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Subsistence hunting and conservation issues in the game reserve of Gile, Mozambique

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Abstract. Ethnozoological research was conducted to gather information on the hunting activities and their relevance for the subsistence of local people in 8 villages around the game reserve of Gile, Mozambique. Two series of data were gathered by questionnaires to: (a) 510 householders from eight villages located in the outskirts of the Reserve; (b) 10 hunters from the village of Gile, the main centre of the study area. Several hunting techniques were recorded: spears, nets, traps (including gin-traps) and wildfires, while the use of guns did not appear relevant. The importance of subsistence hunting for local people was underlined by the high percentage of respondents who declared that they usually conduct this activity and sell bushmeat. The proportion of hunters per village was related to the village size but not to its geographical location of villages and the household composition. A positive relationship existed between the proportion of hunters, crop production and fishing activities, indicating that hunting is part of an integrated system of subsistence activities. Most animals harvested were mammals (89.5%, of which 46.7% were ungulates) and most were captured within the Reserve (96%). A higher percentage of animals was sold (56%), representing a relevant income source for the villagers. Small animals were mainly captured by traps during solitary hunting, medium-sized animals in collective net hunting; larger prey were captured by gin-traps adopted by both solitary and collective hunting. In the diet of the local people wild animals represented a higher protein source than domestic animals.

Introduction

In tropical Africa the meat of wild animals represents an important part of the staple diet of hundreds of thousands of people, as well as a remarkable source of income for rural hunters (Bellamy 1993; Carpaneto 1994; Carpaneto and Fusari 2000; Colell et al. 1994; Fa et al. 1995; Fa and García Yuste 2001; FitzGibbon et al. 1995; Kock 1995; Lahm 1993; Wilkie et al. 1992; Ziegler 1996). Recent data reveal that bushmeat harvests are unsustainable in several African countries (Alvard et al. 1997; Fa and Peres 2001; Fa and García Yuste 2001; Barnes 2002; Bennett et al. 2003; Ling et al. 2003; Robinson and Bennet 2003). This situation is particularly severe especially where rural people hunt within poorly managed protected areas.

In this paper, we studied the impact of hunting in the game reserve of Gile (GRG), Zambezia Province, Mozambique. This Reserve, first established on 1932, suffered since 1982 from a decrease in management and lack of financial resources, owing to civil war. The result was a drastic decline in staff, including

rangers, and patrol activities. This situation and the accompanying rapid worsening of human life conditions, encouraged an increased exploitation of natural resources in the protected area (Chande et al. 1997; Carpaneto, 2001). The understanding of how local dwellers exploit indigenous resources was considered essential to develop an appropriate conservation strategy and to ensure a food supply for local population. In this optic, the aim of the present work was to assess the extent of subsistence hunting activities in the surroundings of the protected area and their relevance for rural livelihood.

The present paper is the first study on bushmeat exploitation in Mozambique and represents an important contribution to the knowledge of this growing activity that is going to evolve from subsistence to market. Mozambique is one of the poorest countries of Africa and it is not surprising that people will take advantage of any opportunity to earn money. After the devastation of 16 years of civil war, Mozambique is undergoing a rapid transformation and also susbsistence activities may change into a trade opportunity. Despite the Mozambique's wildlife was decimated during the war, poaching continues to occur throughout the country and is becoming an easy source of income. The quantitative data emerging from the present research may provide wildlife managers and conservation officers a tool for assessing the extent of bushmeat trade in the country. Through a quantitative description of bushmeat harvest, the present paper attempts to look at the correlations between hunting and other activities of the villagers, so that predicting models of wildlife exploitation in changing rural economies could be developed in the future.

Study area

Geographic location and local people

The GRG is located in the north-eastern part of Zambezia Province. It represents, together with the Niassa game reserve and the Quirimbas National Park, one of the most important protected areas in Mozambique north of the Zambezi River (Figure 1). Originally, the Reserve extended over an area of approximately 5000 km^2, and was mainly created to protect black rhinos and elephants, but also for professional and sport hunting to other large game, such as antelopes and buffaloes. Despite the intended protection regime, the black rhino was eradicated from the area by 1973 (Dutton et al. 1973), and elephants were reduced to very low densities (Martines and Ntumi 2002). In 1960, the GRG was reduced to its actual size of 2100 km^2, because a large buffer zone, in the northern part of the Reserve, was abandoned owing to the impossibility of governmental authorities to manage the area. The GRG is included in the Districts of Gile (154,988 inhabitants, population density 15.4/km^2) and Pebane (150,538 inhabitants, population density 15.8/km^2). Both districts experience high rates of population growth: Gile (4.9%) and Pebane (3.3%), which led to an estimated 202,668 and 189,883 inhabitants in 2010 respectively (INE 1997).

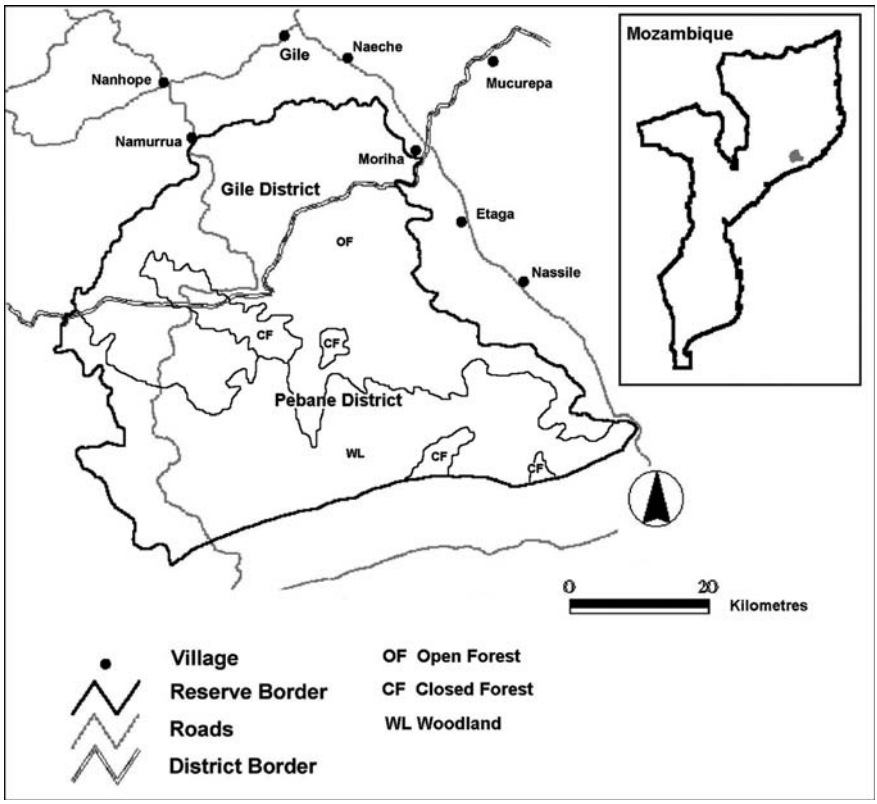

Figure 1. Location of the study area: the game reserve of Gile, Zambezia, Mozambique.

