UNIVERSIDAD POLITÉCNICA DE MADRID
Escuela Técnica Superior de Ingeniería de Montes, Forestal y del Medio Natural

Wild Meat Utilization and Species Conservation in Pico Basilé, Bioko Island: Developing Sustainable Management Strategies for a Critical Biodiversity Hotspot

DOCTORAL THESIS

Submitted for the degree of Doctor by:

María de Gracia Grande Vega
Conservation Biology MSc.

Madrid, 2024

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Title: Wild Meat Utilization and Species Conservation in Pico Basilé, Bioko Island: Developing Sustainable Management Strategies for a Critical Biodiversity Hotspot

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Doctoral Programme: Ingeniería y Gestión del Medio Natural

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External Reviewers:

Thesis Defense Committee:

Thesis Defense Date:

This thesis has been partially supported by:

Beca Copito de Nieve para la Realización de Proyectos de Investigación en Primates (2009). Zoo de Barcelona.

Ayudas del Consejo Social de la UPM a la formación de doctorandos (2009).

Rufford Small Grants for Nature Conservation (2009). The Rufford Foundation.

Programa de Ayudas de Viaje de Cooperación para el Desarrollo (2010). UPM.

Programa de Investigación y Conservación en los programas Específicos de Investigación propuestos por externos del Zoo de Barcelona (PRIC) 2010.

Ayudas en el Marco del Programa Propio del Personal Investigador en Formación para la Realización del Doctorado en sus Escuelas, Facultades, Centros de I+D e Institutos Universitarios (RR01/2011). UPM.

Subvenciones y Ayudas para Acciones de Cooperación Universitaria para el Desarrollo (2010). UPM.

Ayudas por la Fundación Biodiversidad, en régimen de concurrencia competitiva, para la Realización de Actividades en el Ámbito de la Biodiversidad, el Cambio Climático y el Desarrollo Sostenible (2010).

Rufford Small Grants for Nature Conservation (2012). The Rufford Foundation.

Programa de Investigación y Conservación en los programas Específicos de Investigación propuestos por externos del Zoo de Barcelona (PRIC) 2012.

Fondos del Contenido Nacional para el Desarrollo Social de Guinea Ecuatorial (2014). Ministerio de Minas Industria y Energía.

A mis padres: Isabel y Carlos

Ignoring the human factor in the sustainable management of bushmeat is a clear recipe for failure

Stephenson and Newby, 1997

Agradecimientos

Deseo agradecer a la Universidad Politécnica de Madrid por la enorme oferta de ayudas para la realización de doctorado y acciones de cooperación al desarrollo de la que he podido beneficiarme y el apoyo recibido a través de mi grupo de investigación SILVANET durante todo el transcurso de la tesis, incluyendo su implicación para buscar fondos y realizar parte de los proyectos relacionados con la tesis.

Agradezco también a las demás entidades que han financiado mis proyectos en Guinea Ecuatorial en una o más ocasiones: el Zoo de Barcelona, la Fundación Rufford, la Fundación Biodiversidad, la Carlson Family Foundation, el Instituto Nacional de Desarrollo Forestal y Manejo del Sistema de Áreas Protegidas de Guinea Ecuatorial (INDEFOR-AP), El Ministerio de Minas Industria y Energía de Guinea Ecuatorial, y Marathon Oil E.G. Production Limited.

A mi supervisora Julia E. Fa. Gracias Julia por llevarme hasta Bioko y meterme en este lío de bonitos resultados gracias a tu apoyo, y en especial a tu intensísima dedicación en la última fase, la más difícil, de la tesis. A mi supervisora Rosario Tejera y mi tutor José Antonio Manzanera que han estado ahí siempre, a Antonio García Abril, Ana Hernando y a todos los miembros del grupo de Investigación SILVANET por ser familia y apoyo profesional siempre.

Al que considero mi tercer supervisor, Javier Barón. Gracias Javier por todo lo que me has enseñado de estadística, activa y pasivamente (con la cantidad de material tan valioso que pones a libre disposición en internet) y de muchas otras cosas pues tu conocimiento es infinito y tu generosidad y vocación por la enseñanza más infinito aun. Has estado siempre disponible ¡Gracias! ¡Gracias! ¡Gracias!

A los revisores Andrew Noss, John Hart y Pedro Mayor, por sus inestimables sugerencias y aportaciones.

