Drivers of change in hunter offtake and hunting strategies in Sendje, Equatorial Guinea

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science and the Diploma of Imperial College London

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Cover photo: A flat-headed cusimanse (*Crossarchus platycephalus*) on sale at the side of the recently paved road going through the middle of Sendje. Photo taken by author

Acronyms

AL	Additional Livelihood
ANDEGE	*Amigos de Natureleza y Desarollo de Guinea Ecuatorial*
BBC	British Broadcasting Company
CARPE	Central African Regional Program for the Environment
CFA	Central African CFA Franc
CI	Conservation International
CIA	Central Intelligence Agency
CPUE	Catch per unit effort
ECOFAC	*Conservation et Utilisation Rationelle des Ecosystèmes Forestiers d'Afrique Centrale*
EG	Equatorial Guinea
GDP	Gross Domestic Product
INDEFOR-AP	National Institute of Forestry Development and Protected Areas
PI	Principal Livelihood
REDD	Reduced Emissions from Deforestation and Forest Degradation
UNDP	United Nations Development Programme
WRI	World Resources Institute
ZSL	Zoological Society of London

Abstract

Bushmeat hunting across Central Africa has been widely recognised as unsustainable, yet few studies have documented changes in hunter offtake and strategy against a background of considerable national economic growth. This project focused on the activities of a group of hunters residing in Sendje, a rural community in Equatorial Guinea – a country which has become increasingly wealthy since the discovery of oil in 1995. Methods used were consistent those of Kümpel (2006), permitting a comparison of data collected during fieldwork completed in 2003 in Sendje and Bata (the capital of Equatorial Guinea's continental region). A combination of interviews and offtake surveys were undertaken and data were collected on the species caught, effort expended and strategies employed by hunters. In addition, livelihood activities of Sendje residents were recorded alongside levels of bushmeat trade in the village and in Bata.

Data revealed a dramatic decline in offtake extracted from Sendje's forests catchment (4, 172 kg in 2003; 1, 361 kg in 2010). There were also fewer active hunters (64 in 2003; 41 in 2010), operating significantly closer to the village (9.5 km in 2003; 3 km in 2010). Changes in hunter behaviour are related to increased opportunity costs (both economic and physical) of hunting. In contrast to results from Sendje, nationally, bushmeat hunting has expanded, with more villages supplying, in total, more bushmeat (10, 316 kg in 2003; 15, 004 kg in 2010); and many of these carcasses are gun-hunted. Decreased mean carcass weights, higher prices and a decreased number of primate carcasses arriving at market all indicate unsustainable levels of hunting.

Equatorial Guinea's developing economy has divergent implications for bushmeat sustainability. Increased employment opportunities may reduce pressure on bushmeat from rural hunters, yet, at a national level, increased consumer demand, accompanied by reduced barriers to entry for gun-hunting could lead to the over-exploitation of vulnerable species and of the local food supply of a number of rural settlements.

Project word count: 12, 717

Acknowledgements

I would like express my sincere thanks to my supervisors Noëlle Kümpel, Marcus Rowcliffe and Heidi Ruffler. It has been a privilege to take on this project and I've enjoyed just about every minute of it! Thank you all for the invaluable encouragement handed out prior to my departure and for the regular and much-needed advice given throughout the fieldwork and write-up stages. Special thanks goes to Heidi for dealing with, on my behalf, an endless number of logistical obstacles, and for the efforts she made to make life in Equatorial Guinea an easy-going and extremely enjoyable experience.

A large number of individuals and organisations supported my project both financially and logistically. Both of the Ministry of Agriculture and Forests and INDEDFOR-AP, assisted greatly with securing research permits and visas, and provided the loan of GPS equipment. The Zoological Society of London (ZSL) contributed to the salaries of two research assistants through funds provided by the Rufford Foundation. Conservation International (CI) provided free accommodation throughout my stay in Bata and Hess-Equatorial Guinea provided in-country flights. Imperial College London also provided a bursary that greatly helped to fund project costs.

Thank you to everybody living in Sendje for participating in the study and for make me feel welcome in the village. In particular, to the village president Joaquín Masolo, and his family, for letting me stay in their house, and for daily supplies of zanzanbía. Also, to Andrés Nze, Díosdado, Salvador Afugu and Volsaíno for keeping me company throughout my stay.

Finally, a huge thanks goes to my two research assistants who went beyond the call of duty on several occasions to make the project succeed. To Teresa Akeng for first showing me around Bata's markets, and to Santiago Enseñ for all of his companionship, good humour and vuvuzela impressions throughout an extremely enjoyable stay in Equatorial Guinea.

1. Introduction

1.1 Problem definition – the over-exploitation of bushmeat in Central Africa

Humans have engaged in the hunting of wild meat at subsistence levels for 100 000 years or more (Milner-Gulland and Bennett, 2003). In recent decades however, the combined effects of human population growth, increased forest access, modern hunting technologies and the loss of traditional hunting controls, have driven and facilitated a transformation of the practice into a large-scale commercial trade (Bennett and Robinson, 2000).

There is growing consensus that the current rate of bushmeat extraction, in particular within Central Africa, is highly unsustainable (Wilkie and Carpenter, 1999, Robinson and Bennett, 2000). Indeed, it is predicted that bushmeat production will decline across the region by 83% in the next half century, compromising food security (Fa et al., 2003) and severely threatening biodiversity (Bennett and Robinson, 2000) through local extinctions (Oates et al., 2000, Brashares et al., 2001) and knock-on effects on ecosystem function (Redford, 1992, Brodie et al., 2009).

However, measuring the sustainability of bushmeat harvesting is problematic (Milner-Gulland and Akçakaya, 2001, Kümpel et al., 2010) and actually achieving this end is further confounded by the fact that bushmeat is, in the majority of cases where control is absent, an open-access resource (Nasi et al., 2008), hunted at relatively low costs and risks (Cannon, 2001), and often sold within countries where urban demand for the resource is high (East et al., 2005).

1.2 The importance of this research

There is a great need both to devise means of measuring sustainability (Kümpel et al., 2010) and to improve our understanding of its influential factors by studying the behaviour of individual resource-users (Milner-Gulland and Rowcliffe, 2007, Solly, 2007).

Simple sustainability indices however ignore human processes (Ling and Milner-Gulland, 2006), and information derived from market studies in isolation generally fail to provide conclusive evidence of depletion through over-exploitation (Allebone-Webb et al., (in press)). In contrast, detailed studies of the strategies employed and effort expended by hunters can, when related to offtake levels, provide insight into sustainability (Rist et al., 2008, Kümpel et al., 2010), and also, when related to the socio-economic profiles of hunters help indicate key drivers of hunter behaviour (Solly, 2007, Kümpel et al., 2009).

Few detailed studies exist that assess the relationships between hunter profile, behaviour and offtake (but see Kümpel et al., 2009), and fewer still have attempted to observe how these factors have differed between two distinct periods of time. However it is the existence of just such a detailed study undertaken in Equatorial Guinea (Kümpel, 2006) that provides the opportunity to explore how these relationships have changed in response to a rapidly changing socio-economic environment.

Since the completion of the study by (Kümpel, 2006) in 2004, economic and infrastructural development has continued apace in Equatorial Guinea (World Bank, 2009). An assessment of how this changing socio-economic environment has affected hunter profile, strategy and offtake for a number of known individual hunters and what the implications of such changes may be for future management of the bushmeat trade, can provide much-needed information to guide national and regional policy.

1.3 Aim and research questions

The overall aim of this study is to investigate if hunter offtake, effort and strategy have changed in the rural community of Sendje, Equatorial Guinea, since 2003, and if so, to identify possible drivers for change.

In order to achieve this aim, five sets of inter-related sub-questions have been established. These examine i) changes in offtake from Sendje in relation to effort, ii) hunter strategy as a driver of offtake, iii) hunter profile as a driver of hunter strategy, iv) relationships between hunter profile and the wider commodity chain and v) market

signals as an indicator of broad-scale socio-economic processes. Unless otherwise specified, the term change refers to the period between fieldwork undertaken in 2003 (Kümpel, 2006) and 2010 (this study).

Set 1 – Absolute change in offtake, prey profile and effort

(a) Has there been a change in the number and biomass of prey captured in Sendje (relating to study periods in 1998 and 2003)?

(b) Have proportions of species sensitive to hunting (e.g. primates) decreased in hunter offtake?

(c) Has the level of effort expended (in terms of trap number laid, and time spent in forest) by individual hunters changed?

(d) Has catch per unit effort (CPUE) of individual hunters changed?

Set 2 – Hunter strategy as a driver of change in offtake, prey profile and effort

(a) Has location of hunt (distance from Sendje) changed and does hunt location influence i) offtake volume, ii), prey profile iii) level of effort and iv) CPUE?

(b) Has hunter gear type changed and does gear type influence prey profile and CPUE?

Set 3 – Hunter profile as a driver of change in effort and hunting strategy

(a) Has there been a change in the proportion of village inhabitants who hunt as a principal livelihood, and does effort and hunting strategy differ between these two hunter groups?

(b) Does access to regular alternative income influence hunting strategy?

(c) Has average age of hunter changed and does age influence hunting strategy?

(d) What reasons do hunters provide for changed hunting strategy?

Set 4 – The relationship between hunters and the wider commodity chain

(a) Has the number of bushmeat carcasses sold and consumed in Sendje changed and does this relate to hunter profile?

(b) Has the first point-of-sale significantly changed for Sendje hunters?

Set 5 - Using market data as an indicator for wider-scale processes

(a) Has the number or location of hunter sites that supply the market changed?

(b) Has the method of capture for animals arriving in the market changed?

(c) Has there been a real-terms increase in the price of carcasses sold at the market?

(d) Has the species composition of offtake arriving at the market changed?

2. Background

2.1 The importance and impacts of the bushmeat trade

Over the past century, increases in human population, together with advances in technology and rises in economic prosperity, have fuelled the exploitation of natural resources across the world to meet an ever increasing consumer demand (Baltz, 1999). A clear example of this is the case of hunting of wildlife for human consumption (bushmeat) in tropical forests, which in recent decades, has dramatically increased in scale across South America, Africa and Asia (Milner-Gulland and Bennett, 2003).

The socio-economic value of the bushmeat trade is tremendous (Robinson and Bennett, 2002) and this is particularly true within the Congo Basin region (Cameroon, Central African Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon and Republic of Congo) where it has been reported that all countries, with the exception of Gabon are dependent on bushmeat to meet the recommended daily protein requirements of their populations (Fa *et al.* 2003). Where few alternative sources of protein exist, bushmeat also acts a safety net for forest-dwelling people during short-term live livelihood crises (Brown and Williams, 2003, de Merode et al., 2004, Allebone-Webb, 2009). Indeed the emergence of the bushmeat trade, from a development perspective, is largely positive: the industry has low barriers to entry, is relatively socially inclusive, contains fewer risks compared to other livelihood activities and provides poor and marginalised sections of society with access to the national economy (Brown and Williams, 2003).

However, current rates of bushmeat extraction from the region are estimated to be far higher than the ecosystem's maximum level of production (Wilkie and Carpenter 1999; Robinson and Bennett 2000). When predicted increases in human population and deforestation are accounted for, bushmeat supply in the Congo Basin region is estimated to drop by 81% within 50 years (Fa *et al*. 2003), potentially eroding the massive benefits that bushmeat provides to poorer, forest-dependent members of society.

What is more, the expansion in the bushmeat trade has been deemed by conservationists to be a severe threat to biodiversity and in some cases poses a greater threat than deforestation itself (Redford 1992). Hunting has been the primary cause of the reported extinction of at least one primate subspecies (Oates et al., 2000) and has caused the local extinction of many other species (Brashares et al., 2001). There is also evidence of depletion of vulnerable taxa (such as large-bodied mammals) from large forest catchments (Cowlishaw et al., 2005a), which furthermore, through the loss of associated ecosystem services such as seed dispersal, has profound effects on ecosystem function (Redford, 1992; Broadie et al. 2009).

The ecological, nutritional, economic and intrinsic values of bushmeat are all at risk of being lost (Bennett et al., 2007) and there is a clear need to monitor the resource in order to implement relevant policy that will promote its long-term sustainability. However, region-wide measures of extraction are not necessarily a good indicator of depletion at a local level, where the behaviours of resource-users (e.g. hunters hunting at varying intensities (Kümpel et al., 2009)) and the state of the resource itself (e.g. post-depletion areas surrounding Takoradi market in Ghana being highly productive (Cowlishaw et al., 2005a)) may be highly variable.

2.2 Problems with measuring bushmeat sustainability

Determining the actual sustainability of bushmeat harvesting requires that both the level of hunter offtake and the size of stock available for exploitation are measurable (Rowcliffe et al., 2003). In practice, however, this would take considerable time and effort to achieve as the majority of species living in tropical forests are elusive and extremely difficult to monitor (Wilkie and Carpenter 1999). Sustainability indices have been developed, e.g. (Robinson and Redford, 1991), based on calculations of offtake rate and expected productivity for a given population (Rowcliffe et al., 2003). Though these indices have been widely applied to assess bushmeat harvest sustainability (Robinson and Bennett, 2002), they fail to incorporate bias or uncertainty in parameter estimation, habitat heterogeneity (Milner-Gulland and Akçakaya, 2001), interactions in multi-species communities (Rowcliffe et al., 2003), or human processes that would provide a basis for implementing management (Ling and Milner-Gulland, 2006).

Market data can be used to indicate faunal depletion through assessing changes in (i) proportions of vulnerable species appearing in offtake, (ii) the distance of origin for hunted species from market and (iii) price (Fa et al., 2000, Crookes et al., 2005). However, market data represent the outcome of several processes and in isolation are of little value without complementary data on hunter and consumer behaviour, spatial dynamics of the trade and the quantity and identity of species filtered at different points in the commodity chain (Crookes et al., 2005, Allebone-Webb et al., (in press)).

Results from Rowcliffe *et al*. (2003) using multi-species models showed that shifts in prey profile in relation to changing levels of hunter effort, could signal over-exploitation, as vulnerable species decline and eventually disappear at high levels of hunting intensity. These principles have been applied in a recent study of offtake from, and hunter behaviour in, the Monte Mitra forests of continental Equatorial Guinea (Kümpel et al., 2010). In this case, data indicated that shifts in prey composition of offtake and changes in hunter CPUE can act as indicators of depletion at local levels (Kümpel et al., 2010). Rist el al. (2009) expanded upon this theme by gathering detailed information on both hunter effort and location of capture of species and showed that hunter effort and habitat have independent effects on species abundance, and so both need to be taken into account to form a clear indication of over-exploitation.

In summary, changes in the strategies and effort employed by hunters, such as location of hunting, gear type used, number and age of traps laid, can serve as meaningful and relatively simple indicators of sustainability at a local level (Kümpel et al., 2010). Furthermore as hunters act as a critical link between the supply of, and demand for, bushmeat (Cowlishaw et al., 2005b), detailed information on hunting strategies in relation to hunter socio-economic profile could also help predict under what conditions hunter behaviour is likely to change and how this would affect the sustainability of the overall harvesting system (Kümpel et al., 2009).