Most people in the northern sector of the Zambezia Province belong to the Lomwé tribe, one of the 20 ethnic groups recognized in Mozambique. Other ethnic groups in the area are the Chuabo, the larger group within the province, and the Macua, mainly settled along the coast. Both the Lomwé and Chuabo are essentially Catholics; however, because of the strong influence of the Swahili culture, most people living on the coast (both Lomwé and Macua) are Muslims.

Most households in Gile District and in the interior of Pebane District depend on subsistence agriculture (Galego and Rasul 2001). Local farmers practise slash-and-burn agriculture producing cassava, maize, rice, sweet potatoes, groundnuts and beans as staple foods. Sunflower, sesame, and cashew nuts (*Anacardium occidentale*) are important cash crops. Nonetheless, their annual production is limited: an average household produces around 60 kg of sunflower, 39 kg sesame and 168 kg cashew nuts, of which 25%, 38% and 79% are respectively sold, and the remainder consumed or used to pay labour (Galego and Rasul 2001). During the study period, crop traders from Nampula, a town north of the study area, bought sunflower, sesame and

cashew nuts for 0.20–0.40 USD per kg. Hence, an average household would earn about 49 USD per year from cash crops. In the area, the only off-farm profit opportunities available to most households, apart from trading bushmeat, are informal, e.g. sale of traditional drinks or temporary labour in neighbours' fields. Animal husbandry, even if limited by diseases, represented an important protein source. An average household owned 7.7 pigeons, 3.3 goats, 2.5 pigs, 6.4 chickens, 2.6 ducks, 2.7 guineafowl, and 3 rabbits (Galego and Rasul 2001). Cattle is very scarce due to poor pasture, occurrence of tsetse fly, and lack of knowledge of cattle rearing by local people. Hence, subsistence patterns and livelihood strategies are largely based on the exploitation of several non-timber forest products (NTFPs), among which bushmeat is essential (IUCN 1998; Carpaneto 2001; Fusari 2002; Galego 2002).

Climate, landscape and vegetation

The study area is 100–200 m above sea level and lies within Walter's tropical summer-rainfall climatic zone (see White 1983), with a distinct wet period between November and April and a dry period through the other 6 months (May–October). Annual rainfall is around 800–1000 mm. The maximum average temperature is 35.7 °C, at the onset of the rainy season, and a minimum is 13.5 °C during the dry season. The landscape is characterized by a gently sloping plain and several granite outcrops (inselbergs) that emerge from woodland. The area has a complex river system with three major watercourses and numerous small permanent or seasonal streams.

A mosaic of deciduous woodland (miombo) and savannah patches characterizes the vegetation within the Reserve. The miombo, classified as closed forest, open forest and woodland according to different canopy cover (DNFFB 1995; Trollope and Trollope 2002; Martines and Ntumi 2002), is dominated by *Brachystegia spiciformis*, *B. boehmii*, *Julbernardia globiflora* and *Pterocarpus angolensis*. Other common trees are: *Afzelia quanzensis*, *Albizia versicolor*, *Annona senegalensis*, *Burkea africana*, *Millettia stuhlmannii*, *Strychnos* spp., and *Swartzia madagascariensis*. Savannah patches consist of edaphic grasslands (dambos) that cover seasonally waterlogged depressions and which harbour some rich and diverse herbaceous communities with *Stipa* sp., *Schizachyrium jeffreysii*, *Eragrostis* spp., and sedges (Cyperaceae). Human activities have modified the landscape around villages, because slash-and-burn practice for field cleaning and fuel wood exploitation have reduced conspicuously the tree vegetation.

Hunting methods

AK-47 machineguns were still common in the area as a legacy from the long civil war. However, their use has decreased due to the high cost and/or scarcity of cartridges, as well as the low numbers of large mammals. Trapping is thus

the commonest hunting technique. Neck and leg snares (*mranko* or *muraho*) are frequently used and hand-made from natural fibres. They allow the capture of small antelopes, hares, small and medium mammals but also game birds. Another trap (*nicolope*) consists of a trunk hanging on a wire and placed along the track of an animal, to catch small to medium size mammals and game birds. Pitfall traps (*intchepe*) are not common in the study area, but are used occasionally and prepared by arming the bottom of large holes dug in the ground with several iron-tip spears (*nevaka*). Gin-traps (*rapito* or *langa*), introduced by the Portuguese colonists, are widespread and intensively used in the study area. These iron-made traps with a jaw-edge, manufactured locally with the leaf springs of old vehicles, allow the capture of mammals of varying size from hares to large ungulates. Netting is conducted by groups ranging from three/five hunters to entire households, including women and children. Nets are still made from natural fibres, although some are made of synthetic materials; lengths vary from 15 m to 35 m, height is normally 1.5 m (Carpaneto 2001).

Fire is used to directly kill small animals that live on the ground (small rodents, elephant shrews and reptiles such as monitors and tortoises), or to detect their dens. Burning is also used to clear ground from grass and bushy vegetation and facilitate both trapping and netting. Hunting with fire was essentially practised at the end of the dry season (September–November), because of high temperatures and drought which facilitate burning, but also on account of the large amount of fuel biomass represented by leaf litter and standing grass. Extended and repeated fires occur annually, with serious effects on the vegetation at GRG (Trollope and Trollope 2002; van Aarde 2002), despite the important ecological role of fire in miombo environments (Chidumayo 1997).