Mi más profundo agradecimiento a la Universidad Nacional de Guinea Ecuatorial (UNGE) y al Instituto Nacional de Desarrollo Forestal y Manejo del Sistema de Áreas Protegidas de Guinea Ecuatorial (INDEFOR-AP), por su apoyo y colaboración para la realización de la tesis y de los cuatro proyectos de conservación y cooperación asociados a la misma.

En especial al Excmo. Sr. Rector de la UNGE en aquel momento, Carlos Nze Nsuga y al Director de Investigación, Maximiliano Fero Meñe. A ambos gracias por vuestro enorme e imprescindible apoyo y vuestro interés y amistad. Maxi, gracias también por tu implicación personal y todo el trabajo tan bonito que hemos podido desarrollar juntos. Gracias también al Decano de la Facultad de Medio Ambiente, José Manuel Esara Echube, al profesor y guía clave Claudio Posa Bohome (que me acogió a mi llegada y me enseñó los pueblos y costumbres de Bioko) y a los profesores Rigoberto Esono, Eulogio Abeso, José Ondo y Kouassi Messan Ague, por el gran apoyo en el diseño y desarrollo del trabajo de campo. A los estudiantes que colaboraron en la investigación, especialmente a Ricardo Oyono (por tu profesionalidad, tu amistad y gran

compañía), a Pastor Cham, Miguel Angel Ndong Bee, Lucrecia Bile Osa y Eusebio Ondo. A las secretarias de Cooperación que tanto me ayudaron con el papeleo.

A Fidel Esono Mbá, Director General de INDEFOR-AP durante el periodo de mi tesis. Fidel, fue un privilegio poder trabajar contigo y con INDEFOR-AP, una persona y una institución con verdadera vocación y entrega al trabajo por la conservación de la naturaleza. Gracias también a Grabiel Ngua, a Jesús Mbá y en general a todos los miembros de INDEFOR-AP y ANDEGE que me apoyaron en distintos momentos y colaboraron en los proyectos. Gracias, Santiago Engonga (Director General de Pesca y Medio ambiente en aquel momento) por tu apoyo.

Mi especial agradecimiento a todos los miembros de las comunidades locales que fueron entrevistados o que colaboraron de alguna manera en el trabajo de campo. En especial a los cazadores y las comerciantes de Basilé Fang, que tanto resistieron las interminables preguntas y estudios realizados en este poblado. A los cazadores a los que acompañé en sus rutas de caza, por todo lo que me enseñaron y me cuidaron. A mis asistentes locales, Ambrosio Ondo (de Basilé Fang) y Justo Sabana (de Basilé Bubi), que con tanto cariño y dedicación han trabajado. A Remigio, presidente de la zona media de Rebola, a Gervasio y Eufrasia de Bososo. A Victoria, a José y Marcelina, a Nena, Mónica, Mansueto, a Angelina, Rosendo, Mbó, Pascual Obiang. Agustina y Manuel, Benedicta…. Queridos habitantes de Basilé Fang y Basilé Bubi, donde tanto hemos trabajado, y también de Rebola, Basacato, Bososo, Bakake Grande, Copé, Bantabaré, Inasa Maule y Bomá, gracias por vuestra enorme acogida y apoyo.

A Heidi Ruffler, entonces directora de Conservación Internacional. Gracias Heidi, por presentarme a las instituciones y dar valor a mi trabajo, por todo lo que pude aprender de ti, por tu enorme profesionalidad y por tu amistad. A Ramón Castelo, antiguo coordinador de la Asociación Amigos de Doñana, colega, supervisor, compañero de casa y hermano. Gracias por todo Ramón, por tu apoyo siempre y tus inestimables consejos y enseñanzas a mi llegada a Malabo, y por todo lo compartido en nuestro querido barrio de Los Ángeles. A Patricia Picazo, entonces subdirectora del Centro Cultural de España en Malabo. Gracias Patricia por tu interés en la conservación y por involucrar al CCEM en ella, e impulsar así los esfuerzos de nuestro trabajo y colaborar conjuntamente. Gracias también al director del CCEM, Carlos Contreras y a la directora posterior, Pilar Sánchez.

Mi especial agradecimiento a Carl Mass, Director del Departamento de Proyectos Sociales de Marthon EG Production Limited, compañía a través de la cual recibimos la financiación de nuestro último proyecto. Gracias Carl por creer en nosotros, hacer nuestros sueños realidad y por tu enorme profesionalidad y apoyo, ¡y sentido del humor, siempre!