2.3 Bushmeat policy

In response to an alleged impending bushmeat 'crisis' (Bennett et al., 2007) a wide range of policy measures have been proposed by conservationists (Wilkie and Carpenter, 1999). These can be largely divided into (i) those that aim to control the supply of bushmeat, such as improved protection and long-term management of national parks (Oates et al., 2000), enforced bans on the hunting of vulnerable species (Milner-Gulland and Bennett, 2003) or the provision of alternative livelihoods for hunters (Kümpel, 2006), and (ii) those that aim to reduce demand for bushmeat, such as through marketing and improved supply of under-developed protein substitutes (East et al., 2005), through price increases of bushmeat relative to substitutes (Wilkie and Godoy, 2001) or through increased public awareness of the bushmeat crisis (Milner-Gulland and Bennett, 2003).

However, there is increasing consensus that no single one of these measures would be effective in isolation (Cowlishaw et al., 2005b, Kümpel, 2006) and, what is more, the implementation of each would have vastly different implications for various stakeholders depending on the values they attach to the bushmeat resource (be they ecological, economical, nutritional or intrinsic). There remains a strong need to find reconciliation between conservation and development approaches to the bushmeat crisis (Bennett et al., 2007).

Sustaining bushmeat for a range of purposes could theoretically be achieved by undertaking a spatially heterogeneous approach whereby secondary forests as part of a mosaic of farmed and fallowed lands, already depleted in vulnerable species yet high in productivity, could be managed to provide a sustainable production of bushmeat for rural communities. In such a setting increased protection could be justified in primary forests relatively low in productivity yet containing vulnerable species (Robinson and Bennett, 2002, Bennett et al, 2007).

Finally, long-term sustainability of a common-property resource requires that local communities have a real sense of long-term ownership and responsibility (Brown and

Williams, 2003). It is therefore of the utmost importance that resource-users are not further marginalised by any policy implementation (such as a complete ban on hunting), but instead should have a genuine role in decision-making processes (ibid). Achieving the land or forest tenure rights required to fulfil this sense of ownership would require considerable government reform, and while this process will be extremely challenging, the pooled resources of conservation and development agencies would be a powerful force to achieve this (ibid).

2.4 Equatorial Guinea: Conservation in a rapidly changing socio-economic environment

The Republic of Equatorial Guinea is a small Spanish-speaking country located between Cameroon to the north and Gabon to the east and south within the Congo Basin region of Central Africa (figure 0.1(a)). It consists of a mainland region (where the majority of the country's area and population are found) and five islands, one of which, Bioko, hosts the country's capital Malabo. The dominant tribe in the country is the Fang, though others include the Bubis who have a stronghold on Bioko and the costal Ndowe tribe. The country's population is growing rapidly, averaging a 2.6% rise from 2005 to 2010 and is now estimated at 633,441 (CIA, 2010).

Since gaining independence from Spain in 1968 the country has experienced considerable political and economic transformation. The first president, Francisco Macias Nguema (Macias), inherited a country with vibrant cocoa, palm-oil and logging industries. However, after a decade of rule which included the neglect of the country's infrastructure, severe economic decline and the death, exile or flight of a third of the population, Macias was overthrown in 1979 in a military *coup d'état* staged by his nephew Obiang Nguema Mbasogo. President Obiang has remained in power ever since though it was not until the discovery of offshore oil reserves in 1995 that the country's economy began to boom once more.

Indeed, the country's rise from economic adversity has been spectacular, with American-based investment fuelling development across the country. Since 1995 GDP has risen year by year, and the country's GDP per capita now exceeds $30, 000,

ranking it 26th in the world ahead of countries such as New Zealand and South Korea (World Bank, 2009). Oil money has also fuelled considerable infrastructure with extensive road networks constructed (*Ministerio de Obras Públicas e Infraestructuras,* 2010), which in part has facilitated mass urbanisation (averaging 2.8% a year from 2005 to 2010) instigating large population growth in centres such as Bata and Malabo (CIA, 2010). Despite the increased growth in economic terms Equatorial Guinea still ranks a lowly 118th in the Human Development Index (UNDP, 2009).

It is important to understand what the implications of such extreme economic development may be for the country's biodiversity. Currently, Equatorial Guinea has relatively high forest cover (56.9%, World Bank 2009) and, though small in size, harbours incredibly high biodiversity (Chapman et al., 1999, WRI, 2003) including over 536 vertebrate species, many of which, such as Western gorilla (*Gorilla gorilla*) and chimpanzee (*Pan troglodytes*), are classified as endangered (IUCN, 2010).

An extensive network of protected areas exists throughout the country covering 16.8% of its area (WRI, 2003). This includes the expansion of the country's largest protected area, Monte Alén National Park, in 2000, that encompasses over 2000 km^2 of the Monte Mitra forests (Sunderland, 2005). Though hunting, within these areas, and of protected species is prohibited under Law No. 8/1988 of 31 December 1998, in practice this law is not enforced, as hunting has been observed to occur intensively within national parks (Fa and García Yuste, 2001, Kümpel et al., 2010) and protected species, such as primates, are traded openly at urban markets (*pers. obs.*).

There is at present little active conservation in the continental region of Equatorial Guinea. In the past, ECOFAC *(Conservation et Utilisation Rationelle des Ecosystèmes Forestiers d'Afrique Centrale)*, an EU sponsored project, provided management of Monte Alén National Park though EU funding has recently ended and the project has subsequently been abandoned.

INDEFOR-AP (the National Institute of Forestry Development and Protected Areas), managed by the Ministry of Agriculture and Forests, contains specialists in zoology, botany, socio-economics and cartography and has legal jurisdiction over protected

areas and logging concessions, though lacks the influence in government to match its technical expertise (CARPE 2010). Fieldwork supported by INDEFOR-AP includes that of Fa and García Yuste (2001) which first described the extent and possible impacts of bushmeat extracted from the Monte Mitra forests, and traded at the nearby village of Sendje.

In recent years Equatorial Guinea's only home-based conservation NGO has also been formed. ANDEGE (*Amigos de Natureleza y Desarollo de Guinea Ecuatorial*) is comprised of 31 professionals from a variety of fields, including some of those working for INDEFOR-AP. The organisation has carried out several small-scale conservation projects (including bushmeat surveys and development of protected area management plans) and is providing assistance to on-going research projects within the continental region (*pers. obs.*). It has a close working relationship with its principal funder, Conservation International (CI).

Until recently, CI has been the only major international conservation NGO to have had a permanent presence on continental Equatorial Guinea and has operated from Bata, the region's capital, since 2002. CI administers USAID funds under the Central African Regional Programme for the Environment (CARPE) to conserve biodiversity within the Monte Alén-Mont de Cristal Inselbergs Forest Landscape spanning the border of Equatorial Guinea and Gabon. CI is about to carry out a nationwide survey of apes and elephants in conjunction with the Max Planck Institute and will be shortly pursuing human-wildlife conflict projects within the country (Heidi Ruffler, *pers. comm.*)

The Zoological Society of London (ZSL) has also recently put down roots within the continental region of the country. In conjunction with Imperial College London, ZSL has conducted considerable research on bushmeat in Equatorial Guinea since 2002, covering a range of topics including, incentives for sustainable hunting (Keylock, 2002, Kümpel, 2006), determinants of urban bushmeat demand (East et al., 2005), monitoring techniques (Rist et al., 2008) and rural dependence on forest products (Allebone-Webb, 2009). ZSL is in the first phase of a US Fish and Wildlife Service funded project to explore feasible alternatives to bushmeat in Equatorial Guinea (ZSL, 2009).

This study describes the offtake levels of hunters operating from the village of Sendje relative to Fa and García Yuste (2001) and Kümpel (2006). In both of these previous studies hunters used Sendje as an access to Monte Alén National Park. Hunters operated at similar distances from Sendje in both periods, typically rotating between established hunter camps (ex-human settlements and logging camps) located up to 35km from the village (Kümpel et al., 2010). Bushmeat harvest, and hunter effort, in terms of trap number, actually increased between these two study periods (Kümpel et al., 2010), with total harvest for 2003 estimated to be in excess of 10, 000 carcasses. Data is then compared exclusively to Kümpel (2006) in order to assess how hunter behaviour and links to the commodity chain have changed in response to an economy that has continued to grow unabated since the last completed bushmeat studies in the area between 2002 and 2004.

2.5 Study sites

Sendje (01º 32´ 001´´ N, 009º 49´ 485´´ E), is a rural community with a population of 317 who predominantly belong to the Fang tribe (Kümpel 2006). It is located 41 km from the region's capital Bata in the continental region of Equatorial Guinea (figure 0.1(b)) and 10km away from the boundary of Monte Alén National Park. Hunting has been identified as the main livelihood for males living in the village, and over 75% of the village's male population hunt (Kümpel et al. 2009) In the past, hunters operating from the village have supplied vast quantities of meat to a market in Bata (Kümpel, 2006, Fa and García Yuste, 2001). Since the most recent study, the road linking Sendje to Bata has been upgraded (*Ministerio de Obras Públicas e Infraestructuras,* 2010) and it is now possible to travel between Sendje and Bata by bush-taxi in half an hour (*pers. obs.*), rather than the 45-60 minutes as was the case in 2003 (Kümpel, 2006).

Bata (1° 51′ 0″ N, 9° 45′ 0″ E), has developed rapidly since offshore oil deposits were discovered, and the population has grown considerably since 2003 (World Bank, 2009). The city is also now well connected by a series of newly developed road networks to far-reaching areas of the country and beyond into neighbouring Cameroon and Gabon (Ministerio de Información, Cultura y Turismo 2010).

Previous studies have collected data on bushmeat offtake from Bata's Central market (East et al., 2005, Kümpel, 2006, Allebone-Webb et al., (in press)). However the market has recently been relocated to a site on the southern edge of the city on the road to Sendje and has been renamed Kilometro Cinco. All market offtake data was collected from Kilometro Cinco though supplementary information was also collected from Bata's other bushmeat-selling market, Mundoasi.

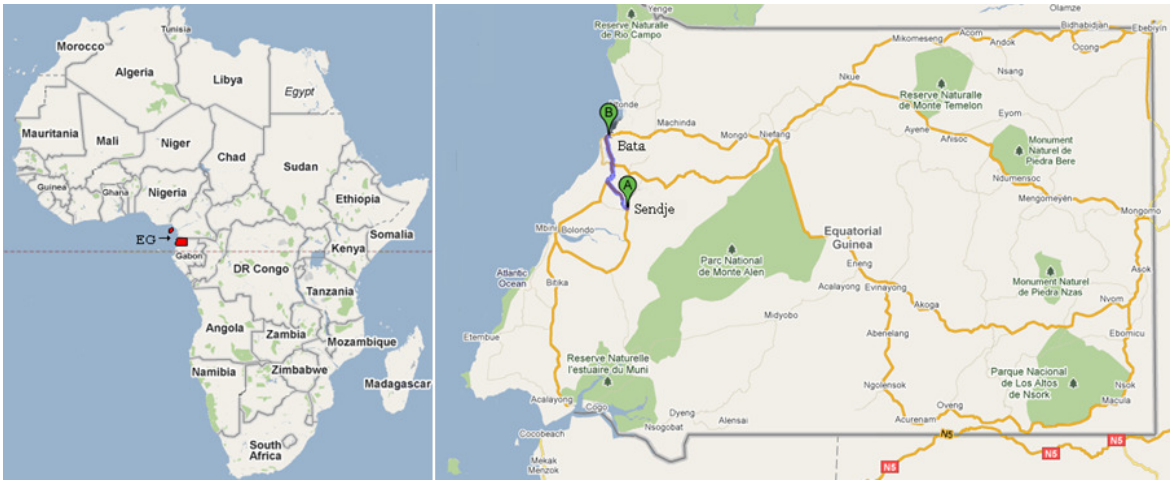

Figure 0.1 (a) Map of Africa with Equatorial Guinea highlighted in red; (b) Map of Equatorial Guinea showing the trade route between the Sendje and Bata. Source: Google Maps.

3. Methods

Methods included focus groups and semi-structured interviews (for hunters and households in Sendje and for market traders based in Bata) and bushmeat offtake surveys (captures by Sendje hunters and carcasses arriving at a Kilometro Cinco market in Bata). Prices of alternative protein sources were also collected from various points of sale in Sendje and Bata. Here follows a description of the preparations made and processes undertaken.

3.1 Preparation: Method formation and the training of research assistants

Methods were adapted from those used by Kümpel (2006) to fit the time constraints and specific research goals of the project in question. Interviews were piloted with three Spanish-speaking associates of the author, with the author's research assistants and finally trialled with various inhabitants of Sendje. Issues relating to language and the clarity and relevance of certain questions – particularly in relation to income levels - were acted upon to produce final drafts of household and hunter interviews. Data sheets for offtake surveys were nearly identical to those used by Kümpel (2006), though slight formatting changes were made based upon discussions with research assistants.

The two local research assistants hired had both been employed in previous research projects in Equatorial Guinea, including that of Kümpel (2006), and so were familiar with the methods in question and with the study sites. Nevertheless training was delivered prior to and during the data collection periods to ensure that research goals were well understood, species identification was accurate and that interviewees were never led in their responses throughout questionnaires.

One female assistant was responsible for collecting data on all bushmeat carcasses arriving in the Kilometro Cinco market and for assisting with trader questionnaires. Three training days were completed between 30th April and 3rd May 2010 within two bushmeat markets where time was devoted to practicing data collection techniques and to drawing a schematic map of the study market. After this period the assistant continued data collection independently, with regular checks on data collection made by the author every ten days for the remainder of the study.

The second assistant, a male resident of Sendje, was responsible for assisting with, and arranging, all interviews completed in the village as well as assisting in the village offtake survey. The author and assistant spent two days (4th-5th May) practising techniques used for interviews and surveys before the data collection period was initiated.

3.2 Data collection

All data collection for the study took place between 5th May 2010 and 26th June 2010

3.2.1 Focus groups

A focus group was conducted in Sendje on 5th May with a group of villagers including the village president, village elders, hunters and the author's research assistant. The main purpose of the group was to allow key members of the village to discuss how recent socio-economic changes had impacted on the livelihoods of those living in Sendje and how current hunting activity had changed in recent years. Notes were taken by the author in order to revise questionnaires and also to provide some qualitative information for the study findings. The members of the group were also asked to amend a schematic village map, originally developed by Kümpel (2006), to show where new houses and bars had been built and others abandoned since the previous study and thus enable a revision of the list of households living in the village.

A second group was completed later on in the study period on 2nd June with three village hunters, the author's research assistant and a former research assistant who had considerable experience working with hunters within the 2003-2004 period. The purpose of this group was to identify the current livelihood activities and locations of all hunters previously active in Sendje, who had since left the village.

A bottle of rum was shared with the participants of each group after the completion of each session to express gratitude and to engender continued support for the study amongst key community members.

3.2.2 Household interviews

One-off semi-structured interviews, aimed at characterising the socio-economic status of the village, were completed with 52 of the 59 (88.1%) inhabited households in Sendje. Average interview duration was 23 minutes (range 9-64 minutes) though this time varied considerably depending on the number of household members. Where possible, interviews were completed in Spanish by the author, though specific points were often clarified by the research assistant in Fang and on occasion, when respondents spoke little Spanish, entire interviews were completed in Fang by the assistant and answers translated to the author throughout the interview.