Methods

The first data set was collected during a 5 month period between June and October 2001, in eight villages close to the GRG: the nearest Namurrua (0.5 km), the more distant Mucurepa (20 km). Six villages are located within the Gile District: Gile (Gile administrative department, population = 13,198); Moriha, Mucurepa and Naeche (Naeche administrative department, population = 3319); Namurrua and Nanhope (Nanhope administrative department, population = 7492). The other two villages were in Pebane District: Etaga (Mihecue administrative department, population = 4227); and Nassile (Namanipe administrative department, population = 2805). It is important to note that there were no human settlements within the GRG (demographic data are from INE 1997).

Although the study was designed to apply a questionnaire per household and 100 questionnaires per each village (800 in total), only 510 questionnaires were completed (64%). This was because many householders refused to respond

because they were worried by questions regarding hunting, which they conducted illicitly. The sample represents ca. 5% of the 9700 estimated households in the studied administrative departments.

Questionnaires were used to collect data related to hunting activities: (1) age of the householder; (2) household composition; (3) the five most hunted animals; (4) use of each species (personal consumption and/or sale); (5) eventual market price of each species. We asked respondents to use vernacular names of animals in Elomwé language to avoid taxonomic misinterpretation (Carpaneto 2001). When possible, remains or entire animal carcasses were examined. However, some records were difficult to assign to species level, so these were classed according to order, family or subfamily. Such difficulties are because, for some taxonomic groups, villagers used the same vernacular name to indicate different species, or because some taxonomic groups were of difficult identification (small rodents and elephant shrews).

We evaluated the proportion of householders who declared that they harvested game, by using multiple regression analyses, considering as possible predictors the following groups of variables: (a) distance of each village from the Reserve border, the distance of each village from Gile (the main human settlement of the study area), the distance of each village from the nearest village (these two variables were considered a measure of remoteness); (b) the size of each village classified according to an ordinal scale (score from 1 to 8; the exact numbers of inhabitants were not available), (c) household composition, i.e. the average number of household's members, proportions of males, females and children; (d) proportion of respondents who declared that they produce from a maximum of 5 to a minimum of 2 crops.

To assess the level of game harvesting in the area, further quantitative data were gathered by interviewing 10 collaborative hunters during 4 months (April–July 2002). For each hunter, a questionnaire was completed approximately every 10 days to monitor their hunting activities by gathering the following information: (1) animals captured; (2) weapon used for each quarry; (3) hunting period for each quarry (day/night); (4) hunting location for each quarry (inside/outside the Reserve); (5) use of each quarry (personal consumption and/or sale); and (6) eventual market price of each quarry. This sample was not included in the previous one, and the data were analysed separately.

Means are reported with $\pm$ 1 S.D. Regression analyses were performed with the least square methods and percentages were normalized with an arcsine transformation.

Results

A total of 510 questionnaires were completed in the eight study villages, an average of 64.5 per village. All respondents were males, with an average age of 39.4 $\pm$ 3.3. Average number of members per household was five. For the 10

hunters of Gile, whose activities were monitored during a 4 month period, the average age was 38.3 ± 16.1 and the number of household members was 5.9 ± 3.2.

Hunting activity

Subsistence hunting (*ossaia*) proved to be an important activity for Lomwé people. During the study period, 416 respondents (81.6%) declared that they harvested game. The highest hunting activity was recorded in the village of Mucurepa (100%), Nassile (98.3%) and Moriha (89.9%), the lowest in Nanhope (72.6%) (Table 1). There were highly significant differences among villages in the number of respondents who declared that they harvested game (Goodness of fit test, $\chi^2 = 26.55$, $p < 0.01$, d.f. = 7). However, the geographical location of villages and their distance from the Reserve did not influence the extent of hunting activities in the study area. Instead, the village dimension proved to be a significant predictor of the proportion of hunters in each village ($R^2 = 0.726$, $F_{1,6} = 15.928$, $p = 0.007$). In particular, there was a negative relationship between village size and proportion of hunters: the smaller the village, the larger the proportion of hunters recorded (Figure 2). Household size and composition, did not correlate with proportion of hunters. However, the percentage of respondents who produced 5 crops was a significant predictor ($R^2 = 0.522$, $F_{1,6} = 6.562$, $p = 0.43$), indicating a positive relationship between hunting and crop production as non-alternative livelihood strategies (Figure 3).

We used data from a previous study in the area (Fusari 2002), considering possible relationships between hunting activities and two further important livelihood strategies for local populations: trade of cultivated products and fish exploitation. The following correlations (Spearman coefficient) were observed: (1) a significant positive correlation between hunters and respondents who

Table 1. Householders who harvested game in eight villages of the study area. N = householders interviewed; H = householders who declared that they harvested game; T = householders who declared that they have sold bushmeat; D = Distance from Reserve border (km); G = Distance from Gile village (km).

Villages	N	H	%	T	% of N	% of H	D (km)	G (km)
Etaga	90	71	78.9	31	34.4	43.7	10	40
Gile	51	41	80.4	38	74.5	92.7	12	–
Moriha	49	44	89.8	31	63.3	70.5	1	24
Mucurepa	24	24	100	24	100	100	20	25
Naeche	87	68	78.2	38	43.7	55.9	5	7
Namurrua	88	65	73.9	29	33.0	44.6	0.5	31
Nanhope	62	45	72.6	31	50.0	68.9	11	18
Nassile	59	58	98.3	43	72.9	74.1	7	48
Total	510	416	81.6	265	52.0	63.7		

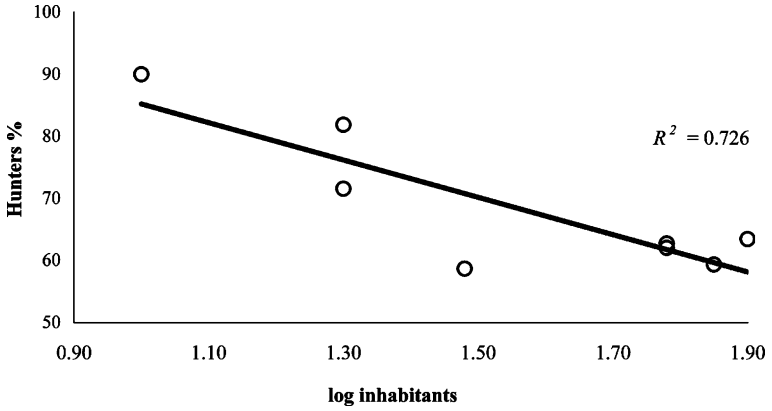

Figure 2. Relation between the percentage of hunters and village size.

harvest freshwater fish ($r_s = 0.762$, $p < 0.05$); (2) a significant positive correlation between bushmeat sellers and respondents who harvest freshwater fish ($r_s = 0.738$, $p < 0.05$). No significant correlation was detected between hunting activities (including bushmeat trade) and crop trade.