A Juan Gómez Soto. Gracias Juan por tu apoyo y colaboración a nivel personal, profesional como biólogo, e institucional a través de la Asociación Ecotono, gracias a la cual pudimos comenzar a hacer proyectos más grandes y de mayor impacto. Y por su puesto, por tu inestimable amistad y todas las cosas bonitas que hemos podido hacer juntos ¡y lo que nos queda!

Gracias a los investigadores Bruno Carpineti (Universidad Nacional de Misiones de Argentina y Universidad Nacional Arturo Jauretche), y Miguel Ángel Farfán Aguilar

(Universidad de Málaga) que colaboraron en los proyectos. Bruno gracias por esa sugerencia CLAVE para la realización de los seguimientos de cazadores. Gracias Migue por tu colaboración tanto en el trabajo de campo de reproducción como en las actividades de apoyo a la gestión en varios proyectos, por tu constante apoyo profesional y, por su puesto, por tu amistad y aventuras trepidantes vividas en la ciudad de Malabo.

Gracias a todo el grupo de Biogeografía, Diversidad y Conservación de la Universidad de Málaga: Mario Vargas, Jesús Olivero, Ana Luz Márquez, Raimundo Real y todos los demás, por vuestra enorme acogida y apoyo durante mis varias estancias (y siempre), y todo lo que aprendí con vosotros.

Gracias a la colega, y en aquel momento consultora del MPyMA, Paloma Ferrer, cuya colaboración en el tercer proyecto (estudio de reproducción) fue clave. Gracias también por tú ánimo e impulso para realizar un nuevo proyecto, el cuarto, que resultó el más grande y de mayor impacto y que diseñamos juntas, junto con Antonio Grunfeld y Rocío Cadahía, expertos en comunicación y audiovisuales, que se unieron para darle mayor diversificación y alcance. Y posteriormente el biólogo marino Alberto Rosell (Tito). Esos dos últimos años fueron muy emocionantes pues sirvieron para ver resultados reales en el terreno tras muchos años de investigación y trabajo previo. Imprescindible fue la colaboración de INDEFOR-AP y de la UNGE, a través de Fidel Esono y Maximiliano Fero, que se involucraron de lleno e hicieron de todos el proyecto por lo que pudo acabar en unas primeras medidas de gestión para el Parque Nacional del Pico Basilé. Imprescindible también en este proyecto fue el apoyo de los colaboradores: Alfonso García Ávila (increíble todo el apoyo y lo que aprendimos de ti) y Marta Luisa Almedia dos Santos (productora y gestora de lo que hiciera falta). Fuisteis familia e hicimos sueños realidad, dejando nuestro granito (no tan pequeño) de arena en la conservación de Guinea Ecuatorial.

Por último, a todos los buenos amigos que hice en Guinea y que conservo aun, que me hicieron la vida más fácil y divertida, vosotros sabéis bien quienes sois pues sois amigos del alma.

A mis niños, que fueron y son mi familia: Didier, Luidgi y Hector. A sus padres Super y Belinda, y también a Miglo y a Javi, a la abuela, y los demás vecinos de Los Ángeles, con especial cariño y agradecimiento: Ernesto y Alfonso.

A mis amigos y familia en España, por su apoyo constante.

Y a mis padres, a quienes les debo todo, y sin los que nada hubiera sido posible.

Abstract

The unsustainable harvest of wildlife threatens global biodiversity and the livelihoods of millions who depend on it for food and income. Effective conservation must balance wildlife protection with human development needs. On Bioko Island, particularly in the Pico Basilé National Park (PBNP), conservation efforts have been undermined by ongoing unsustainable wild meat hunting inside and outside the park's borders. This thesis investigates wild meat hunting by communities around PBNP, focusing on its contribution to rural diets and incomes while exploring solutions tailored to local circumstances.

Through direct observation, interviews, and consumption diaries from 155 households in 10 villages, this research examined whether wild meat was a significant source of protein or income and explored factors influencing this reliance. In-depth studies conducted in two villages—Basilé Fang (engaged in commercial hunting) and Basilé Bubi (subsistence hunting)—allowed for further investigation into whether households involved in commercial hunting were economically and nutritionally advantaged compared to those practicing only subsistence hunting, due to higher income from the wild meat trade and greater access to wild meat protein.