Interviews were completed at times where the majority of household members were likely to be at home, normally early in the morning, late in the afternoon or at weekends. In all cases the household head was present for the interview though all individuals present were encouraged to respond and provide information to each of the four following interview components:

- In section one a census of all household members currently living in or sharing resources with the household was completed. Information was recorded on the age, sex, relation to household head, tribe, level of education and type of work for each member.
- In section two, for each respondent aged sixteen or above, the three livelihood activities carried out in order of greatest frequency were stated from a list of twenty options.
- In section three, respondents were asked to state the frequency with which the household as a whole consumed each of 25 different protein-based foods. The consumption level of each food was placed within one of the following categories: ‘every day or almost every day’, ‘every week’, ‘every month’, ‘rarely’, or ‘never’. Mean scores for different categories of protein type were calculated using the following values (every day = 5, every week = 4, every month =3, rarely = 2, never = 1)
- The final section involved questioning each individual household member on which of their livelihood activities they received an income for, and for each of these activities, how much money they had earned in the previous month.

Respondents were provided with income code sheets in which they could silently indicate what the appropriate income bracket was for a given activity, e.g. 10, 000-20, 000 CFA (1US $ = CFA 443.67). Finally, household heads were asked to declare any additional contributions received from relatives living away from the village or from the rent of property.

Income comparisons between studies take into account the effects of inflation. Inflation, measured in terms of changes in consumer price for the period between 2002 and 2009, is at 39% (World Bank, 2009).

3.2.3 Hunter interviews

One-off hunter interviews, with an average duration of 24 minutes (range 11-39 minutes), were completed with 33 of the 36 (91.7%) resident Sendje hunters. Hunters were selected for interview opportunistically depending on availability. Each hunter was asked a series of questions referring to past and current livelihood activities, motivations to hunt, preferred and commonly selected gear types, preferred hunted species, the state of the forest, hunt location and trap number presently and retrospectively for the period they could reliably remember, and opinions on the existence of hunting restrictions in the area. The majority of questions were open-ended and so care was taken not to lead the questioning. However hunters were provided with options for a question regarding why hunters chose to hunt, as Kümpel (2006) had found that hunters failed to give responses other than 'I hunt because I hunt' when the question was left open-ended.

3.2.4 Trader interviews

Initial negotiations with chief bushmeat traders at the two bushmeat markets in Bata revealed that there were at the time of study 30 and 37 traders operating at Kilometro Cinco and Mondoasi markets respectively. Though efforts were made to carry out short interviews with all traders, the reluctance of some traders to respond to questions of a personal nature limited the number of completed questionnaires to 15 and 14 traders at Kilometro Cinco and Mondoasi market respectively. Each questionnaire on average lasted 6 minutes (range 3-10 minutes). Traders were

questioned on where they sourced bushmeat from in the past and present, specifically if they had bought meat from Sendje, about motivations for moving between villages to source bushmeat and about the level of supply of, and demand for bushmeat within the market. All questions were open-ended to avoid leading responses.

3.2.5 Offtake surveys – in Sendje and in an urban bushmeat market

A record of species offtake captured by hunters in and around the forests of Sendje was recorded over a period of 47 days. Previous studies (Fa and García Yuste, 2001, Kümpel, 2006) had measured offtake by recording all commercial trade at a fixed point within the village. However it was found through focus group discussions that the nature of the trade had completely changed: only one bushmeat trader continued to visit Sendje and some hunters avoided trading with her, often giving preference to selling carcasses to passing cars on the main road or directly to market. As no set location existed to observe bushmeat trade within Sendje, efforts were made to visit hunters soon after they returned from the forest to observe prey caught and to undertake short interviews. Information was collected on the species, sex, age, state, method of capture, location of capture, and first point of sale for each carcass. As it was impossible to judge exactly when each hunter would return from the forest, occasionally it was necessary to question hunters about their capture after it had already been sold or eaten. On occasions where hunters refused to respond, records of hunter activity were used to estimate quantities of offtake missed from the survey for each hunter (see results section 4.1.1).

Data for each carcass sold in Kilometro Cinco market, regarding its origin, method of capture, cost price, sale price and state, were collected over a 52 day period by the Bata based research assistant working six days every week for seven hours each day – by which time the vast majority of bushmeat carcasses had been sold. Data collection was usually carried out between Monday and Saturday where trade levels were highest, though collection was carried out on two Sundays to estimate levels of trade not observed on these days.

Kingdon (2004) was used to assist species identification for both village and market surveys.

3.2.6 Price of alternative protein sources

Prices of various alternative protein goods were collected from Sendje and Bata on one occasion for each location surveyed. In Sendje prices of frozen products provided in two shops were collected. In Bata prices of frozen protein products were collected from two supermarkets and from Kilometro Cinco market. All price comparisons made between studies in sections 3.2.5 and 3.26 take inflation into account as measured in section 3.33.

3.3 Statistical Analysis

All analyses and graphics were performed and produced using R statistical package version 2.9.0. Data were plotted to test for normality, and where appropriate, log-transformed to permit the following statistical tests:

Linear models were applied to data with continuous response variables. Some linear models included interactions between explanatory variables. Though in all cases interactions were removed subject to model simplification where a likelihood ratio test was used to test if variables could be removed without significant loss in explanatory power. One-sampled t-tests and ANOVAs were used to analyse variance of means between datasets. Paired t-tests were used to test variance between means of variables for individual hunters active in both study periods.

Where data could not be normalised, non-parametric tests were applied. Wilcoxon rank-sum tests and Kruskal-Wallis tests were used to test for variations in median values between various explanatory variables. Differences between median values for hunters active in both study periods were investigated using Wilcoxon–signed rank tests.

Chi-squared contingency tables, and where appropriate Fisher's exact test, were used to test for equality of proportions.

Significance was accepted where $p \leq 0.05$.

4. Results

The following five sections, in order, address five key research questions. Section 1 describes how the level and species composition of hunter offtake in Sendje has changed in relation to data collected from a corresponding period in 2003 (where some comparisons to an earlier study in 1998 are also made). In section 2, offtake data and hunter interviews are analysed to investigate whether a relationship exists between offtake and hunting strategy. Section 3 uses data from hunter and household interviews to investigate how hunter profile may drive hunting strategies. Section 4 looks at changes in the links between hunters and the commodity chain. Finally, in section 5, data from an urban market are analysed to act as an indication of broad-scale socio-economic processes linked to the bushmeat trade.

4.1 Changes in hunter offtake, effort and composition of species profile

4.1.1 Has there been a change in the number and biomass of prey captured in Sendje?

Between 8th May and 25th June 2010 a total of 302 carcasses from 35 species were recorded as captured by hunters active in the forests surrounding Sendje. This represented a total extracted biomass of 1190.6 kg. As records for some hunters in the study were incomplete, estimations for number and weight of species missed in the data collection period were calculated based on the proportion of days spent hunting and the rate of capture for each hunter as follows:

Estimated offtake not recorded = Days of unknown activity x Proportion of study days hunting x Capture rate

Based on these calculations total offtake extracted within the study period is estimated at 351 carcasses weighing in total 1360.9 kg. 2010 overall biomass decreased compared to corresponding time periods (8th May – 25th June) in 1998 and 2003 (table 1.1) and there was significant variation in log mean weight per carcasses between the three studies (F value = 68.124, df = 2, $p < 0.001$). However, though log mean carcass weight had significantly decreased since 1998 (Tukey HSD: $p < 0.001$) no difference was observed since 2003 (Tukey HSD: p = NS).

Table 1.1 Total carcass number, total biomass and mean biomass per carcass (kg) collected from three corresponding offtake surveys undertaken between 8th May and 25th June in 1998, 2003 and 2010. * 2010 figures include an estimate of offtake not measured

Study Period	Carcass number	Biomass (kg)	Mean biomass per carcass (kg)
May – June 1998	267	1774.9	6.60
May – June 2003	1046	4172.0	3.99
May - June 2010	351*	1360.9*	3.88

Between 2003 and 2010, each individual hunter also caught less, as geometric mean carcass number dropped from 15.4 to 5.9 ($t = -3.975$, $p < 0.001$), and geometric mean biomass caught dropped from 41.72 kg to 19.0kg ($t = -2.647$, $p = 0.011$)

4.1.2 Have proportions of species sensitive to hunting decreased in offtake?

Despite a trend of decreasing offtake (see Table 1.1), the diversity of species recorded in the village offtake survey increased between each study period from 23 species in 1998, to 28 species in 2003 and finally to 34 species in 2010. Species recorded in the 2010 study period not recorded in hunter offtake throughout the entire 2003 study included black-casqued hornbill (*Ceratogymna atrata*) (n=17) and palm-nut vulture (*Gypohierax angolensis)* (n=3), though see appendix 1.2 for a full list of offtake species and scientific names.

A significant difference was observed among proportions of the seven main taxonomic groups recorded between the three study periods with ungulates decreasing in proportion (largely due to a drop in number of blue duiker (*Philantomba monticola*) – see figure 1.3) and birds and primates increasing in proportion within the 2010 offtake (figure 1.1).

Offtake composition of gun-hunted animals also changed significantly between 2003 and 2010 with a notable increase in the proportion of gun-hunted bird carcasses appearing in the offtake survey (figure 1.2)

There was no significant relationship observed between species r_{max} (the maximum rate of population increase) and proportion change in mammal abundance from the offtake survey. Species that dropped notably both in number and proportion include blue duiker, brush-tailed porcupine (*Atherurus africanus*) and black colobus (*Colobus satanus*), whilst northern talapoin (*Miopithecus onguensis*), increased in number and proportion (figure 1.4).

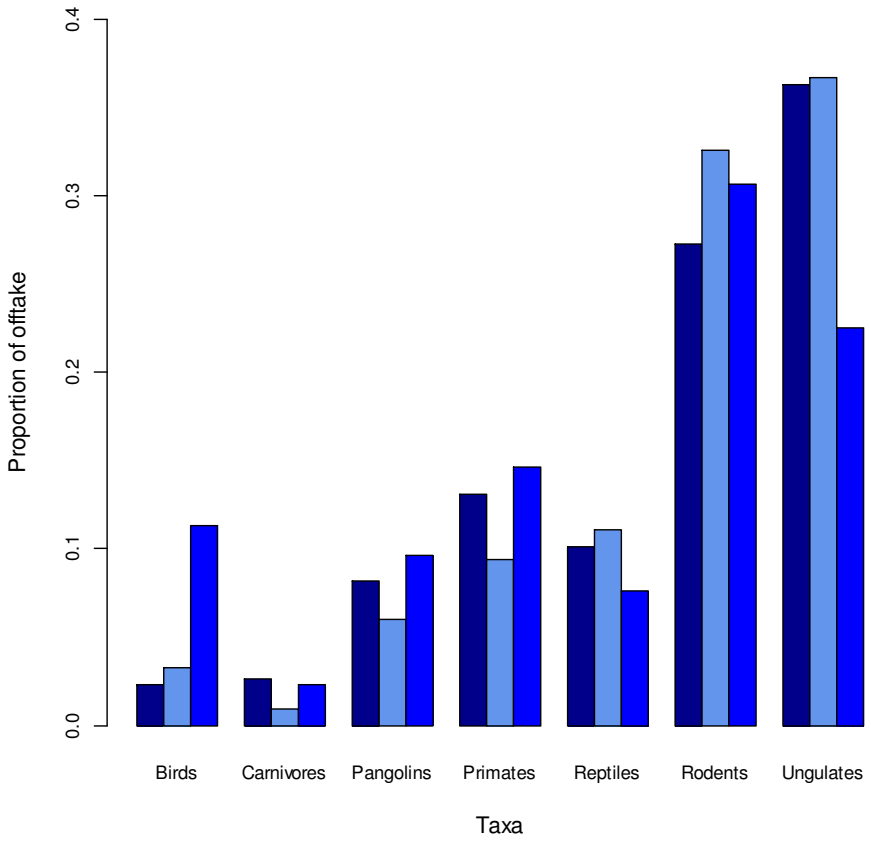

Figure 1.1 The proportion of total offtake for seven taxonomic groups from three distinct, but corresponding, study periods in 1998 (n=267), 2003 (n=1046) and 2010 (n=302). Counts for each taxonomic group varied significantly between studies (X^2 = 73.8094, df = 12, $p < 0.001$)

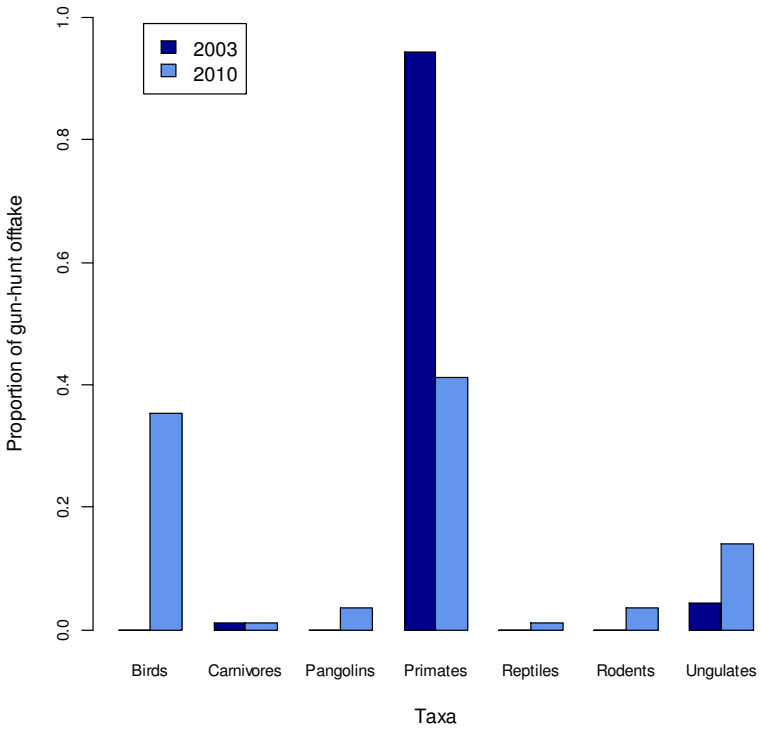

Figure 1.2 Proportion of total gun-hunter offtake for seven taxa from two distinct, but corresponding, study periods in 2003 (n=91) and 2010 (n=86). Counts for each taxon varied significantly between studies (Fisher's Test, $p < 0.001$)

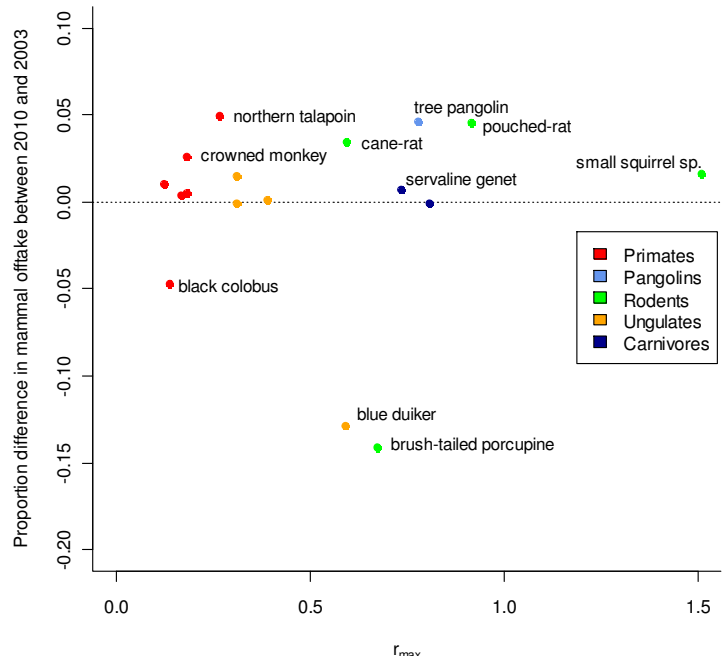

Figure 1.3 Differences in proportion of Sendje offtake between 2003 and 2010 for commonly recorded mammal species (at least five records between surveys) had no significant relationship with r_{max}. Species below the black line have decreased in proportion and number since 2003. See appendix 1.2 for latin names.