Species hunted

Householders reported that the most commonly harvested species are: (1) common duiker (*Sylvicapra grimmia*), declared by 299 hunters (74%); (2) larger cane rat (*Thryonomys swinderianus*), 272 hunters (67.3%); (3) two species

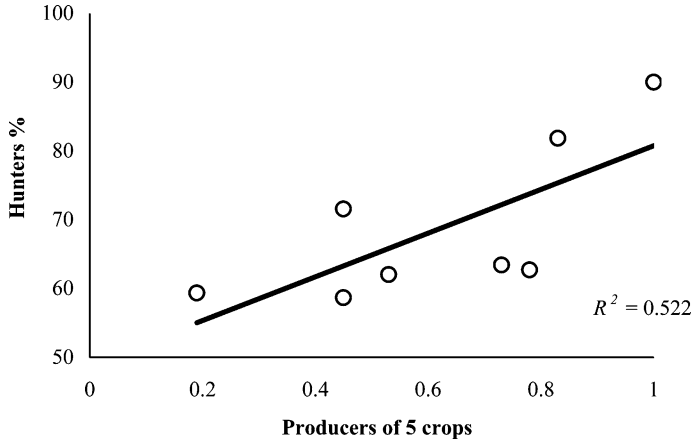

Figure 3. Relation between the percentage of hunters and crop producers.

of hares (*Lepus saxatilis* and *Pronolagus crassicaudatus*), 268 hunters (52.5%); (4) giant pouched rat (*Cricetomys gambianus*), 190 hunters (37.3%); (5) banded mongoose (*Mungos mungo*), 120 hunters (23.5%). Another 15 species or taxonomic groups of vertebrates (11 mammals, 2 birds and 2 reptiles) were hunted (Table 2). Highly significant differences were recorded among villages in the number of respondents who declared that they hunted a given species (common duiker, $\chi^2 = 80.83$, $p < 0.01$, d.f. = 7; larger cane rat, $\chi^2 = 42.80$, $p < 0.01$, d.f. = 7; hares, $\chi^2 = 103.39$, $p < 0.01$, d.f. = 7; giant pouched rat $\chi^2 = 57.47$, $p < 0.01$, d.f. = 7; banded mongoose, $\chi^2 = 47.25$, $p < 0.01$, d.f. = 7), as reported in Figure 4. The proportion of householders declaring to exploit any species was not related to the geographical location of the village or to its size.

The off-take of the 10 hunters from Gile consisted of 257 animals, 25.7 ± 6.1 per hunter (range 21). A total of 230 mammals (89.5%), 19 reptiles (7.5%), and 8 birds (3%) were hunted. Almost half of captures were ungulates (46.7%) (Table 3). Duikers and suni represented by far the most captured species (21%); in particular, the common duiker was the main prey (12.8% of total). Large rodents (larger cane rat and giant pouched rat) were the second most harvested category (11.3%), followed by the yellow baboon *Papio cynocephalus* (10.2%), hares (7.8%), and southern reedbuck *Redunca arundinum* (7.4%). Each hunter monthly harvested 6.4 ± 1.5 animals (range 5.2) of which 63% have a biomass higher than 5 kg, and 37% were antelopes.

The bushmeat trade

In the study area, to elude surveillance of the governmental authorities, hunters conducted a hidden bushmeat trade. Bushmeat was sold at village level, simply informing other villagers of game availability. No important trade of bushmeat to the major centres of Nampula and Quelimane was detected. Some 265 householders declared to have sold bushmeat (52% of respondents, 63.7% of hunters). The highest percentage of sellers was recorded in Mucurepa (100%) and Gile (74.5%, 92.7%), whereas the lowest percentage was recorded in Etaga (34.4%, 43.7%) (Table 1). Differences recorded among villages were highly significant ($\chi^2 = 57.05$, $p < 0.01$, d.f. = 7). The distance between villages was significantly positively correlated with the percentage of bushmeat sellers ($R^2 = 0.661$, $F_{1,6} = 11.692$, $p = 0.14$) (Figure 5). Both village size and household composition were not significant predictors. Instead, percentage of respondents who cultivated five crops was correlated with bushmeat trade in each village ($R^2 = 0.510$, $F_{1,6} = 6.247$, $p = 0.47$) (Figure 6). Respondents reported five species or groups of species most commonly commercialised: larger cane rat (34.3% of hunters) for an average price of 0.73 ± 0.43 USD per specimen; hares (29.3%), for an average price of 0.78 ± 0.07 USD per specimen; common duiker (19.4%) for an average price of 0.75 ± 0.1 USD per kg; giant pouched rat (18.9%) for an average price of 0.46 ± 0.12 USD per

Table 2. The most common prey items in eight villages of the study area (% = percentage of hunters who declared that they harvested each item).