Overall, wild meat was not a primary source of protein for communities around the PBNP, as they generally had access to domestic meat and fish, frozen and imported. However, wild meat provided a significant source of income, comparable to that from wage employment, although wage work was typically preferred. Commercial hunting did not result in higher wild meat consumption unless access to alternative protein sources was also limited.

This study also highlights the importance of local biological data collection for species like the Bioko blue duiker to assess the sustainability of its harvesting and demonstrates the value of participatory research in supporting adaptive wildlife management. Managing protected areas for ecotourism emerges as a promising strategy to reduce hunting pressure, create jobs, and strengthen the economy. Ecotourism can provide sustainable livelihoods while promoting conservation by employing hunters as wildlife guards or park guides. Long-term financial support for institutions and partners is critical to realising this potential.

In addition to focusing on protected areas, efforts should explore developing local animal protein sources and continue supporting conservation training and awareness campaigns to ensure the sustainability use of wildlife, as well as the community livelihoods on Bioko Island.

Resumen

La caza insostenible de la fauna salvaje amenaza la biodiversidad mundial y los medios de vida de millones de personas que dependen de ella para alimentarse y obtener ingresos. Una conservación eficaz debe equilibrar la protección de la fauna salvaje con las necesidades de desarrollo humano. En la isla de Bioko, especialmente en el Parque Nacional de Pico Basilé (PBNP), los esfuerzos de conservación se han visto socavados por la continua caza insostenible de carne salvaje dentro y fuera de los límites del parque. Esta tesis investiga la caza de carne salvaje por parte de los pueblos de los alrededores del PBNP, centrándose en su contribución en la dieta e ingresos rurales, al tiempo que explora soluciones adaptadas a las circunstancias locales.

A través de la observación directa, entrevistas y diarios de consumo en 155 hogares de 10 aldeas, esta investigación examinó si la carne salvaje era una fuente importante de proteínas o ingresos, y exploró los factores que influían en esta dependencia. Los estudios en profundidad realizados en dos aldeas -Basilé Fang (dedicada a la caza comercial) y Basilé Bubi (caza de subsistencia)- permitieron investigar más a fondo si los hogares dedicados a la caza comercial se veían favorecidos económica y nutricionalmente en comparación con los que sólo practicaban la caza de subsistencia, debido a los mayores ingresos procedentes del comercio de carne silvestre y al mayor acceso a la proteína de la carne silvestre.

La carne silvestre no era una fuente importante de proteínas para las comunidades de los alrededores del PBNP, ya que generalmente tenían acceso a carne doméstica y pescado, congelados e importados. Sin embargo, la carne de caza constituía una importante fuente de ingresos, comparable a la del trabajo asalariado, aunque normalmente se prefería el trabajo asalariado. La caza comercial no se tradujo en un mayor consumo de carne salvaje a menos que el acceso a fuentes alternativas de proteínas también fuera limitado.

Este estudio también pone de relieve la importancia de la recogida local de datos biológicos sobre especies como el duikero azul de Bioko para evaluar la sostenibilidad de su captura y demuestra el valor de la investigación participativa para apoyar la gestión adaptativa de la fauna salvaje. La gestión de zonas protegidas para el ecoturismo se perfila como una estrategia prometedora para reducir la presión cinegética, crear empleo y reforzar la economía. El ecoturismo puede proporcionar medios de vida sostenibles al tiempo que fomenta la conservación empleando a cazadores como guardas de la fauna salvaje o guías de parques. El apoyo financiero a largo plazo a instituciones y socios es fundamental para aprovechar este potencial.

Además de centrarse en las áreas protegidas, los esfuerzos deben explorar el desarrollo de fuentes locales de proteína animal y seguir apoyando las campañas de formación en conservación y concienciación para ganrantizar la sostenibilicac de la vida salvaje y los medios de subsitencia de la comunidad en la isla de Bioko.