4.1.3 Has the level of effort expended by hunters changed?

The number of hunters active throughout corresponding study periods decreased from 64 in 2003 to 41 in 2010 (this latter figure includes five one-off visitors). Offtake records exist for 16 hunters using hunter camps in 1998, though as no records exist for village-level trapping, average and total trap numbers for 1998 are not taken as representative of the entire hunting community. The total number traps set from Sendje, in corresponding time periods, decreased from 5252 in 2003 to 1818 in 2010. Though median trap number per hunter decreased from 89 (n=63, range 2 – 211) in 2003 to 61 (n=26, range 15 - 184) in 2010, this difference was not significant (W =583, p = NS).

The duration of each hunter trip was used as an indicator of economic effort expended by hunters, with values of hunting trips of less than one day calculated by dividing the number of hours by eight. The median duration of forest trip decreased significantly from 2.96 days (n=64, range: 0.44-8.22 days) in 2003 to 0.89 days (n=26, range: 0.13-4.13 days) in 2010 (W = 930, p <0.001). This trend was found to be consistent when data were re-analysed exclusively for hunters active within both time periods as median hunt time decreased significantly from 2.12 days (n=14, range: 0.63 – 4.54 days) in 2003 to 1.13 days (n=14, range: 0.38 – 4.43 days) in 2010 (V=6, p = 0.018).

Finally no difference was observed in the trip duration of gun-hunters between 2003 (n=13) and 2010 (n=8) measured as log number of days per hunt, (t = 1.495, df = 11.881, p = NS).

4.1.4 Has the catch per unit effort of hunters changed?

Catch per unit effort (CPUE) significantly decreased between the two study periods when measured as the number of carcasses caught per trap, and for total biomass caught per trap. However, when data were analysed exclusively for hunters active within both study periods no significant change in CPUE was observed in the number of carcasses or biomass caught (Table 1.2). Changes in CPUE in economic terms (volume of prey caught divided by number of days in forest) were not compared between studies as 2003 data were absent for the duration of unsuccessful trips.

Table 1.2 Differences in CPUE (measured in number of carcasses per trap and biomass collected per trap) between study periods in 2003 and 2010 for all hunters and exclusively for hunters active in both periods

	(a) All trappers		(b) Trappers active 2003 and 2010 (n=28)	
	2003 (n=63)	2010 (n=26)	2003 (n=14)	2010 (n=14)
CPUE (carcasses - mean)	0.3203	0.148	0.295	0.158
	(t = 3.008, df = 54.761, p = 0.004)		(t = 1.284, df = 7, p= NS)	
CPUE (biomass - median)	0.570	0.290	0.559	0.379
	(W = 715, p = 0.005)		(V = 29, p = NS)	

4.2 Hunting strategy as a driver of change in offtake profile and hunter effort

4.2.1 Has location of hunt changed and does hunt location influence i) offtake volume, ii level of effort), iii) CPUE and iv) prey profile?

The median distance of trap groups from Sendje decreased significantly from 9.5km (n = 61, range: 1.0 – 29.5km) in 2003 to 3km (n = 26, range: 0.5 – 21.0 km) in 2010 for all hunters present in either study (figure 2.1), though no significant shift in distance was recorded for hunters active within both study periods (V=18, p = NS). The observed reduction in trap distance can be explained partly by the significantly fewer number of hunters using hunter camps in 2010 compared to 2003, whilst the number of hunters trapping closer to Sendje has remained relatively stable. No significant shift away from hunter camps has been observed for 2010 hunters also active in 2003 however (table 2.1).

The relationship between the distance of traps from Sendje and a number of dependent variables derived from both study periods was explored using the following model: (y ~ distance). Models included the effects of year (y ~ distance + year) and the interactions between year and distance (y ~ distance * year). As none of the variables varied significantly as a function of year, and as no interaction between year and distance was observed, it was deemed acceptable to retain distance as the sole explanatory variable (table 2.2).

Log distance was subsequently found to have a significant relationship with log biomass, log trap number, log CPUE (biomass) and log CPUE (carcasses) (figure 2.2))

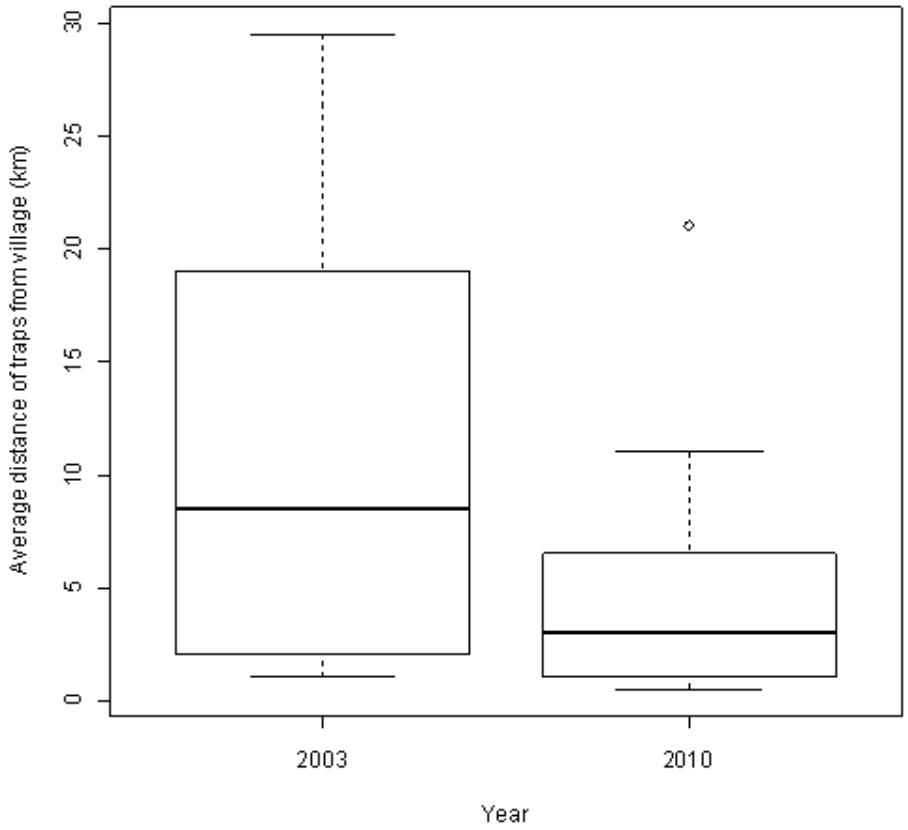

Figure 2.1 Box and whisker plot of trap group distance from Sendje for study periods in 2003 and 2010. Lowest and highest boundaries of the box designate the 25th and 75th percentiles, respectively; the whiskers above and below the box specify the 95th and 5th percentiles, respectively; the solid line within the box indicates median values, dots above or below the box represent outliers. **(W = 474.5, p= 0.003)**

Table 2.1 Number of hunters trapping from hunter camps, in forests surrounding Sendje and in fields were significantly different between 2003 and 2010 (X^2= 14.5233, $p < 0.001$). Data is also presented for hunters active during both study periods (Fisher's exact test, p = NS)

	All hunters		Hunters active 2003 and 2010	
Year	2003 (n=64)	2010 (n=26)	2003 (n=14)	2010 (n=14)
Trap in fields	16	9	4	4
Trap in forests near Sendje	17	15	5	8
Trap from hunter camps	31	2	5	2

Table 2.2 The inclusion of 'year' and 'interaction between distance and year' as explanatory variables had no significant effect on models fitting the following variables as function of distance

Dependent variable	As a function of year	Interaction between distance and year
Log biomass	p = 0.346, F = 0.903	p = 0.381, F = 0.779
Log trap number	p = 0.316, F = 1.020	p = 0.474, F = 0.518
Log CPUE (biomass)	p = 0.978, F = <0.001	p = 0.831, F = 0.046
Log CPUE (carcasses)	p = 0.123, F = 2.451	p = 0.134, F = 2.307

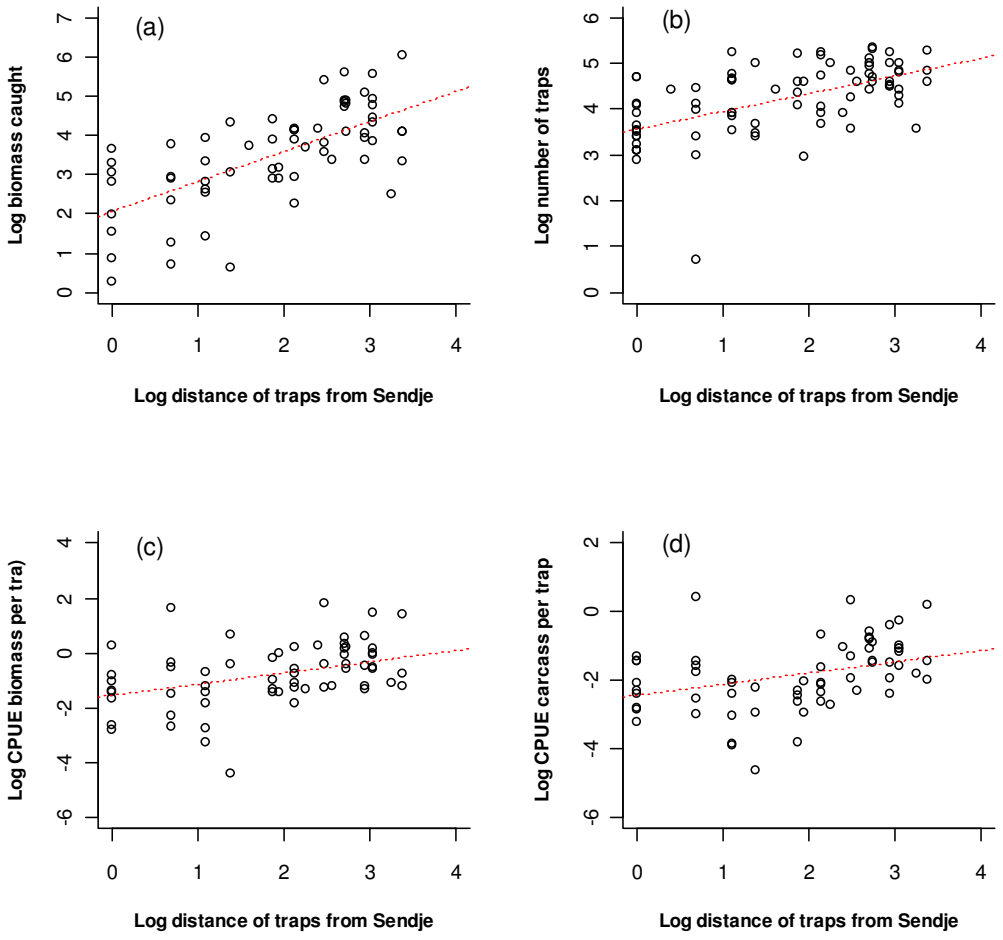

Figure 2.2 The relationship between log distance of traps from village and (a) total log biomass caught per hunter (t=7.664, $p < 0.001$, Adj. $R^2 = 0.470$); (b) log number of traps per hunter (t=6.288, $p < 0.001$, Adj. $R^2 = 0.3224$ (c) log CPUE per hunter (biomass per trap) (t=3.583, $p < 0.001$, Adj. $R^2 = 0.1582$ and (d) log CPUE per hunter (carcasses per trap) (t= 3.205, p = 0.002, Adj. $R^2 = 0.1265$)

CPUE in economic terms (taken as the volume of prey caught divided by the number of days spent in the forest) was analysed for hunters active in 2010 only (no data available for 2003). No significant relationship with distance was observed (t = 0.414, Adj. R^2 = - 0.034, p = NS)

Finally the relationship between mean distance of capture for several commonly caught species (recorded at least five times in either study), and the proportional change in offtake number for each of these species between 2003 and 2010 study was fitted to the following model: proportion change in offtake ~ mean distance of capture. A significant negative relationship exists between these two variables (figure 2.3)

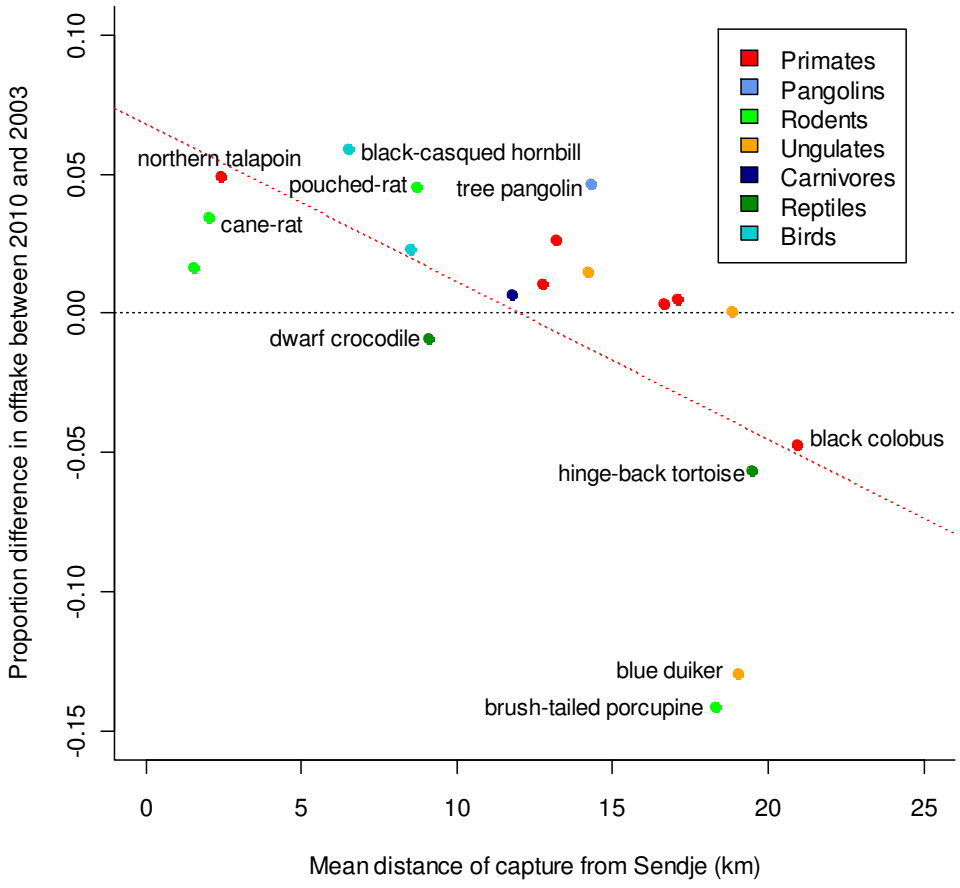

Figure 2.3 Proportion change in hunter offtake between 2003 and 2010 study periods in relation to mean distance of capture for each individual species (t = -3.370, Adj. R^2 = 0.365, p = 0.003), where all species below the black line have decreased in proportion since 2003. See appendix 1.1 for latin names.