Scientific name	Common name	Etaga	Gile	Moriha	Mucurepa	Naeche	Namurrua	Nanhope	Nassile	Total	%
Mammals											
Sylvicapra grimmia	Common duiker	58	33	27	24	65	30	18	45	300	72.1
Thryonomys swinderianus	Larger cane rat	38	22	20	21	43	55	24	49	272	65.4
Leporidae spp.	Hares	47	25	39	11	11	50	37	48	268	64.4
Cricetomys gambianus	Giant pouched rat	37	15	27	19	19	11	25	37	190	45.7
Mungos mungo	Banded mongoose	23	15	20	7	9	2	17	27	120	28.8
Rodentia spp.	Small rodents	25	14	23	3	1	7	20	13	106	25.5
Redunca arundinum	Southern reedbuck	24	7	3	14	37	4	1	9	99	23.8
Macroscelidea spp.	Elephant shrews	9	21	17	–	3	22	8	6	86	20.7
Potamochoerus larvatus	Bush pig	21	3	2	1	13	4	2	6	52	12.5
Papio cynocephalus	Yellow baboon	9	3	6	6	9	2	1	6	42	10.1
Otolemur crassicaudatus	Greater galago	5	2	7	–	4	1	4	9	32	7.7
Hippotragus niger	Sable antelope	12	–	1	5	–	–	–	–	18	4.3
Tragelaphus scriptus	Bushbuck	5	4	–	–	2	1	–	4	16	3.8
Phacochoerus africanus	Common warthog	13	–	–	–	1	1	–	1	16	3.8
*Genetta*sp.	Genet	–	–	1	2	–	–	–	–	–	–
Civettictis civetta	African civet	2	–	1	2	3	–	–	2	10	2.4
Birds											
Numida meleagris	Helmeted guineafowl	11	3	11	–	4	3	5	6	43	10.3
Francolinus spp.	Francolins	6	2	1	–	–	1	2	2	14	3.4
Reptiles											
Varanus spp.	Monitors	8	4	5	–	4	4	6	23	54	13.0
Kinixys belliana	Bell's hinged tortoise	3	5	2	7	4	5	1	16	43	10.3

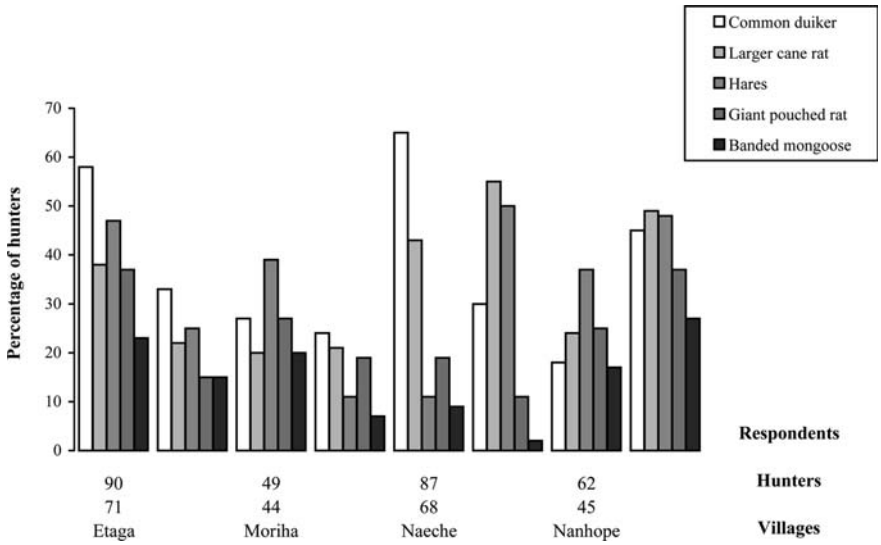

Figure 4. Differences between villages in the percentage of hunters who declared that they exploit a given species.

specimen; southern reedbuck (5.7%) for an average price of 0.97 ± 0.18 USD per kg (Table 4). For a comparison, during our surveys, the price for poultry was 1.3 USD per specimen.

According to the data gathered from 10 hunters of Gile, most quarry was sold (56%), whereas the remainder (44%) was consumed. An average hunter earned circa 29 USD from selling bushmeat over the four month study period. This income was relevant if we consider that the income of an average household per year from crop trade was 49 USD.

Hunting methods

Animals were captured/killed using five different methods: nets (40%, used by 8 hunters); traps (25%, 4 hunters); gin-traps (20%, 5 hunters); spears (12%, 9 hunters), and guns (2.3%, 1 hunter). Two hunters used simultaneously 4 methods, three hunters used 3 methods, four hunters used 2 methods and one hunter use only 1 method (traps). Only one hunter used a lent gun during a single beat. Spears and gin-traps were usually bought from local artisans whereas nets and snares were self-made. The proportion of animals captured during the day (53%) and the night (47%) was very similar. Most animals (96%) was captured within the Reserve.

Netting and trapping activities (including gin-traps) were conducted in groups that varied between 10 and 30 people. Off-take from netting and trapping was shared out among the group members following a complicated

Table 3. The off-take of 10 hunters from the village of Gile during the study period (April–July 2002).

Scientifc name	Common name	*H*1	*H*2	*H*3	*H*4	*H*5	*H*6	*H*7	*H*8	*H*9	*H*10	Total	%
Reptiles													
Kinixys belliana	Bell's hinged tortoise	–	1	1	2	–	–	–	1	–	–	5	1.9
Varanus albogularis	White-throated monitor	–	4	2	3	2	3	–	-	–	–	14	5.4
Birds													
*Francolinus*sp.	Francolins	–	-	–	1	–	2	–	-	–	-	3	1.2
Numida meleagris	Helmeted guineafowl	–	-	–	3	–	2	–	-	–	-	5	1.9
Mammals													
Papio cynocephalus	Yellow baboon	2	6	6	–	2	–	3	2	1	4	26	10.1
Otolemur crassicaudatus	Greater galago	–	-	–	2	2	–	-	–	1	2	7	2.7
Petrodromus tetradactylus	Bush pig	–	-	–	1	–	-	–	-	–	-	1	0.4
Leporidae spp.	Hares	–	2	1	3	2	5	1	2	1	3	20	7.8
Paraxerus cepapi/palliatus	Squirrels	–	2	–	2	1	3	–	-	–	-	8	3.1
Anomalurus derbianus	Lord Derby's anomalure	–	1	–	1	–	1	–	-	–	-	3	1.2
Thryonomys swinderianus	Larger cane rat	2	–	1	4	–	3	1	1	2	2	16	6.2
Cricetomys gambianus	Giant pouched rat	1	1	–	3	2	4	–	1	–	1	13	5.1
Muridae spp.	Wild rats and mice	–	-	–	1	–	-	–	-	–	1	2	0.8
Mungos mungo	Banded mongoose	–	-	–		–	-	1	–	-	1	2	0.8
Atilax paludinosus	Marsh mongoose	–	-	–	1	–	2	–	-	–	-	3	1.2
*Genetta*sp.	Genet	–	-	–	1	–	-	–	-	–	-	1	0.4
Civettictis civetta	African civet	1	–	-	2	–	3	–	-	–	2	8	3.1
Phacocherus africanus	Common warthog	–	-	–	-	–	-	2	2	–	1	5	1.9
Potamochoerus larvatus	Bush pig	4	–	1	–	-	–	4	4	3	4	20	7.8
Tragelaphus strepsiceros	Greater kudu	–	-	–	-	–	-	1	–	1	–	2	0.8
Sylvicapra grimmia	Common duiker	2	6	6	–	4	1	3	3	3	5	33	12.8
Cephalophus natalensis	Natal duiker	1	–	-	–	-	–	-	3	1	3	8	3.1
Neotragus moschatus	Suni	2	2	2	2	1	–	-	2	–	2	13	5.1
Redunca arundinum	Southern reedbuck	3	3	2	–	3	–	2	1	1	4	19	7.4
Kobus ellipsiprymnus	Waterbuck	3	–	-	–	-	–	4	2	1	1	11	4.3
Alcelaphus lichtensteinii	Hartebeest	1	–	-	–	-	–	1	–	-	–	2	0.8
Hippotragus niger	Sable antelope	2	–	-	–	-	–	4	1	–	-	7	2.7
Total		24	28	22	32	19	29	27	25	15	36	257	100

