2). These results highlight the relevance of wealth and isolation of households in the consumption of different food types.

Consumption of giant snails was clearly related to household inaccessibility, with higher consumption also associated with poorer families. As for wild vertebrate animals, particularly fruit bats and introduced mammals, consumption was mostly associated with an increasing inaccessibility of the households, but also with relative wealth (Fig. 5). In the case of wild birds, the patterns were not so clear, and the consumption is more widely distributed throughout the sample: bird consumption within less isolated and poorer households is also perceptible from ordination plots.

DISCUSSION

Wild meat consumption

We show that wild meat is an essential part of the diets in rural communities of São Tomé and that protein intake is typically sustained by sea fish and introduced West African snails. The importance of fish is well known in Central African countries, in which fish resources can represent 25-50% of the total food supply (Watson and Brashares 2004, Jenkins et al. 2011, Grande Vega et al. 2013). In contrast, land snails are a well-documented wildlife protein source in countries like Nigeria and some other parts of Africa, but its actual importance as human food and in the livelihoods of local people is a point generally overlooked in most of the studies about bushmeat consumption (Osemeobo 1992, Nasi et al. 2008).

As demonstrated in our results, in São Tomé rural areas, land snails are particularly important for the more economically vulnerable people, namely the more isolated and poorer groups. All social groups, including women and children, harvest snails, making this food resource widely accessible to most members of the community (Hardouin 1995). In the case of the West African snail, a recently introduced species that has rapidly expanded and which could have a large potential impact over native flora and fauna (Gascoigne 1994, Cowie et al. 2009), management of these species may contribute to food security of the island's rural population at the same time as exercising control over invasive species.

Introduced mammals, and to a lesser extent native fruit bats, are also particularly important for protein intake in the most isolated but wealthier households. Nevertheless, they are not a generally preferred food and wild meats can be eaten as a consequence of the lack of alternatives and not as a superior food (Brashares et al. 2011). The lack of preference for bushmeat was already described in the islands of Bioko, Equatorial Guinea (East et al. 2005) and Madagascar (Jenkins et al. 2011), but also for the rural people in Gabon who are highly price sensitive with respect to their choice of meat, with taste playing a smaller role (Wilkie et al. 2005). More research is needed on the availability and price of domestic and wild vertebrates in rural communities to further understand the determinants of their consumption.

The consumption of wild birds is apparently not influenced by any of the socioeconomic or geographic variables assessed in our study. Also not mentioned as a preferred food, birds are nevertheless broadly consumed in the communities sampled. They are opportunistically harvested without any costs, often with slingshots and traps, during the daily routines of children and farmers (M. Carvalho, *personal communication*). We show that subsistence consumption of wild birds in rural communities extends to several endemic species, with higher numbers associated with all four species of pigeon. Endemic birds represent a very small part of the rural diets but its consumption is possibly seen as a natural contribution to family meals in a context in which meat is relatively scarce.

In this study, the objective was to specifically assess consumption of endemic fauna determined by the use of a seven-day recall period. We are confident that despite the longer recall period used, we obtained, through trained local interviewers, an accurate measurement of animal protein use and the relative importance of the different sources of meats.

Conservation implications

Wild meat subsistence consumption in São Tomé constitutes a rare situation in the documented African context. The island's high conservation value is related to relatively small-bodied species, which typically have a lower value to local harvesters (Bennett and Robinson 2000). In São Tomé, most wild species used for food were introduced and have a potential negative impact on the native ecosystem (Dutton 1994, Jones and Tye 2005). This situation contrasts to the islands of Bioko and Madagascar, on which subsistence harvest of endemic and native mammals represents an acknowledged threat to their conservation (Fa et al. 2000, Albrechtsen et al. 2006, Jenkins et al. 2011).

Nevertheless, endemic birds and native fruit bats are harvested for household consumption and constitute a commonly used resource that needs to be regulated. Even occasional consumption of wild species by individual households can result in an important pressure on a species when human populations are high relative to area of natural habitat (Robinson and Bennett 2000), or if targeted species have demographic characteristics making them vulnerable (Peres 2000). There are signs that the exploitation of these species has an impact on their abundance and distribution throughout the island (Rainho et al. 2010, Carvalho et al. 2015*b*), and some of these species are also intensively targeted by commercial hunting, worsening their status (Carvalho et al. 2015*a*).

Further understanding of the dynamics of the wild species consumed on the island is required to develop specific conservation and management guidelines. Still, this is the first study of its kind to quantify consumption of introduced species by rural inhabitants. Promoting the replacement of native wildlife for hunting and consumption of introduced species may ensure a constant, culturally acceptable, and readily available low-cost source of meat (Desbiez et al. 2011). Adequate policies and awareness programs are needed to create awareness of the global importance of endemic species in the Gulf of Guinea islands and encourage the local population to divert attention toward the introduced fauna.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/7831

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Appendix 1. General description of the communities sampled within the scope of this study

Please click here to download file 'appendix1.xlsx'.

Appendix 2. Values used for the conversion of unit animal foods to weight and edible weight consumed by interviewed households (expressed in kg). Edible quantity was estimated from reference to the edible proportion of each species or group of species.

Food items	***Species (where applicable)***	***Weight per unit (Kg)***	***Edible weight (%)***	***Price per unit (Euro)***	***Price per kg (Euro)***	***References (weight and conversion)***
Fish		*Variable*	0.55	Varies	2,45	Torry res.stat. (1989)[1], Holland et al. (1983)[2]
Chicken		1.300	0.65	3,5	2,65	Bender (1992)[3], Chan et al. (1996)[4]
Duck		3.00	0.60	12,5	4,08	Albreschtsen et al.(2006)[5]
Domestic pig		48.30	0.60	*Variable*	4,08	Bender(1992)[3], Chan et al. (1996)[4], Bonfim (2002)[6]
Goat		25.00	0.60	50	3,27	Bender(1992)[3], Chan et al. (1996)[4]
Sheep		20-30.00	0.60	60	4,08	Bender (1992)[3], Chan et al. (1996)[4]
Egg		0.050	1.00	0,24	4,90	Holland et al. (1989)[7]
West African giant snail	*Archachatina marginata*	0.116	0.38	0,016	0,14	Ajayi et al. (1978)[8]
Obo snail	*Archachatina bicarinata*	0.116	0.38	na	na	Ajayi et al. (1978)[8]
Feral pig	*Sus domesticus*	50.00	0.60	Na	4,08	Bonfim (2002)[6]
Mona monkey	*Cercopithecus mona*	2.733	0.60	5 to 15	2,55	Albreschtsen et al.(2006)[5]
African civet	*Civectis civetta*	12.335	0.60	25	2,03	Albreschtsen et al.(2006)[5]
Fruit bat	*Eidolum helvum*	0.300	0.60	0,8	2,4	Albreschtsen et al.(2006)[5]
São Tomé green pigeon	*Treron sanctithomae*	0.230	0.50	1,2	5,32	Omojola et al.(2012)[9]
Bronze naped pigeon	*Columba malherbii*	0.165	0.50	1	6,06	Omojola et al.(2012)[9]
Maroon pigeon	*Columba thomensis*	0.400	0.50	1,5	3,75	Omojola et al.(2012)[9]

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