4.2.2 Has selection of gear type changed and does gear selection influence prey profile and CPUE?

Significant variation in gear type composition was observed between 2003 and 2010, as gun-hunters, though not changing in number, represented a higher overall proportion of the hunter population in Sendje (table 2.3). Significant variation in the method of capture of carcasses recorded in offtake surveys between 2003 and 2010 was also observed, where numbers of species caught by shotgun or neck-trap increased in proportion in the latter study (table 2.4)

Trap specificity between the two major trap types (leg traps and neck traps) was observed amongst commonly trapped species (caught by either trap type at least five times), with some species such as blue duiker and bay duiker being exclusively caught by leg traps, with others such as giant pouched rat or cane-rat being caught predominantly by neck traps. (Fisher's exact test, $p < 0.001$)

Table 2.3 Differences in counts of hunters who trapped, trapped and gun-hunted or exclusively gun-hunted between 2003 (n=64) and 2010 (n=41) (Fisher's exact test, p = 0.009).

	Trappers	Proportion	Traps and Gun	Proportion	Gun-hunters	Proportion
2003	50	0.781	13	0.203	1	0.016
2010	26	0.634	7	0.171	8	0.195

Table 2.4 Method of capture for all species recorded in offtake surveys in 2003 (n= 1046) and 2010 (n=302). Counts for each method significantly varied between studies ($X^2 = 228.3359$, df = 3, $p < 0.001$).

	Hand	Lasso	Leg-trap	Neck-trap	Shotgun
2003 (count)	37	19	867	32	91
2010 (count)	9	3	138	66	86
2003 (proportion)	0.035	0.018	0.829	0.031	0.087
2010 (proportion)	0.030	0.010	0.457	0.219	0.284

Finally, no significant difference in CPUE was observed between the two main trap types either for the number carcasses caught per trap (t = -1.047, df = 32.999, p = NS), or as biomass caught per traps (W= 263, p = NS).

4.3 Hunter profile as a driver of change in hunter strategy and effort

4.3.1 Has there been a change in the proportion of village inhabitants who hunt as a principal livelihood, and does effort and hunting strategy differ between these two hunter groups?

A village census undertaken using household interviews (n=52) revealed that male population had slightly increased from 93 in 2003 to 97 in 2010. In 2010, 32 adult males (33.0%) living in the village actively hunted, representing a significant decrease in the number of hunters since 2003 where 70 (75.3%) Sendje adult males engaged in hunting ($X_2 = 33.1336$, df = 1, p = <0.001). The drop in number is in part explained by an exodus of 2003 hunters to other areas of the country (n=29) after securing fixed employment (n=18). Hunting as a principal livelihood has decreased significantly relative to other livelihood activities in the village (Figure 3.1)

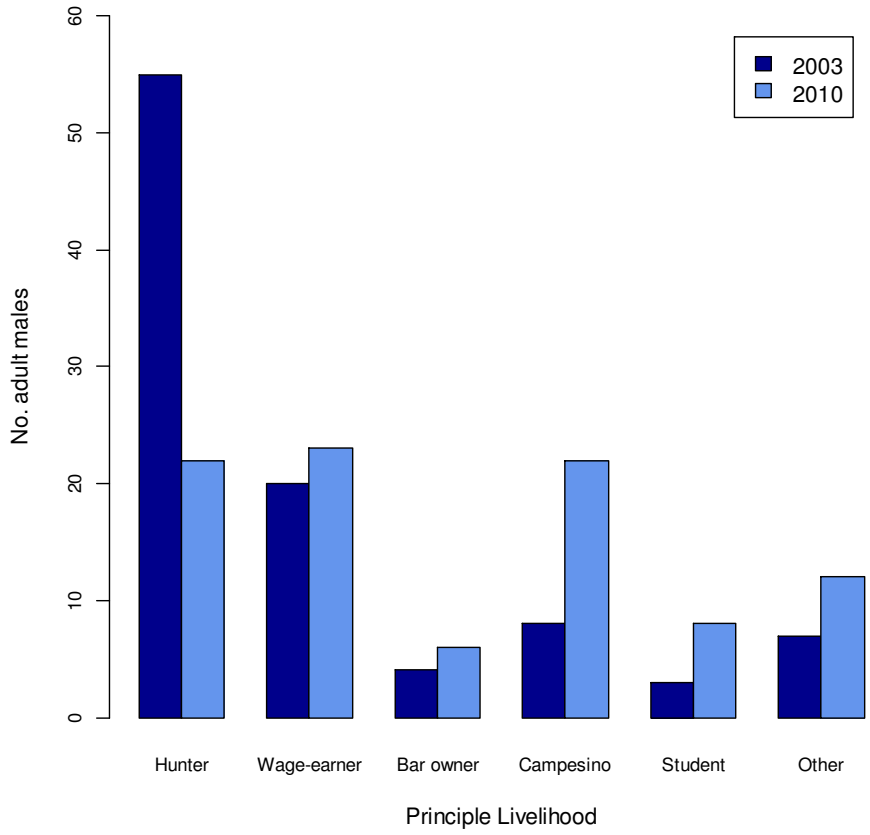

Figure 3.1 Principal livelihood activities for all males above the age of 16 living in Sendje in 2003 (n=93) and in 2010 (n=98). Livelihood activities varied significantly between years ($X^2 = 24.801$, df = 5, p < 0.001).

Whether a hunter hunted for a principal (PL) or additional livelihood (AL) was shown to have an important effect on hunter effort and hunting strategy employed.
Indeed, hunters that hunted as a principal livelihood laid a significantly higher number of traps (PL median = 61.5, AL median = 31.5) (figure 3.2 (a)), trapped significantly further away from the village (PL median = 4km, AL median = 1km) (figure 3.2 (b)) and spent more days hunting in the forest over the study period (PL mean = 15.1 days, AL mean = 6.4 days) (figure 3.2 (c)). However, whether a hunter hunted as a principal livelihood or not had no significant effect on gear selection (Fisher's exact test, p = NS).

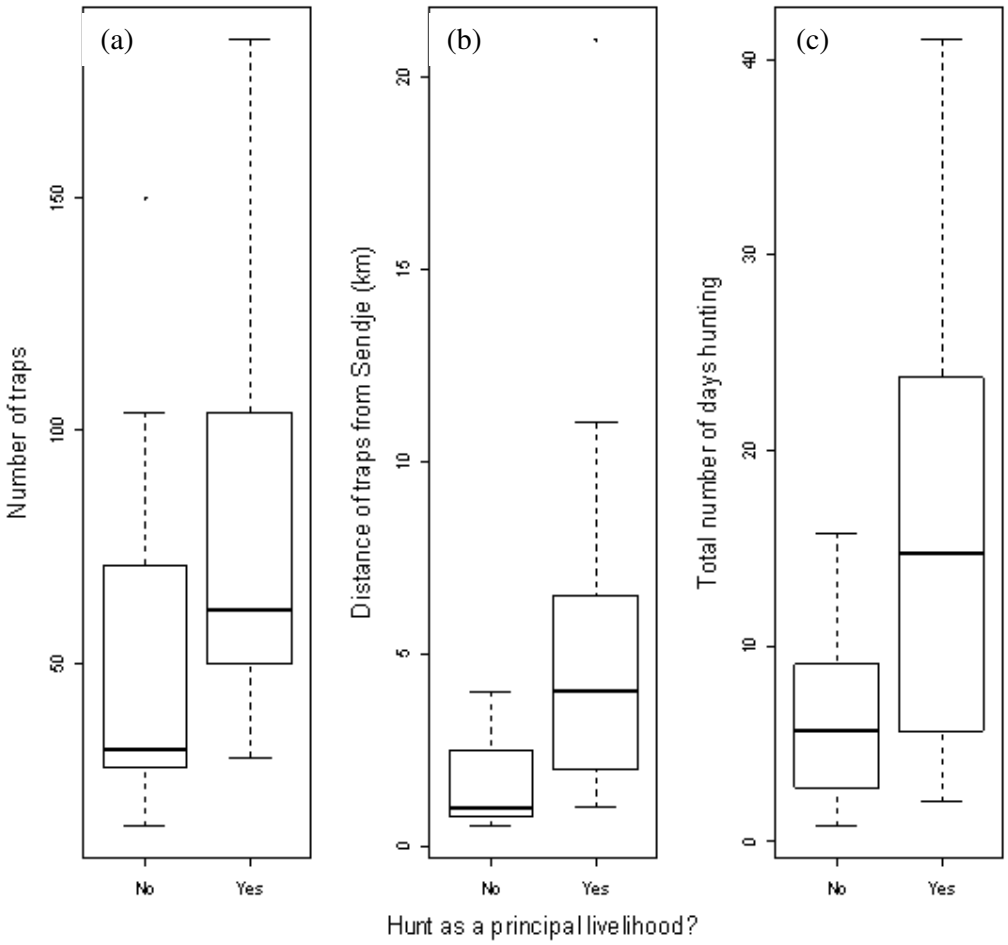

Figure 3.2 Box and whisker plots for different degrees of hunter effort between trappers who hunt as a principal (n=16) or additional livelihood (n=8). Significant differences were observed between these two hunter profiles for **(a)** the total number of traps per hunter (W=120, p = 0.045), **(b)** distance of trap groups per hunter (W=120, p = 0.007) and **(c)** total number of days hunting within the study period (t = -2.355, df = 11.608, p = 0.037).
Lowest and highest boundaries of the box designate the 25th and 75th percentiles, respectively; the whiskers above and below the box specify the 95th and 5th percentiles, respectively; the solid line within the box indicates median values, dots above or below the box represent outliers.

4.3.2 Does access to a regular income influence hunting strategy?

Hunter income in Sendje was highly variable though, in real terms, mean and median income decreased between study periods. Mean income from fixed employment increased between the study periods, though median income value decreased suggesting increased inequality amongst wage-earners (table 3.1).

Table 3.1 Monthly income levels for hunters and wage earners in Sendje. Data for 2003 is derived through recall surveys (Kümpel, 2006), and data for 2010 are taken from one-off household interviews and then adjusted for inflation. (1US $ = CFA 443.67).

	Study	Mean monthly income (CFA)	Median monthly income (CFA)	n	Range (CFA)
Hunting	2003	43, 043	36, 650	83	0 – 195,678
	2010	40, 432	27,536	26	0 - 181,159
Wage-earners	2003	88,394	88,333	30	20,000 – 160,000
	2010	115,519	54,347	13	13,043 - 525,946

As the number of wage-earners had also increased slightly (see figure 3.1) it was of interest to see if hunters had increased access to other income sources; and for those that did, whether hunting strategies were modified as a result.

There was no significant difference in trap group distance ($W = 81$, $p = NS$) nor the trap number ($W = 53$, $p = NS$) between hunters whose household had access to regular income (through fixed employment or bar or shop ownership) and those without. However, hunters whose household had access to a regular income source were more likely to gun-hunt (53.8%, $n = 13$) than those without such access (20.8%, $n = 24$) (Fisher's exact test, $p = 0.040$).

4.3.3 Has average age of hunter changed since 2003 and does age influence hunting strategy?

Mean hunter age increased slightly but not significantly between studies from 44.9 ($n=72$) to 48.2 years ($n=34$) ($t = -0.891$, $df = 68.063$, $p = NS$). Age had no explanatory power for distance of traps laid from Sendje, (Adj. $R^2 = -0.040$, $p = NS$) nor for the number of traps laid per hunter (Adj. $R^2 = -0.037$, $p = NS$). Furthermore

no significant difference in age was observed between three categories of gear use 'trap-hunt', 'trap and gun-hunt' or 'gun-hunt' (F value = 0.962, df = 2, p = NS).

4.3.4 What reasons do hunters provide for changed hunting strategy?

Responses from hunter interviews also indicated a changed hunter strategy with 21/34 hunters moving site in the last two years, and 14 of these now hunting closer to the village. Of these 21 hunters, 13 stated that disturbance from elephants was the principal reason for moving location (typically closer to, and to the west side of the village, away from the national park (n=8)). Other reasons stated for hunting closer to Sendje include being either too old or tired to hunt seriously (n=4), to be close to job opportunities (n=1) and to protect crops (n=1). Interestingly, all seven hunters who stated they hunted further away from Sendje said they did so because animals were depleted close to the village. This result is supported by responses given by all hunters in which 26/34 (76.5%) stated that there were fewer animals in the forest today than in the past.

Responses to the question 'Why do you hunt' in the hunter interviews also revealed that strongest incentives to hunt were: because there were no other forms of employment (30/34, 88.2%), to provide food for family (18/34, 52.9%) or to protect crops (17/34, 50%). No respondent hunted because they enjoyed it and 31/34 (91.1%) hunters stated that they did not wish their sons to follow in them in their footsteps.

4.4 The relationship between hunters and the wider commodity chain

4.4.1 Has the number of bushmeat carcasses sold and consumed in Sendje changed since 2003 and does this relate to hunter profile?

Bushmeat consumption within Sendje remained relatively stable between study periods, dropping only slightly from 119 to 113 carcasses consumed (figure 4.1(a)). Consumption scores (see section 3.2.2 for calculation) were given by respondents in the 2010 study. Mean consumption score for commonly available bushmeat was 2.0, and was significantly lower than those provided for fresh fish: 2.4 ($t = -2.403$, $df = 85.595$, $p = 0.039$), frozen products: 4.1 ($t = -16.088$, $df = 99.942$, $p < 0.001$) or dried products: 4.5 ($t = -16.237$, $df = 97.671$, $p < 0.001$). Bushmeat consumption also varied significantly amongst households with bushmeat consumption rates higher

amongst households containing a hunter (t = 3.578, df = 49.257, p<0.001) and for households with access to other incomes sources (t = 2.070, df = 41.517, p = 0.045). Counts for carcasses sold and consumed in Sendje significantly varied between studies with number of carcasses sold dropping from 927 carcasses in 2003 to 162 in 2010 (figure 4.1). 2010 hunters who hunted for a principal livelihood were also more likely to sell species caught (69.3% of carcasses) than those who hunted for an additional livelihood (19.6% of carcasses) (figure 4.1(b)).