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Abbreviations and Acronyms

AAD	Asociación Amigos de Doñana
ANDEGE	Amigos de la Naturaleza de Guinea Ecuatorial
BB	Basilé Bubi village
BBPP	Bioko Biodiversity Protection Program
BF	Basilé Fang village
CPUE	Catch per Unit Effort
EUEAPF	Escuela Universitaria de Estudios Agropecuarios Pesca y Forestal
FMA	Facultad de Medio Ambiente
GCSR	Gran Caldera Scientific Reserve
GEF	Global Environment Facility
INDEFOR-AP	Instituto Nacional de desarrollo Forestal y Gestión del Sistema de Áreas Protegidas
IUCN	International Union for Conservation Nature
KFI	Kidney Fat Index
MPyMA	Ministerio de Pesca y Medio Ambiente de Guinea Ecuatorial
NSPA	National System of Protected Areas
PBNP	Pico Basilé National Park
PBR	Potential Biological Removal index
r_{max}	Maximum Intrinsic rate of natural increase
SNAP	Sistema Nacional de Áreas Protegidas
UICN	Unión Internacional para la Conservación de la Naturaleza
UNDP	United Nations Development Programme
UNGE	Universidad Nacional de Guinea Ecuatorial

Chapter 1: INTRODUCTION








Photo captions can be found in Appendix P

1.1 Over-exploitation of wild meat in tropical forests

Humans have hunted wild animals for food for thousands of years, and this practice remains prevalent worldwide today. While hunting for sport or recreational purposes has gained popularity, particularly in temperate, high-income countries such as those in Europe, the USA, and Canada, hunting for meat continues to be common in tropical and subtropical regions (Robinson and Bodmer, 1999; Fa *et al.*, 2022). In these areas, hunting remains a crucial source of animal protein, micronutrients, and income for many people (Milner-Gulland *et al.*, 2003; Wilkie *et al.*, 2005; Sarti *et al.*, 2015; Van Vliet *et al.*, 2017a).

In Africa, the meat from wild animals has been referred to as "bushmeat" (meat from the bush). Though this term has been widely used, the IUCN–World Conservation Union General Assembly in 2000 agreed to use "wild meat" to refer to terrestrial wild animals used for food worldwide (IUCN World Conservation Congress 2000). Coad *et al.* (2019) also adopt this definition and suggest the review of the Secretaría del Convenio sobre la Diversidad Biológica (2011) description of wild meat hunting, which refers to 'the harvesting of wild animals in tropical and subtropical countries for food and for non-food purposes, including for medicinal use' to focus only on the hunting of wild animals for their meat anywhere in the world.

The wild meat trade, in its broadest sense targets all invertebrates, amphibians, insects, fish, reptiles, birds, and mammals. However, in terms of weight and numbers, mammals constitute most of the trade (Fa and Brown, 2009; Benítez-López *et al.*, 2017). Among mammals, ungulates are the most significant group. In Neotropical forests, peccaries, deer, and tapirs (the largest animals on the continent) are preferred game, while in Africa, forest duikers and pigs, and in Asia, pigs and deer are heavily hunted and consumed (Robinson and Bennett, 2000).

Wild meat is consumed by rural communities and urban residents (Fa, 2000; Milner-Gulland and Clayton, 2002). Thus, many people benefit from this food source, including those who eat it as part of a forest-dependent subsistence lifestyle, those who trade and transport it to all points along different supply chains, and those who consume it in restaurants and homes, often far from the source habitats (Nasi *et al.*, 2008).

Over the past few decades, there has been a measurable increase in the scale of offtake and consumption of wildlife from forest areas in the tropics and subtropics. Accelerating human population growth, modernisation of hunting techniques, and greater accessibility to remote forest areas have promoted the commercialisation of wild meat from rural to urban areas (Kümpel, 2006; Fa and Brown, 2009). This has increased pressure on tropical forest species, particularly large-bodied species, which have declined rapidly (Ripple *et al.*, 2016). Hunters often target these species first because they provide the highest return on investment (Bennett *et al.*, 2002). However, they have low reproductive rates, large home ranges, and naturally low population densities (Cardillo *et al.*, 2005). Evidence suggests that many medium and large vertebrate species have experienced dramatic population declines (Hart, 2000; Walsh *et al.*, 2003; Cardillo *et al.*, 2005; Maisels *et al.*, 2013; Harrison *et al.*, 2016), and in many cases,

local extinctions (Van Vliet *et al.*, 2007; Jimoh *et al.*, 2013; Harrison *et al.*, 2016) due to overhunting.