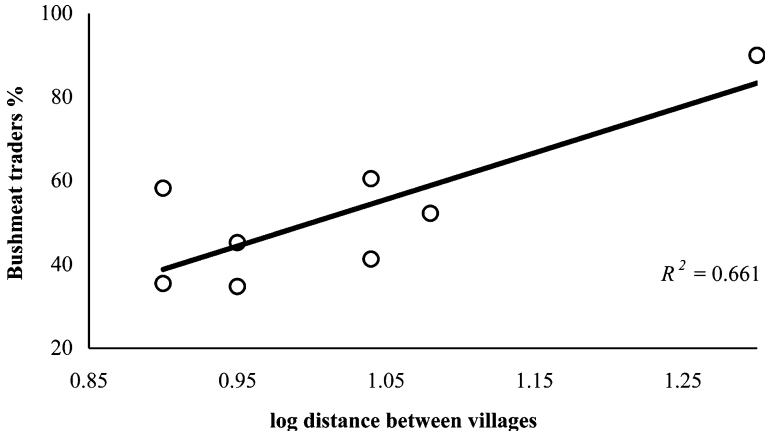

Figure 5. Relation between the percentage of bushmeat traders and the distances between villages.

system of traditional rules (see: Carpaneto 2001, for ethnological details). An average group of 20 hunters captured 24.1 ± 6.7 animals, of which 15 ± 5.8 animals were caught by nets and traps, and 10.6 ± 5.5 by gin-traps. The off-take of an average hunter operating in a group was 4.3 ± 3.8 animals of which: 0.7 ± 0.3 animals captured with nets and various traps; 0.5 ± 0.3 animals captured with gin-traps; 3.8 ± 3.7 animals with spears. On the other hand, an average hunter who only operated by himself captured 29.3 ± 2.5 animals over the same period, using mainly snares and sometimes a spear. Highly significant differences between hunters were recorded in the average

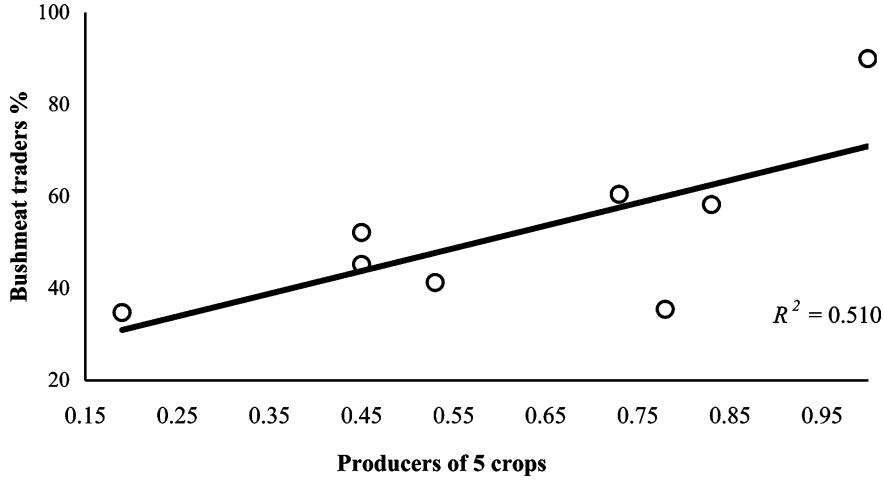

Figure 6. Relation between the percentage of bushmeat traders and crop producers.

Table 4. The most commercialized prey items and their average price in USD (±S.D.).

Taxon	Common name	Etaga	Gile	Moriha	Naeche	Namurrua	Nanhope	Nassile	Total	%	Price USD
Thryonomys swinderianus	Larger cane rat	20	16	13	31	16	13	34	143	34.4	0.73 ± 0.43 each
Leporidae spp.	Hares	19	17	19	–	18	19	30	122	29.3	0.78 ± 0.07 each
Sylvicapra grimmia	Common duiker	6	24	11	8	11	–	21	81	19.5	0.75 ± 0.1 per kg
Cricetomys gambianus	Giant pouched rat	11	9	10	11	3	12	23	79	19.0	0.46 ± 0.12 each
Redunca arundinum	Southern reedbuck	–	7	–	17	–	–	–	24	5.8	0.97 ± 0.18 per kg

number of animals captured (One-way ANOVA, $F_{9,107} = 30.9$, $p < 0.01$). Numerically, the average off-take of a solitary hunter was more than six times the off-take of a group-operating hunter. Nevertheless, collective hunting allowed the capture of larger animals, e.g. large ungulates, whereas solitary hunters obtained mostly small animals, such as rodents, hares, small antelopes, birds and tortoises. A biomass comparison between the booty of solitary and collective hunting, based on the animal weight reported by several authors (Skinner and Smithers 1990; Kingdon 1997; Bothma 2002) showed that the prey body mass was always higher from the latter (Table 5). However, in the study area hunters operated either in-group or alone. We did not consider in the previous analyses the off-take obtained with the gun (2.3% of total) because only one hunter (who was not the owner of the weapon) used it during only one hunting beat. Moreover, no one of the 510 householders reported to use guns, highlighting its scarce relevance as hunting tool.