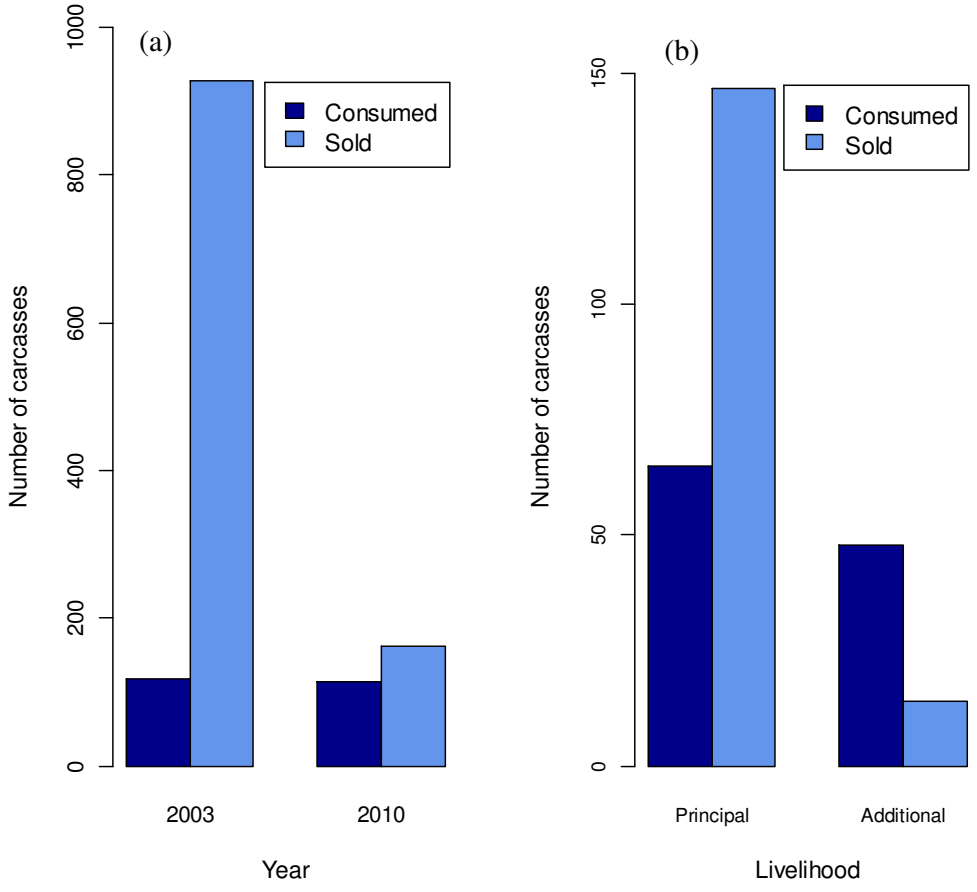

Figure 4.1 Barplots for number of carcasses sold or consumed by the hunter/household in Sendje. A significant difference in proportions was observed between (a) corresponding study periods in 2003 (n=1046) and 2010 (n=275) (X_2 = 130.750, df = 1, p-value < 0.001) and between (b) hunters active in 2010 who hunt for a principal (n = 16) or additional livelihood (n= 8) (X_2 = 41.376, df = 1, p-value < 0.001).

4.4.2 Has the first point-of-sale significantly changed for Sendje hunters?

The first point of sale for bushmeat carcasses captured by Sendje hunters varied significantly between the two study periods, with market traders buying a smaller proportion of the carcasses and sales direct to market, within the village or on the roadside all increasing. The emergence of a roadside bushmeat trade in Sendje now accounts for 25.7% of the village trade (figure 4.3)

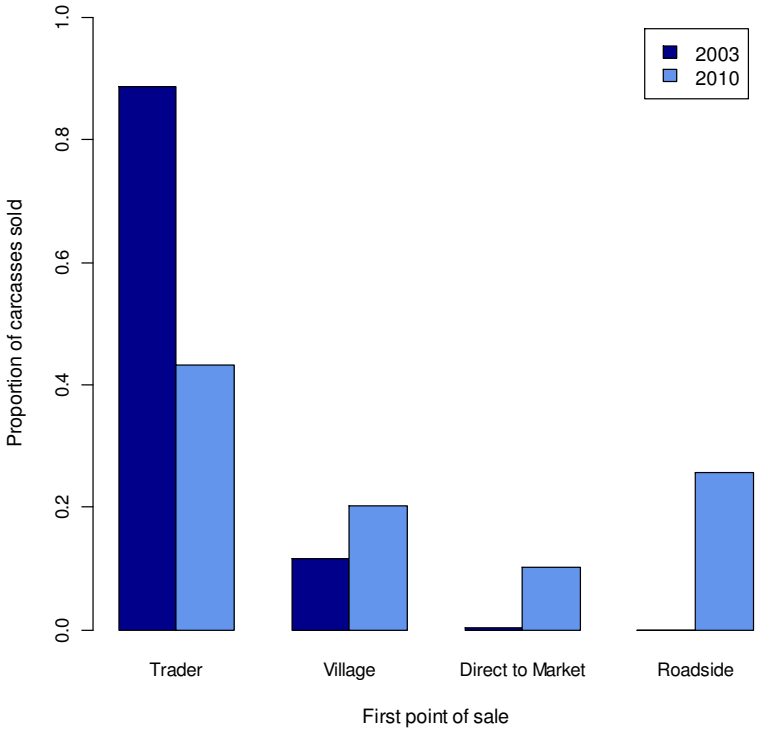

Figure 4.2 The proportions of all sold carcasses to various clients between 2003 (n=927) and 2010 (n=162). Counts for each point of sale varied significantly between studies (X^2 = 346.5945, df = 3, $p < 0.001$)

4.5 Market data as an indicator of broad-scale socio-economic processes

The level of trade in a bushmeat market in Bata expanded in terms of the number and total biomass of carcasses on sale between two corresponding studies in 2003 and 2010. However log mean carcass weight was significantly lower in 2010 than in 2003 (table 5.1)

Table 5.1 Number and total biomass of carcasses arriving at an urban bushmeat market in Bata between the two corresponding study periods in 2003 and 2010. A significant difference was observed between log mean biomass ($t = 9.8143$, $df = 3540.735$, $p < 0.001$). * One Forest elephant carcass (*Loxodonta africana cyclotis*) was removed from mean weight calculations due to large influence on data).

Year	Carcasses	Total Biomass (kg)	Mean carcass weight (kg)
2003	1717	10315.6	6.01
2010	2591	15004.0	5.04*

4.5.1 Has the number of hunter sites that supply the market changed?

With the exception of the district of Ebibeyín, supply of bushmeat increased in every single district and there was significant variation in supply from each district between the two study periods, in part due to the dramatic increase in trade from Cogo (bordering north Gabon) and Cameroon (figure 5.1). An increase in trade volume was accompanied by an increase in the number of individual villages that supplied bushmeat to market; rising from 22 villages in 2003 to 58 in 2010. Villages in Equatorial Guinea on average each supplied less bushmeat with mean number of carcasses traded per village dropping from 49.2 in 2003 to 30.8 in 2010. Evidence of a reduction in bushmeat supply per village is supported by responses given in trader interviews in which 25/29 traders (86.2%) stated that individually, they sold less bushmeat today compared to the past – though only ten of these traders (34.5%) felt that certain species were beginning to decline. This drop in carcass number was particularly evident in Sendje where the number of carcasses on sale declined dramatically from 418 to 100 carcasses in the respective study periods (see figure 5.1). Interviewed market traders who had previously bought bushmeat from Sendje but now sourced it from elsewhere (n=8) responded with a variety of reasons for changing site, including too much competition from other traders (n=3) and it being cheaper and easier to wait for bushmeat to arrive in the market via hunters (n=3).

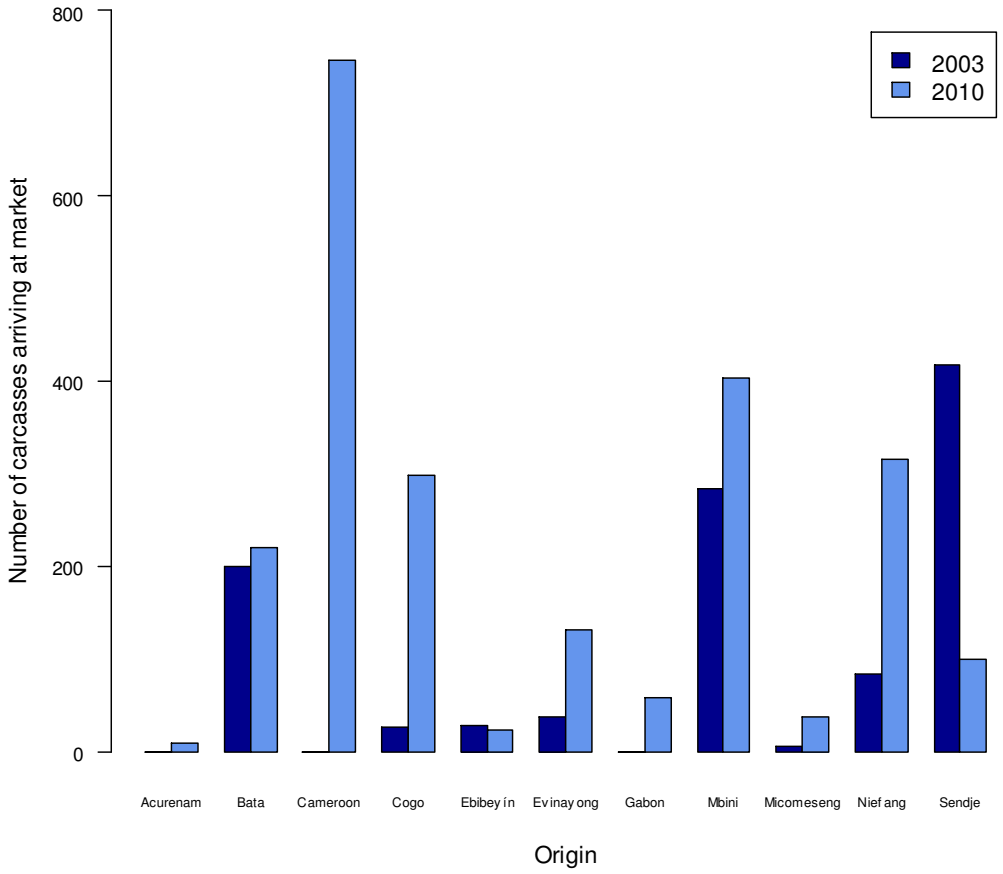

Figure 5.1 Supply of bushmeat carcasses to a Bata market (Central/Kilometro Cinco) from eight districts, Gabon, Cameroon and the village of Sendje, between two study periods in 2003 and 2010. Carcass count for each location varied significantly between study periods ($X^2 = 1161.428$, df = 10, $p < 0.001$)

4.5.2 Has there been a change in the method of capture for animals arriving in market?

Counts of the method of capture for carcasses arriving in Central market / Kilometro Cinco market varied significantly between 2003 and 2010 with the number of hand caught or shot animals increasing between study periods (figure 5.2). The large increase in gun-hunted animals arriving at market is in part due to the large flux of gun-hunted animals arriving from Cameroon (n=430). However increased gun-capture was significant when data was re-analysed exclusively for carcasses sourced from Equatorial Guinea ($X^2 = 199.793$, df = 2, $p < 0.001$), with gun-hunted carcass number more than doubling in the districts of Cogo, Evinayong, Micomeseng and

Niefang. The apparent increase in shotgun use is not restricted to specific prey groups with significant increases observed for the number of gun-hunted carnivores, pangolins, primates, rodents and ungulates (figure 4.3)

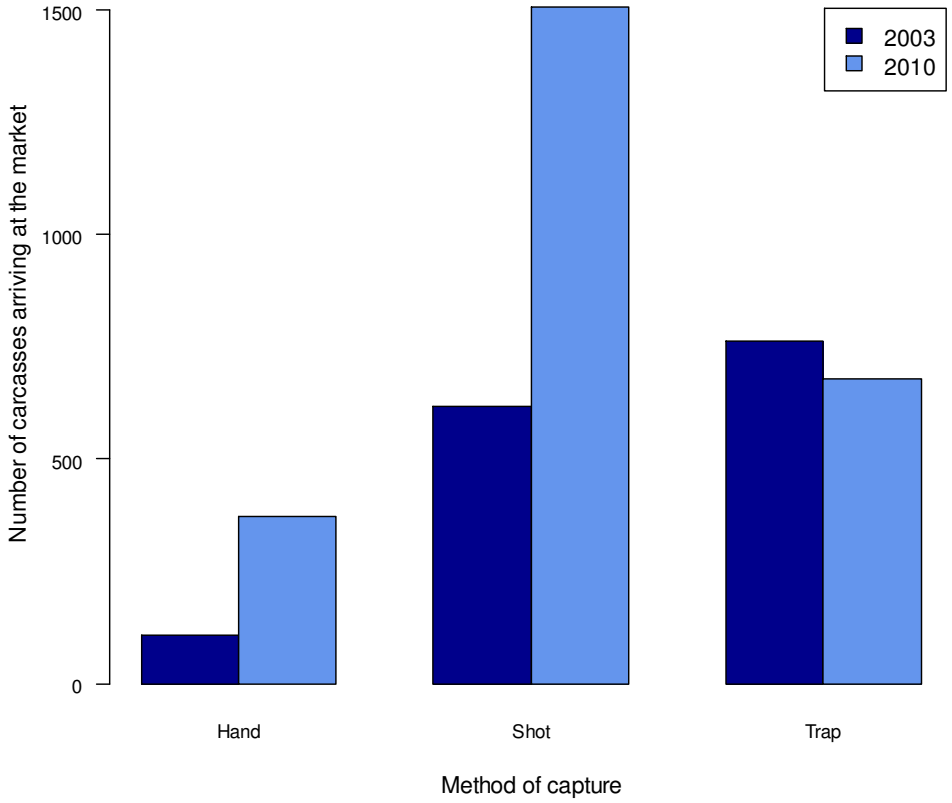

Figure 5.2 Total number of carcasses observed at Bata market (Central / Kilometro Cinco) found to be hand-caught, trapped or shot between 2003 and 2010 ($X^2 = 259.2378$, df = 2, $p < 0.001$);

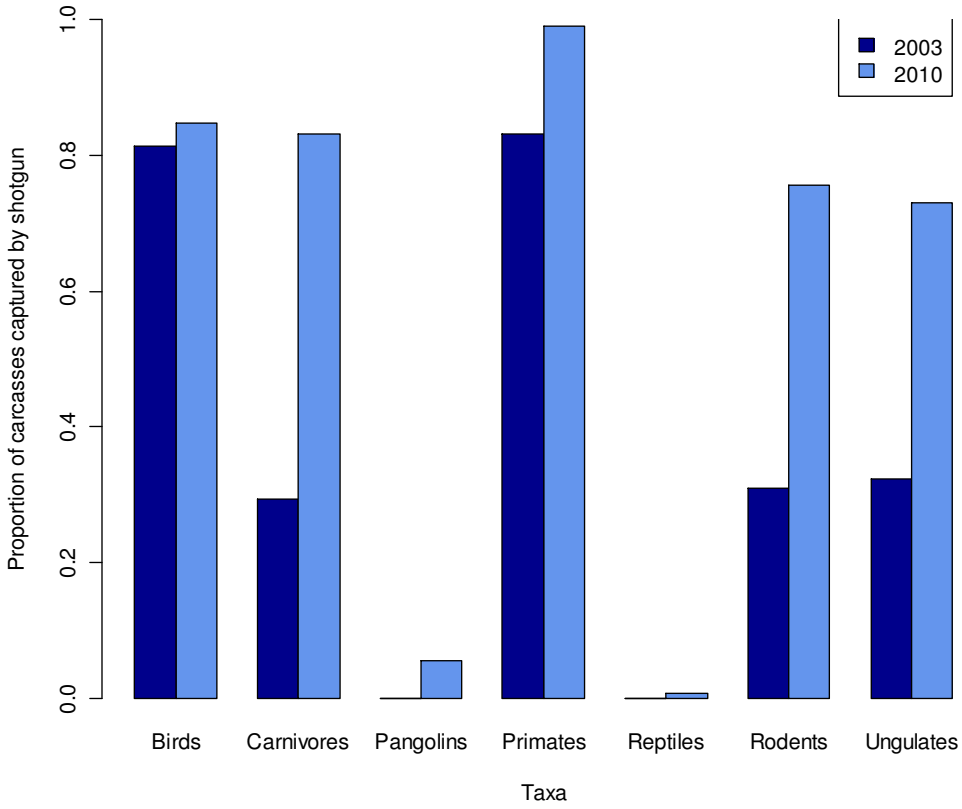

Figure 5.3 The proportion of carcasses gun-hunted for seven main taxonomic groups for 2003 and 2010. Significant increases were observed for carnivores (Fisher's exact test, p <0.001), pangolins ($X^{2=}$ 7.653, df = 1, p = 0.02), primates ($X^{2=}$ 36.832, df = 1, p < 0.001), rodents ($X^{2=}$ 139.711, df = 1, p < 0.001) and ungulates (X^{2} = 137.56, df = 1, p < 0.001)

4.5.3 Has there been a real-terms increase in the price of bushmeat carcasses sold at market?

Bushmeat prices collected for all commonly observed species (n > 20 in 2010 study) increased significantly in real terms. Median real-terms price for bushmeat carcasses rose from 2962 CFA per kg to 4621CFA per kg (V=3, p < 0.001) with real terms prices more than doubling for species such as tree pangolins (*Phataginus tricuspis*) and Nile monitors (*Varanus niloticus)* (see appendix 1.1).