Although habitat loss, degradation, and fragmentation are also key drivers of species losses, there is a consensus that most mammals experiencing local extinctions in otherwise suitable habitats are species targeted by hunters (Ripple *et al.*, 2016; Bogoni *et al.*, 2018). This human-driven depletion and disappearance of medium- and large-sized vertebrates, known as defaunation, is one of the most pervasive threats to biodiversity in the tropics and subtropics (Milner-Gulland *et al.*, 2003; Galetti and Dirzo, 2013; Dirzo *et al.*, 2014). Concern over this issue has generated much research attention (Fa *et al.*, 2022) and has promoted international intervention programs, such as the "bushmeat crisis taskforce" (Bennett *et al.*, 2002; Eves *et al.*, 2008) and more recently, the EU-funded initiative, Sustainable Wildlife Management Program (SMW, 2024).

The impact of overexploitation of wildlife for food and non-food purposes has been considered more severe in Asia (Corlett, 2007; Harrison, 2011; Harrison *et al.*, 2016), followed by Africa (Fa and Brown, 2009), with some authors warning that it was becoming increasingly severe in the heart of Amazonia (Peres, 2000; Silva Regueira and Bernard, 2012; Parry *et al.*, 2014). These continental differences obey a clear chronological sequence that reflects human population pressures and major impacts of development and forest loss in the three continents (Fa and Peres, 2001).

The situation in Asia differs from that in the other continents because of the reliance on large-scale wildlife trade involving long-distance, international trade chains (Esmail *et al.*, 2020). In Africa, some hunters participate in criminal networks that facilitate the global trade of animal carcasses (see e.g., Chaber *et al.* (2010)) and their parts, such as elephant ivory and rhino horn (United Nations, 2020), and more recently, pangolin scales (Challender *et al.*, 2020). However, a significant proportion of hunting of wild animals in Africa is undertaken by rural communities and Indigenous Peoples to meet their nutritional needs and earn some income (Lescuyer and Nasi, 2016). Despite this, an increasing amount of wild meat is sold in local or national markets.

Levels of wild meat extracted in the Congo Basin, which includes data from markets, show that about 5 million tons (Fa and Peres, 2001; Fa *et al.*, 2002a; Nasi *et al.*, 2011) are extracted annually and impact around 60% of hunted mammals species (Fa *et al.*, 2003). Such exploitation levels are around twice the level of production calculated for the hunted species and could drastically reduce animal populations in the medium to long term (Fa *et al.*, 2002a).

The loss of wildlife through overhunting has significant effects. First, it leads to biodiversity loss and the consequent degradation of essential ecosystem processes and services. This includes critical cascading effects on seed dispersal, forest regeneration, and trophic relationships (Emmons, 1989; Redford, 1992; Nasi *et al.*, 2011; Galetti and Dirzo, 2013; Dirzo *et al.*, 2014). Second, it threatens the livelihoods of millions of people who depend on wild meat for food and income (Van Vliet *et al.*, 2012). Ensuring that wildlife hunting is sustainable is crucial for both the long-term benefits to people and the conservation of species and ecosystems (Bodmer and Robinson, 2004).

There is increasing attentiion to finding practical solutions to the wild meat trade that involves its sustainable use (Rowcliffe, 2002; Bennett *et al.*, 2007). Establishing sustainable hunting practices is a complex process that must integrate the socioeconomics of rural people, species' biology, institutional capacities, and national and global economic pressures (Bodmer and Robinson, 2004). In the following sections, I will discuss these various elements.

1.2 Ensuring wildlife hunting sustainability

Hunting is sustainable when the harvest does not exceed the production rate. The harvest rate is driven by consumer demands on one hand and controlled by the socioeconomic, cultural, and political context on the other. The production rate of the resource is determined by the density of individuals and per capita reproductive rates, both of which depend on the species and the environment in which it lives (Bennett and Robinson, 2000; Parker *et al.*, 2009).

The first step in the process of achieving a sustainable harvest of a hunted species is to ensure biological sustainability. This means maintaining the population at a density high enough to guarantee its long-term persistence and the persistence of the ecosystem components it influences. Additionally, social sustainability must be ensured, which involves safeguarding cultural appropriateness, social support, and institutions that can function long-term. Finally, financial sustainability is necessary, meaning the activity must outcompete unsustainable alternatives in profit generation (Sample and Sedjo, 1996; Milner-Gulland and Rowcliffe, 2007).

These ideas align with the definition of sustainable use given in Article 2 of the Convention on Biological Diversity: Sustainable use means the use of the components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations (CBD 1993).