Discussion

In many African countries, bushmeat is largely traded and represents a primary source of income for rural people (Juste et al. 1995). In recent years, there was a progressive and important transition from subsistence to commercial hunting, essentially because of the increase in human population density, the modernisation of hunting techniques and a greater accessibility to remote forest areas (Wilkie and Carpenter 1999; Fa and García Yuste 2001). In this context, the present study underlines the importance of subsistence hunting and bushmeat trade for villagers settled around GRG. This protected area is threatened by the increasing rural population, the persistent lack of management and a better accessibility to the forested area, due to the construction and/or rehabilitation of roads for logging and mining.

Results of the regression analyses showed that the proportion of householders who declared to have harvested game is not correlated to the geographical location of the village but is inversely correlated with village size. These results can be explained as follows: (1) the distance from the Reserve border did not prevent hunting because of the importance given to this activity; (2) hunting expeditions are arranged by villagers who spend several days within the Reserve

Table 5. Number and percentage of animals captured over four months during solitary and collective hunting, in relation to their body mass (animal mass was obtained from Skinner and Smithers 1990; Kingdon 1997; Bothma 2002).

Body mass	Solitary hunting	Collective hunting	Total
Less than 5 kg	53 (60.2%)	42 (24.9%)	95 (36.9%)
Between 5 and 30 kg	17 (19.3%)	79 (46.7%)	96 (37.4%)
More than 30 kg	18 (20.5%)	48 (28.4%)	66 (25.7%)
Total	88 (100%)	169 (100%)	257 (100%)

hunting and smoking bushmeat; (3) large villages offer alternative livelihood strategies such as trade and labour, whereas small villages are more dependent on natural resources including bushmeat; (4) the depletion of game around large villages induced a decrease in hunting activity because it became unprofitable. However, the proportion of hunters in each village was positively correlated to crop production. Such a result led us to consider that: (1) hunting is not an alternative to agricultural production because crops, such as starch foods and vegetables, cannot replace meat protein; (2) an increase in crop production may facilitate the purchase of hunting equipments (cartridges, gin-traps and nets). Most villagers interviewed (78.5%) hunted and fished, revealing the importance of these activities that appeared to be not alternative but complementary.

The species most commonly harvested by householders were all mammals and included antelopes, hares, large rodents and carnivores (mongooses). The geographical location of villages and their size were not correlated with proportions hunted of each species, which can be ascribed to the different hunting techniques adopted. Within his four month booty, an average hunter secured 2.9 wild ungulates (antelopes and wild pigs), the equivalent of 50% of domestic ungulates (goats and pigs) kept by an average householder. Thus, wild meat was the main animal protein source for local people during the study period.

According to data gathered from all householders and ten Gile hunters, the four most captured species were also the most traded. The remoteness of a village was associated with a more intensive bushmeat trade: small and remote villages did not offer alternative activities to generate money. A further explanation is given by the surplus of game hunters harvested from these less inhabited areas. The bushmeat trade was positively correlated with crop production, once more underlying that hunting and agricultural development were not alternative strategies for subsistence in the study area. The profits obtained by the ten hunters of Gile during four months (circa 29 USD) revealed that bushmeat trade was probably the most relevant income source for local people, exceeding the revenue derived from crop trade on annual basis (circa 49 USD). The use of firearms has declined mainly because of the high cost of cartridges and maintenance. Hunters almost exclusively used nets and traps (including gin-traps) either alone or in a group. Lone hunters captured a higher proportion of small animals but les medium-sized animals, in contrast to hunters who operated in group, while the proportion of larger animals was similar. In fact, small animals were mainly captured by traps adopted in great number during solitary hunting; many medium-sized animals were captured in collective net hunting; larger mammals were captured by gin traps used during both solitary and collective hunting. Hence, local hunters adopted both strategies, to increase diversity of preys and their body mass range. According to the ten hunters from Gile, 96% of the animals was captured within the Reserve, revealing the importance of the protected area as a source of bushmeat for rural people, but at the same time, underlining the threat represented by subsistence hunting for wildlife conservation.

Conclusions

The patterns of wildlife exploitation derived from the present research are likely valid for all the rural communities close to and within miombo woodland ecosystems in Zambezia. Hunting is an important livelihood strategy for people and bushmeat represents the major animal protein supply, owing to scarcity of domestic animals. Local hunters adopt essentially trapping techniques and collective net hunting. Gin-traps are largely used and destructive, but the use of fire-weapons declined. The results indicate that smaller the village, higher is the proportion of hunters. Hence, patrolling activities for poaching control should be mainly conducted in small villages. As hunting activity is not dependent on the distance between villages and the Reserve borders, all the householders within a radius of 20 km need to be considered as possible harvesters of faunal resources within protected areas. Moreover, our data show that hunting activities and bushmeat trade are not alternative to agriculture practices as livelihood strategies. The results indicate that a mere increase of crop production in the study area (pursued by many conservation projects as a strategy to diminish the impact of subsistence hunting) would not produce an effective decrease of bushmeat exploitation. Wildlife represents the most relevant protein source for the villagers and also an important income for local bushmeat traders. An average bushmeat trader can earn a relevant income, larger than crop trader, because the off-farm profit opportunities are practically inexistent. To prevent wildlife exploitation other ways should be explored, e.g. to assess the potentiality of local pastures for cattle grazing out of the protected areas, and to develop projects for improving the people's knowledge of cattle rearing. All these considerations should be taken into account by the reserve authorities of Zambezia's protected areas and NGOs, for planning future projects of sustainable development.

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References

Alvard M.S., Robinson J.G., Redford K.H. and Kaplans H. 1997. The sustainability of subsistence hunting in the Tropics. Conserv. Biol. 11: 977–982.

Barnes R.F.W. 2002. The bushmeat boom and bust in west and central Africa. Oryx 36: 236–242.

Bellamy R. 1993. Ethnobiology in Tropical Forests. Royal Geographical Society, London, UK.