Prices have not increased in real-terms for a selection of substitute goods (mainly frozen) found in the market with median price actually dropping slightly from 1200 CFA to 1145 CFA (V = 39, p = NS)

4.5.4 Is there a shift in prey profile of species arriving in the market?

Overall, the number of carcasses arriving at market increased for all major taxonomic groups except primates, in which carcass number dropped slightly from 352 to 319. In particular the number of rodents and pangolins increased greatly in the market and there was significant variation in carcass count across taxonomic groups between study periods (figure 4.4). Though in general species with low r_{max} had decreased in offtake number, no significant relationship was found between r_{max} and proportion of offtake change between 2003 and 2010 (figure 4.5).

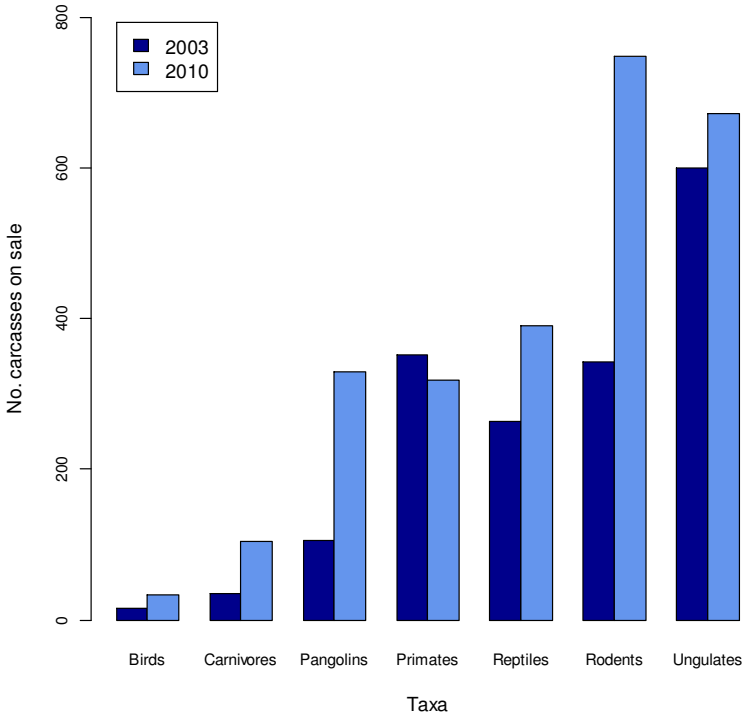

Figure 5.4 The number of carcasses on sale at an urban market divided by taxa. Carcass count across taxa varied significantly between 2003 and 2010 ($X^2 = 163.664$, df = 6, $p < 0.001$)

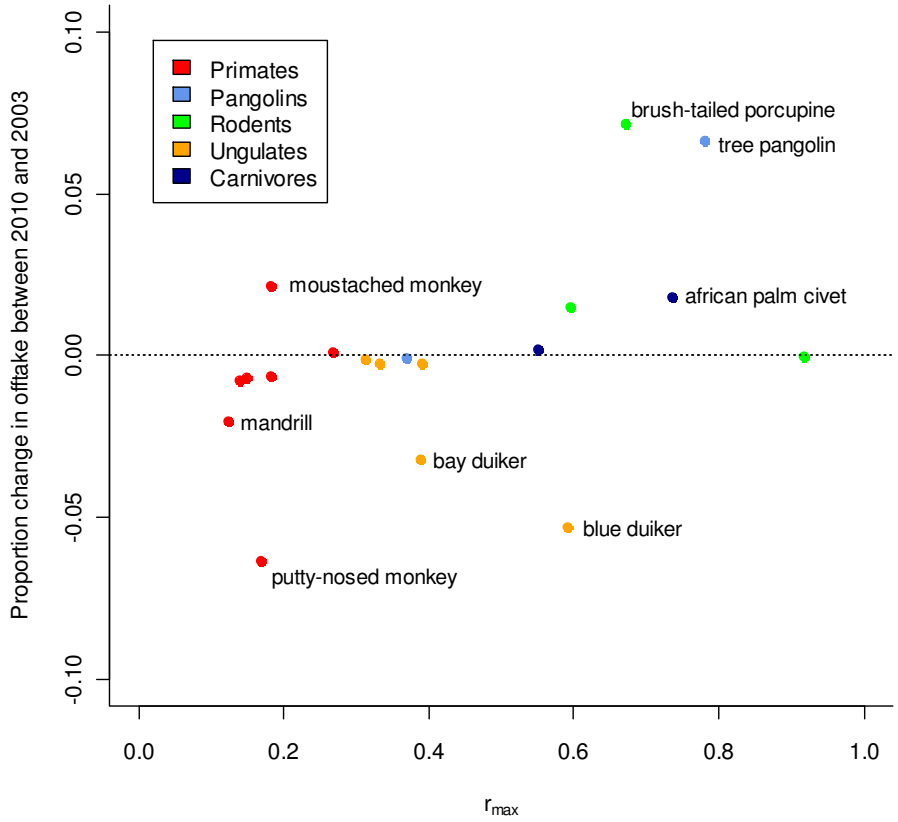

Figure 5.5 No relationship was observed between proportional change in offtake between 2003 and 2010 for mammal species and r_{max} (Adj. $R^2 = 0.161$, $t = 2.112$, $p = NS$). Species below the dotted line have decreased in proportion since 2003.

5. Discussion

The aim of this project was to investigate if hunter offtake, effort and strategy (area and gear choice) have changed in Sendje since 2003, and if so, to identify possible drivers for change. An examination of the relationships illustrated below in figure 5.1, in reference to other relevant research, forms the backbone of the discussion section. Sets of drivers for change will be discussed in order of the immediacy of their impact on offtake. This will begin with hunting strategies, move on to hunter profile and finish by summarising wider-scale process through an examination of the commodity chain and market data.

Following on from this, the limitations of the study will be assessed, providing a basis to discuss directions for future research.

Finally, the main conclusions of the study will permit considerations of future policy and management options in the area.

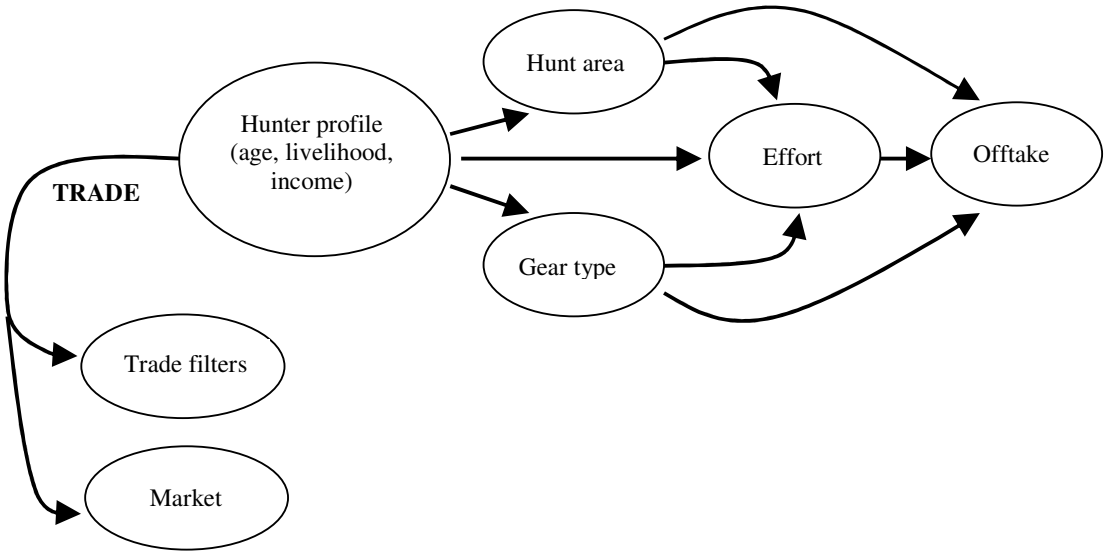

Figure 5.1 The driving forces of hunter offtake. The strength and nature of these relationships is examined in the following section. Diagram developed by author but based on one presented in Kümpel (2006).

5.1 Drivers for changes in offtake, effort and strategy

5.1.1 Hunting strategy as a driver for change in offtake, effort and CPUE

Dramatic decreases in total offtake in terms of number and biomass of carcasses caught (table 1.1), have occurred at a village and individual hunter level. Village-wide drops in bushmeat extraction can be accounted for by a decrease in the number of active hunters and total number of traps laid, but an obvious question remains regarding, why, with less competition, individual hunters, in terms of overall capture rates were less successful? A drop in trapping effort does not explain this as the number of active traps per hunter did not significantly change between study periods. Instead, mean drops in CPUE (in terms of biomass caught per trap) (table 1.2) observed here could indicate depletion in forests surrounding Sendje (Kümpel et al., 2010) and these findings are supported by responses given during hunter interviews claiming declines in local fauna.

However, though composition of offtake prey-profile changed significantly, there is no evidence that was as a result of prey depletion (r_{max} has remained constant and primates have actually increased in proportion). Instead it is important to analyse the impacts of changed hunting strategy both on CPUE and prey profile before concluding that the surrounding forests are depleted in wildlife.

Distance of trap groups from Sendje dropped significantly (figure 2.1), with the use of hunter camps based within and close to the national park all but abandoned (table 2.1). However in both study periods (in 2003 and 2010), hunters who trapped further from Sendje caught a greater biomass of prey and had higher CPUE (in terms of trapping effort), suggesting that evidence of depletion, may only be relevant to areas surrounding Sendje and are thus not representative of the forest as a whole. It is unlikely that a change in gear selection affected offtake totals, as no difference was observed in catch rate between trap types, and gun-hunting, represented a relatively small proportion of the 2003 offtake.

A contraction in hunter range (figure 2.3) and a change in gear selection (table 2.3) have affected composition of prey profile. Species typically found distant from Sendje such as blue duiker and brush-tailed porcupine had by the far biggest drop in

proportion of overall offtake, whilst reverse shifts in proportion were observed for species found close to the village, in particular those susceptible to gun-hunting such as black-casqued hornbill and northern talapoin (figure 1.1). It is notable that black colobus, a species predicted to be sensitive to gun-hunting (Kümpel et al., 2008), has dropped considerably in number. However, this result is most likely a product of the fact that hunters simply aren't travelling far enough to reach black colobus troops that were on average shot 23km away from the village in 2003.

In summary, hunt location, and to a lesser extent, gear selection affect CPUE and prey profile and so need to be considered when evaluating the sustainability of bushmeat hunting. These results, though in this case related to offtake, echo those of Rist et al. (2009) where habitat and hunting have independent effects on species abundance. A large-scale contraction in the hunting catchment east of Sendje provides few offtake records within the National Park so it is impossible to infer the state of wildlife within these areas. It is possible however, that species such as primates which in the past, were limited in population growth by hunting, could be recovering within this catchment. However, an important question still remains. If at greater distances, hunters catch a greater amount of offtake, and do so, on average, with fewer traps, then why has there been such a large contraction in the range of their activity?

5.1.2 Hunter profile as drive of change in hunting strategy

Though hunting at greater distances from Sendje offers high offtake returns relative to trap number, the benefits of doing so in relation to economic costs are not so clear-cut. Hunters who trap further do not catch significantly more prey per day spent in the forest. Choosing to hunt further must also reduce a hunter's ability to pursue other livelihood activities – and indeed those with other means of generating income, such as bar ownership or construction work, set traps significantly closer to home. It is likely that hunters who expend the greatest effort are those currently not able (rather than not willing) to engage in other practices as almost without exception, Sendje hunters do not enjoy hunting, do not wish their sons to become hunters and state a lack of other means of generating income as a reason for choosing to hunt. It is also of note that the only two hunters that continue to set traps from hunter camps deep in the forest are also the only two hunters to have no level of formal education (though

level of education was found to be a poor predictor of hunting in 2003 (Kümpel, 2006)).

The idea that village hunters have contracted their range (or in many cases left hunting and / or Sendje altogether) due to increased opportunity costs of hunting is supported by the fact that hunter incomes have decreased slightly and that a number of the 2003 hunters have moved on to find other means of employment, mainly in the construction industry. Indeed, on two occasions towards the end of the study period, a group of four hunters ceased trap-checking to undertake temporary employment with a Canadian hydroelectric company for 4, 000 CFA per day (1US $ = CFA 443.67). At the time of writing the company was scoping out areas for dam construction close to Sendje and it is highly possible that many of Sendje's resident hunters will take-up employment with the company in the future.

Increased opportunity costs of hunting appear to have been matched by an increased perceived risk of hunting. Thirteen respondents declared that they had abandoned traps laid close to the national park due to increased disturbance by elephants that have, in the opinion of the hunters, increased greatly in population over recent years

Predictions from Damania et al. (2005) and Kümpel (2006) that increased income levels would lead to an increase in gun-hunting at the expense of cheaper but less efficient trap-hunting, are supported in this study due to the higher proportion of gun hunters in the area and by the fact that gun hunting is more common amongst income earners.

Finally, a small local demand for bushmeat consumption appears to support low levels of bushmeat hunting. Eighteen respondents claimed to hunt as a means to provide food for their family, and the number of carcasses consumed in Sendje did not change significantly between studies. However, for the majority living in Sendje, bushmeat remains a luxury. Indeed even amongst hunters, frozen goods, on sale throughout the week in Sendje, are consumed far more frequently than bushmeat, which is more often than not sold on to the next link in the commodity chain.

5.1.3 The commodity chain from hunter to market: an indication of wide-scale processes

The drop in hunting activity from Sendje has unsurprisingly been accompanied by a significant drop in bushmeat sales to market traders. Only one trader was observed visiting Sendje throughout the 2010 study compared to seven in 2003. In spite of this, the trade in Sendje was far from a monopsony. Hunters often traded carcasses on the main road to passing traffic and, in search of a higher price, were commonly observed to walk past the trader to do so. Traders, who had previously bought bushmeat from Sendje, acknowledged the fact that trade had dropped from the village, though cited high competition with other traders as a reason to move custom (either to other villages, or to wait at market for the arrival of hunters).

Indeed the expansion of the trade into new villages has been dramatic. In 2010 bushmeat on sale was recorded from almost double the number of villages observed in 2003, and these sites were often located in distant districts or even across the border into Cameroon or Gabon. As trade with remote sites (which offer potentially higher amounts of prey) is to some extent limited by journey cost (Allebone-Webb et al., in press) it is possible that an improved road network is the driver behind what may be an increasingly regular trade with a number these villages.