Therefore, techniques for obtaining information about the species' biology, habitat requirements, and hunting's effects on population dynamics are needed. Additionally, it is crucial to understand the human context within which hunting occurs, who is involved, their motives, and how the culture and institutions drive their exploitation patterns (Milner-Gulland and Rowcliffe, 2007).

1.2.1 Measuring biological sustainability

1.2.1.1 Harvest models based on biological indicators

The demographic viability of many hunted vertebrate populations depends on the rate at which they are harvested, the total hunting area exploited, and the site-specific productivity of different target species (Peres and Nascimento, 2006). Thus, many algorithms used for assessing biological sustainability require knowledge of the rate of population increase and abundance. Some have had a greater degree of acceptance due to their simplicity. This is the case of the production model (Robinson and Redford,

1991), which has become a standard in sustainability analyses, accounting for over 34% of all assessments (Weinbaum *et al.*, 2013).

This model employs site-specific density (*D*) or density at carrying capacity (*k*), which can be obtained from data collected in unexploited or lightly hunted areas or from empirical relationships between density, diet and body size. It also utilizes the intrinsic rate of population increase (r_{max}), which is the maximum per capita growth rate and can be estimated using Cole's (1954) equation:

$$1=e^{-r_{max}} + be^{-r_{max}(a)} - be^{r_{max}(w+1)}$$

where *a* is the age at first reproduction, *w* is the age at last reproduction, and *b* is the annual birth rate of female offspring per reproductive female. Since this formula assumes the unrealistic assumption that there is no mortality of juveniles or adults before age *w*, Robinson and Redford (1991) suggested using the average life span of a species as an index of the number of animals that would have died in the absence of human hunting (*F*). They proposed that human harvest might be able to take 0.6 of the production in very short-lived species (those whose age of last reproduction is < 5 years), 0.4 of the production in short-lived species (those whose age of last reproduction is 5 - 10 years), and 0.2 of the production in long-lived species (those whose age of last reproduction is > 10 years).

Using these parameters, Robinson and Redford (1991) calculate the maximum possible production (and maximum possible sustainable harvest) of a population based on the logistic model of population growth as follows:

$$P_{max} = D\,(e^{r_{max}} - 1)\,F$$

or

$$P_{max} = 0.6k\,(e^{r_{max}} - 1)\,F$$

(assuming that the maximum production for a prey population is at around 60% of its carrying capacity)

and this P_{max} can then be compared with actual data on offtakes.

As Robinson and Redford (1994) themselves stated, their model only allows the evaluation of whether an actual harvest is not sustainable (whenever harvest exceeds maximum possible production) but not whether it is sustainable since low harvests might be a consequence of depleted game densities, less than maximum birth rates, higher than minimum mortality rates, etc. Other authors have also warned of the excessive simplicity of this index. Slade *et al.* (1998) suggest that the multiplicative factors (F) that account for natural mortality tend to overestimate growth rates and maximal production (and thereby underestimate overharvesting) and suggest some alternative computations of $e^{r_{max}}$ that depend on more realistic estimates of pre-reproductive an adult survival. Weinbaum *et al.* (2013) sensitivity and specificity results also support the argument that the Robinson and Redford model poorly classifies unsustainability.

On the other hand, Slade *et al.* (1998) analysis also suggests that in other situations, Robinson and Redford's model may be too conservative as it underestimates maximum rates of increase for some species compared to production estimates from complete life tables. This statement fits in with the fact that some harvested species at a level that, according to Robinson and Redford's model would be unsustainable, have been maintained over time (Alvard *et al.*, 1997; Novaro *et al.*, 2000; Ohl-Schacherer *et al.*, 2007; Koster, 2008). Other authors also address the issue of the high simplicity of this index and its shortcomings (Milner-Gulland and Akçakaya, 2001; Van Vliet and Nasi, 2008).

An alternative to Robinson and Redford's model is Bodmer's model (Robinson and Bodmer, 1999), which uses fecundity rates instead of r_{max} to calculate population production. However, when tested, it also turned out not to be sufficiently precautionary, and therefore, like Robinson and Redford's, is likely to overestimate sustainable extraction levels (Slade *et al.*, 1998; Milner-Gulland and Akçakaya, 2001).