Bennett E.L., Milner-Gulland E.J., Bakarr M., Eves E.H, Robinson G.J. and Wilkie D.S. 2003. Hunting the world's wildlife to extinction. Oryx 36: 328–329.

Bothma J.P. 2002. Game Ranch Management. Van Schaik Publishers, Pretoria, RSA.

Carpaneto G.M. 1994. Parc National d'Odzala: ethnozoologie, faune et ecotourisme. Rapport Final. Republique du Congo - Ministère des Eaux et Forêts, AGRECO/CTFT, Bruxelles, Belgium.

Carpaneto G.M. 2001. The Sustainable Exploitation of Wildlife in the National Reserve of Gile (''Reserva do Gilé'', Zambezia, Mozambique). Final Report. Movimondo, Rome, Italy.

Carpaneto G.M. and Fusari A. 2000. Subsistence hunting and bushmeat exploitation in central-western Tanzania. Biodivers. Conserv. 9: 1571–1585.

Chande B., Zolho R., Chidiamassamba C., Longamane F. and Cumbane R. 1997. Reconhecimento bio-ecològico da Reserva do Gilé. Ministério para a Coordenação da Acção Ambiental-MICOA, Maputo, Mozambique.

Chidumayo E.N. 1997. Miombo Ecology and Management: an Introduction. Intermediate Technology Publications, London, UK.

Colell M., Maté C. and Fa J.E. 1994. Hunting among Moka Bubis in Bioko: dynamics of faunal exploitation at the village level. Biodivers. Conserv. 3: 939–950.

DNFFB 1995. Mapa Florestal da Provincia da Zambézia. Direção National de Floresta e Fauna Bravia, Maputo, Mozambique.

Dutton T.P., Dutton E.A.R. and Balsinhas A. 1973. Preliminary Ecological Reconnaissance of the ''Reserva Especial do Gilé'' and the Adjoining ''Regime de Vigilancia'', District of Zambezia. Report for the Servicio de Veterinaria de Moçambique, Maputo.

Fa J.E., Juste J., Del Val J.P. and Castroviejo J. 1995. Impact of market hunting on mammal species in Equatorial Guinea. Conserv. Biol. 9: 1107–1115.

Fa J.E. and García Yuste J.E. 2001. Commercial bushmeat hunting in the Monte Mitra forests, Equatorial Guinea: extent and impact. Anim. Biodivers. Conserv. 24(1): 31–52.

Fa J.E. and Peres C. 2001. Hunting in tropical forests. In: Reynolds J.D., Mace G.M., Redford K.H. and Robinson J.G. (eds), Conservation of Exploited Species. Cambridge University Press, Cambridge, UK, pp. 203–241.

Fitz Gibbon C.D., Mogaka H. and Fanshawe J.H. 1995. Subsistence hunting in Arabuko-Sokoke Forest, Kenya, and its effects on mammal populations. Conserv. Biol. 9: 1116–1126.

Fusari A. 2002. Utilization of the Indigenous Resources by Dwelling People in the National Reserve of Gile (Zambezia Province-Mozambique). Final Report. Movimondo, Rome, Italy.

Galego J.L. 2002. Caterpillars, Traps and Bees: Livelihood Dependence on Wild Resources in the National Reserve of Gile. Final Report. Movimondo, Rome, Italy.

Galego J.L. and Rasul I. 2001. Baseline Survey (Food Security Programme in the Districts of Ile and Gile, Zambezia Province-Mozambique). Final Report. Movimondo, Rome, Italy.

INE 1997. II Receseamento Geral da População e Habitação. Instituto Nacional de Estatística, Maputo, Mozambique.

IUCN 1998. Mozambique Bush Meat Trade Study Report. IUCN Mozambique's Consultancy for the TRAFFIC East/Southern Africa (TESA). IUCN, Maputo, Mozambique.

Juste J., Fa J.E., Del Val J. and Castroviejo J. 1995. Market dynamics of bushmeat species in Equatorial Guinea. J. Appl. Ecol. 32: 454–467.

Kingdon J. 1997. The Kingdon Field Guide of African Mammals. Academic Press, London, UK.

Kock R.A. 1995. Wildlife utilization: use it or lose it - a Kenyan perspective. Biodivers. Conserv. 4: 241–256.

Lahm S.A. 1993. Utilization of forest resources and local variation of wildlife populations in Northeastern Gabon. In: Hladik C.M., Linares O.F., Pagezy H., Semple A. and Hadley M. (eds), Tropical Forests, People and Food. UNESCO, Paris, France, pp. 213–226.

Ling S., Kümpel N. and Albrechtsen L. 2003. No new recipes for bushmeat. Oryx 36: 330.

Marks S.A. 1994. Local hunters and wildlife surveys: a design to enhance participation. Afr. J. Ecol. 32: 233–254.

Martines A. and Ntumi C. 2002. Plant Diversity, Vegetation Ecological Status, Spatial and Temporal Movements of Elephants and Economic Value of Natural Resources in the National Reserve of Gile, Zambezia Province-Mozambique. Final Report. Movimondo, Rome, Italy.

Robinson G.J. and Bennett E.L. 2003. Will alleviating poverty solve the bushmeat crisis? Oryx 36: 332.

Skinner J.D. and Smithers R.H.N. 1990. The Mammals of the Southern African Subregion. University of Pretoria Press, Pretoria, RSA.

Trollope W.S.W. and Trollope L.A. 2002. Fire Management Program for the National Reserve of Gile in Zambezia Province, Mozambique. Final Report. Movimondo, Rome, Italy.

van Aarde R.J. 2002. The Potential for Game Farming and the Rehabilitation of Wildlife Resources in the National Reserve of Gile (''Reserva do Gilé'', Zambezia, Mozambique). Final Report. Movimondo, Rome, Italy.

White F. 1983. The Vegetation of Africa. UNESCO, Paris, France.

Wilkie D.S., Sidle J.G. and Boundzanga G.C. 1992. Mechanized logging, market hunting and a bank loan in Congo. Conserv. Biol. 6: 1–11.

Wilkie D.S. and Carpenter J.F. 1999. Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. Biodivers. Conserv. 8: 927–955.

Ziegler S. 1996. An initial study of hunting in the Upper Niger National Park. Wildlife Nat. 4: 13–28.