The increase in village number (though each village on average supplied less bushmeat) has helped support a still thriving national bushmeat trade which has increased in terms of the number of traders, the biomass of carcasses on sale and the real-terms price of bushmeat carcasses. Furthermore, prices, for protein substitutes in the market, have remained stable or even decreased in real-terms suggesting an increasing urban demand for bushmeat.

Moreover, the continued rise of income levels within the country, in combination with a re-developed road network, may well have reduced barriers to entry for gun-hunting. The proportion, and number, of gun-hunted species arriving in market increased dramatically, with nearly all districts supplying more gun-hunted carcasses.

The data collected from the market at Kilometro Cinco provides a few indications, that on a national scale, bushmeat extraction is unsustainable. The average weight of carcasses has decreased, price has increased (suggesting that supply is not meeting demand), and primates, the taxon most sensitive to hunting are the only group to decrease in number of market sales. Though these findings act as a warning that the some species may be over-exploited, it is important to recognise the complexity of market signals (Allebone-Webb et al., (in press)), and that this study only represents a snap-shot in time that may fail to account for longer-term fluctuations in species population dynamics and hunter and consumer behaviour.

5.2 Limitations of the project

5.2.1 Sources of bias and uncertainty in data

Achieving the aim of this project required accurate data collection on hunter behaviour and was thus dependent on a good degree of co-operation from hunters living within Sendje. Time was taken at the start of the study, during a village meeting, and focus groups, to explain the aims of the study and engender support for its continuation. Extensive efforts were made to keep data confidential, and the use of a research assistant, who very much had a position of respect and trust in the village, aided a steady flow of data from hunters. However, potential sources of bias and uncertainty in the study are reviewed below

In cases where hunter offtake was not observed, inaccurate hunter responses would have lead to an inaccurate estimation of total offtake and species composition – which form the very basis of the study. It is unlikely that capture could have been exaggerated as offtake data was often triangulated from other sources such as through another hunter, trader or village buyer. Hunters may have had an incentive not to declare carcasses, in particular, species protected by law or high in value. However hunting laws are rarely, if ever, enforced in Equatorial Guinea (Keylock, 2002, Kümpel, 2006), a fact acknowledged by nearly all hunters during interviews, and high value species such as pangolins or protected species such as primates were commonly paraded by hunters. Recall periods were almost without fail on the same day as

hunter catch, and so the likelihood that a hunter would have forgotten exactly what he had caught was low. As all sales between hunters and the market trader were observed, it is possible that the dataset is slightly biased - as both road-sales and village consumption were probably underrepresented in this study.

Recall of trap distance could have been inaccurate due to a low ability of hunters to estimate distance in the forest, or biased if hunters did not wish to reveal activity within the national park. Accuracy of stated distance was aided by the declaration of known landmarks such as ex-hunter camps or a rivers that could later be mapped with the help of the research assistant, who himself had considerable experience working in the forest. It is also extremely unlikely that hunters could have been active within the national park without the author, who commonly witnessed the departure and arrival of hunters from the forest, being aware of this, due to the long time duration required to inspect traps in this area.

A poor ability of hunters to remember trap number would have made estimations of trapping effort and CPUE invalid. Project time constraints made it impossible to triangulate these estimations with actual observations of trap number in the forest through 'hunter follows'. However as a previous study completed at the same site observed a high correlation between actual and recall trap number (Kümpel et al., 2009), estimations of trap number were taken as a good indicator.

Income levels could not be measured over long time periods, so instead had to be estimated during one-off interviews. For this reason it is highly likely that incomes for certain livelihoods will be biased by seasonality. However, the most recent study undertaken in Sendje revealed that hunting levels remained relatively constant year-round (Kümpel, 2006). Actual, in preference to typical, values for income earned in the previous month were requested from respondents to increase accuracy and income code sheets were used to aid confidentiality. Drops in hunter incomes are at least in part supported by the significant drop in bushmeat trade in the village

5.2.2 Directions for future research

The completed research has identified that the route used by Sendje hunters and Bata traders no longer acts as a major avenue for bushmeat trade within the country. Indeed the delocalisation of the trade from, and potentially to, new areas within and outside the country certainly merits further study if the scale of the trade – and its regional impacts – is to be grasped. One ambitious idea may be to investigate the level of bushmeat passing through a sample of the vast number of police road-blocks found in the country, using methods similar to those adopted by (Chaber et al., 2010). This, through strategic positioning of study sites at differing geographical areas, could aid the localisation and quantification of the trade in the country and provide complimentary information to market studies. The completion of such a study would require considerable governmental buy-in and support, though given that the country is a CITES member and has commitments to monitor cross-boundary trade, gaining permission to implement such a study may not be impossible.

Such a study could also reveal key information on movements of gun-hunters in the country – believed by some to be travelling independently between forests and urban centres. Understanding the profiles and hunting strategies of these hunters is becoming increasingly important. Critical questions include:

1) What proportion of income are hunters receiving from gun-hunting?
2) Where are gun-hunters hunting, and are gun-hunters highly mobile, operating between several locations?
3) Are gun-hunters targeting particular species?
4) Do transient gun-hunters impact on the livelihoods of sedentary trap-based village hunters?

There is also relatively little knowledge about how wildlife is actually fairing within Equatorial Guinea's national parks and reserves. Questions remain regarding whether or not some species, such as *Colobus satanus* have increased in population, due to what appears to be a reduction in hunting around the western edge of Monte Alén National Park. Field surveys to evaluate this, and the status of other species sensitive to hunting are required if priority areas for biodiversity protection are to be designed.

Finally, and most importantly, continued research that focuses on the behaviours and needs of key research users is required. For example, an investigation into the factors that influence individual and community discount rates (relating to the differences in value placed on using a resource in the present or in the future) could help predict under what set of circumstances individuals would be likely to sustainably use a resource. Other key questions remain regarding the feasibility of developing bushmeat substitutes, for producers and consumers, and whether such implementation would actually reduce dependence on the bushmeat resource. Where possible, research should be participatory; in order to build capacity within local communities for long-term monitoring programmes.

5.3 Implications for policy and concluding remarks

5.3.1 Policy implementation

The results from this study suggest that the development and diversification of rural livelihood options can genuinely affect hunting strategy in a way that decreases pressure on the resource. It is also likely that demand for bushmeat could be reduced, if preferred fresh alternatives are provided at competitive prices (East et al. 2005), and therefore the development of small-scale livestock production or aquaculture in rural areas, as proposed by the ZSL, could ease two sources of pressure simultaneously (ZSL, 2009).

There is widespread awareness (amongst traders and hunters) in Equatorial Guinea that bushmeat as a resource is beginning to dwindle, yet without a genuine incentive to sustain this resource into the long-term, how can those on the poverty line be expected to adapt their use of an open-access resource? Ensuring that the benefits received by the bushmeat trade endure into the future depends on significant institutional change that includes the acknowledgment of the role of bushmeat in the national economy, the decentralisation of government (to engage local communities in policy development and management), and the reformation of tenurial systems that would both guarantee benefits to local people, and provide real incentive to harvest bushmeat sustainably (Nasi et al., 2008). Similar reform has recently been achieved

in Kenya (BBC, 2010), and whilst this process may be both lengthy and difficult, its succession may be a necessary precursor for the country to obtain economic and social benefits from initiatives such as reduced emissions from deforestation and forest degradation (REDD) schemes (Sunderlin, 2010) and poverty reduction strategies (Brown and Williams, 2003).

A right of exclusivity amongst local resource-users would also help negate the potentially negative impacts from external hunters on local sustainability (Nasi et al., 2008). However, national level protected area management may still be essential to secure core areas high in biodiversity and to provide refuge for species sensitive to over-hunting (Milner-Gulland and Bennett, 2003). Protected area policy must however take into account limits in capacity (human resource and financial) and, where possible, other land-use practices should be incorporated into their design (Nasi et al., 2008).

5.3.2 Conclusion

Bushmeat offtake from a catchment of forest surrounding Sendje has emphatically decreased since 2003 due to changes in hunting strategy by village-based hunters. The economic and social benefits of fixed employment have attracted hunters away from Sendje, and of those remaining, many have decreased their hunting range due to the combined impacts of poor economic gains and high physical risks of travelling far into the forest. Whilst it is possible that wildlife in these areas on the west side of Monte Alén National Park is recovering, data collected from an urban market indicates that, nationwide, wildlife as a whole could be deteriorating. The increased development of road networks and use of shotguns could have detrimental impacts on several primate species in the country, and on the villages whose resource-base could become over-exploited by external hunters. The development of income-generating strategies for rural communities, alongside institutional change that promotes local ownership of the bushmeat resource could help promote sustainable harvesting at a local level; though such measures could be in vain if the impacts of mobile gun-hunters are not also addressed.

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7. Appendices

Appendix 1.1 Mean prices for frequently recorded bushmeat carcasses (n>20) and for substitute protein goods on sale at Kilometro Cinco / Central market in 2003 and 2010. Prices for bushmeat are taken from fresh adult carcasses and weights are from Kümpel (2006), where dressed weights = 65% of total adult weight. 2010 prices account for inflation (see methods section for calculation). 1US $ = CFA 443.67.

Food Type	Latin name	Species	Weight (kg)	2003 dressed price per kg (CFA)	2010 dressed price per kg (CFA)
Bushmeat	*O. tetraspis*	Dwarf crocodile	6.3	7, 993	12, 459
	P. tricuspis	Tree pangolin	2	3, 278	8, 844
	V. niloticus	Nile monitor	4.3	2, 885	6, 902
	N. binotata	African palm civet	2.6	3, 709	6, 745
	A. africanus	Brush-tailed porcupine	3.2	3, 308	5, 865
	T. swinderianus	Marsh cane-rat	4.6	3, 100	5, 421
	K. erosa	Hinge-back tortoise	1.7	2, 715	5, 034
	C. pogonias	Crowned monkey	4	2, 911	4, 207
	C. nictitans	Putty-nosed monkey	4	2, 154	4, 126
	M. sphinx	Mandrill	13.8	3, 152	3, 519
	C. cephus	Moustached monkey	5.2	2, 927	3, 417
	P .monticola	Blue duiker	4.8	2, 236	2, 835
	T.s spekei	Sitatunga	36	1, 716	2, 682
	C. dorsalis	Bay duiker	18	2, 997	2, 285
	Mean price			**3, 220**	**5, 310**
Fresh fish	-	Skipjack tuna	1	-	4, 000
	-	Sea-bream	1	-	2, 672
	Mean price			**-**	**3, 336**
Frozen		Beef.Tail	1	1, 800	1, 798
		Beef	1	1, 500	1, 434
		Pork.tail	1	1, 200	1, 439
		Pork.chops	1	1, 200	1, 223
		Chikcen.stomach	1	1, 200	1, 079
		Ckicen.wings	1	1, 200	1, 079
		Turkey.thighs	1	1, 200	1, 043
		Chicken.thighs	1	800	1, 007
		Beef.Intestine	1	1, 500	935
	Mean price			**1, 177**	**1, 146**

Appendix 1.2 Carcasses observed in Sendje and Kilometro Cinco market offtake surveys May - June 2010

Taxon	Fang / Spanish name	English name	Scientific name	Sendje no.	Market no.
Ungulates	Okong - antilope gris	Blue duiker	*Philantomba monticola*	53	548
	So - dorsalis	Bay duiker	*Cephalophus dorsalis*	8	74
	Mvu - sitatunga	Sitatunga	*Tragelaphus spekei*	5	24
	Nnok - daman arborea	Western tree-hyrax	*Dendrohyrax dorsalis*	2	1
	Nguiñ-mise - jabali	Red-river hog	*Potamochoerus porcus*	-	19
	Nzip - silvicultor	Yellow-backed duiker	*Cephalophus silvicultor*	-	3
	Nkwa - girafa	Bushbuck	*Tragelaphus scriptus*	-	2
	Nzok - elefante	Forest elephant	*Loxodonta africana cyclotis*	-	1
	Nnat - búfalo	Buffalo	*Syncerus caffer*	-	1
	Sub-total			**68**	**673**
Rodents	Ngom - puercoespin	Brush-tailed porcupine	*Atherurus africanus*	44	689
	Kuin - rata	Giant pouched-rat	*Cricetomys emini*	29	7
	Akuekuin - marmota	Marsh cane-rat	*Thryonomys swinderianus*	11	45
	Osen - ardilla pequeña	Small squirrel species	?	5	-
	Mvok - ardilla gigante	Large squirrel species	?	2	-
	? – rata pequeña	Small rat species	?	1	-
	Owonguin	Beecroft's anomalure	*Anomalurus beecrofti*	1	-
	Sub-total			**93**	**741**
Primates	Onsem - titi	Northern talapoin	*Miopithecus onguensis*	14	9
	Esuma - mona	Crowned monkey	*Cercopithecus pogonias*	10	41
	Ngem-tchogo - cola roja	Moustached monkey	*Cercopithecus cephus*	6	108
	Avem - nariz blanca	Putty-nosed monkey	*Cercopithecus nictitans*	6	76
	Esaga - mandril	Mandrill	*Mandrillus sphinx*	6	68
	Mvam - colobo negro	Black colobus	*Colobus satanus*	2	13
	Fung - obispo	De Brazza's monkey	*Cercopithecus neglectus*	-	2
	Ngi - gorila	Western Gorilla	*Gorilla gorilla*	-	2
	Sub-total			**44**	**319**
Pangolins	Ke - pangolin arborea	Tree pangolin	*Phataginus tricuspis*	28	320
	Fima - pangolin gigante	Giant pangolin	*Smutsia gigantea*	1	10
	Sub-total			**29**	**330**
Carnivores	Mvein - civeta de palmeras	African palm civet	*Nandinia binotata*	3	91
	Nze-ngum - cusimanse	Flat-headed cusimanse	*Crossarchus platycephalus*	3	1
	Nsing - geneta	Servaline genet	*Genetta servalina*	1	4
	Nsuen - lobo	African civet	*Civettictis civetta*	-	6
	Mva	Mongoose species	?	-	2
	Sub-total			**7**	**104**
Birds	Ongum - caláo	Black-casqued hornbill	*Ceratogymna atrata*	18	26
	Kuna - tucan	Great blue turaco	*Corythaeola cristata*	7	2
	Nkang - gallina de Guinea	Plumed guinea fowl	*Guttera plumifera*	3	4
	Nkun	Palm-nut vulture	*Gypohierax angolensis*	3	1
	Evolo - gallina de bosque	Black guinea fowl	*Agelastes niger*	1	-
	? - águila coronada	Crowned hawk-eagle	*Stephanoaetus coronatus*	1	-
	Nkulengu	Nkulengu rail	*Himantornis haematopus*	1	-
	Sub-total			**34**	**33**
Reptiles	Etug - tortuga	Hinge-back tortoise	*Kinixis erosa*	17	230
	Ncomgan - cocodrilo	Dwarf crocodile	*Osteolaemus tetraspis*	3	129
	Nka - iguana	Nile monitor	*Varanus niloticus*	2	22
	? – serpiente pequeña	Small snake species	?	1	2
	Nvom - pitón de Seba	African rock-python	*Python sebae*	-	8
	Sub-total			**23**	**391**
Molluscs	? - caracol	Giant land snail	*Achatina sp.*	4	-
	Sub-total			**4**	**-**
	TOTAL			**302**	**2591**