Milner-Gulland and Akçakaya (2001) found that another similar method, used for marine mammal management, was more precautionary and reduced the risk of extinction considerably compared to the Robinson and Redford, Bodmer, and logistic models: The National Marine Fisheries Service (NMFS) index (also called the Potential Biological Removal index-PBR), employs an estimate of the current population abundance instead of carrying capacity and explicitly incorporates uncertainty. This study drew attention to the fact that the most used indicators for assessing the sustainability of wildlife hunting 'do not perform well under realistic conditions' (p.686). Thus, Milner-Gulland and Akçakaya (2001) suggest using methods that explicitly incorporate uncertainty (Barychka *et al.*, 2020). They state that such methods already exist in the fisheries literature and in the Red List of Threatened Species, and suggest an exchange of ideas between disciplines to improve the assessment and management of hunted species.

In a subsequent review, Weinbaum *et al.* (2013) show how, despite the favourable results of the PBR over the Robinson and Redford and the Bodmer indices and its popularity in fisheries and marine mammal, turtle and seabird bycatch studies, the approach remains very rarely used and cite only two studies related to wild meat where it has been applied (Cowlishaw *et al.*, 2005a; Dillingham and Fletcher, 2008). One of the criticisms of this index is that it is too precautionary and, therefore, does not facilitate maximum harvesting. In the context of wild meat, it is important to balance the species' needs and those of the people who depend on them; therefore, efforts should be made to develop models capable of maximizing yields and the persistence of populations (Weinbaum *et al.*, 2013).

In Milner-Gulland and Açakaya's (2001) simulation, full demographic models outperformed simpler models in population persistence and maximum harvest rates. The disadvantage is that while the latter models use only a few parameters (*K* depending on the model) and a simple equation to calculate the sustainable production level, the full demographic model is data-intensive, requiring life history information and knowledge of the many processes affecting populations, as well as the use of specific software packages to model populations.

Obtaining realistic reproductive parameters for hunted species in the dense vegetation conditions of tropical forests is particularly challenging yet essential for effective conservation. The complexity of the environment, combined with the elusive nature of many species, makes it challenging to gather accurate data on key biological parameters such as breeding rates, population sizes, and survival rates. These challenges are exacerbated when dealing with species subject to hunting pressure, as their populations may decline or their behaviours altered, further complicating data collection efforts.

The need for more realistic demographic and reproductive data from wild populations is a significant limitation in applying sustainability models (Van Vliet and Nasi, 2008; Mayor *et al.*, 2017). 6 Another problem identified in using these models, as highlighted by some authors (e.g. Peres, 2001; Sirén *et al.*, 2004; Novaro *et al.*, 2005; Pople *et al.*, 2007), has been the need for a spatial component. Studies assessing sustainability at very localised scales may detect 'depleted' populations. However, this localised depletion might not reflect the broader ecological context, where hunting could be balanced by dispersing animals from non-hunted populations in surrounding areas (Weinbaum *et al.*, 2013).

Weinbaum *et al.* (2013) recommended that future studies focus on the Potential Biological Removal (PBR) index and the full demographic model and emphasised the need for research to obtain primary life history data for exploited species whose biology remains poorly understood. They also stressed the importance of long-term population monitoring. Biological systems are multifaceted and influenced by deterministic processes and stochastic events (Ling and Milner‐Gulland, 2006), as well as randomness and uncertainty in estimating the above biological parameters and hunting pressure (Barychka *et al.*, 2020). Therefore, a prey population can only be known to be sustainably exploited when there has been sufficient time to observe whether population estimators are sufficiently accurate, predictions are met, and the system is stable (Fa *et al.*, 2022).

Although direct monitoring of population abundance or demography may be the ‘golden standard’, Weinbaum *et al.* (2013) proposed using catch per unit effort (CPUE) estimates as an alternative when direct measurements of density and demography are challenging to measure in the field.

1.2.1.2 Catch per unit effort (CPUE) as an index of abundance

The most direct way to assess a species' biological sustainability is to regularly estimate its population size and ensure it does not consistently decline, especially below critical thresholds like the population size at maximum sustainable yield (NMSY) (Milner-Gulland and Rowcliffe, 2007). Population estimation is crucial for conservation monitoring and forms a vital part of research in ecology and population biology (Caughley, 1977; Sutherland, 1996).

There is extensive literature on techniques for estimating animal abundance (for an overview of the methods, see Milner-Gulland and Rowcliffe, 2007). New developments and additions to the field, such as advances in camera trap technology and analytical techniques (e.g., (Sollmann *et al.*, 2013; Howe *et al.*, 2017; Miles *et al.*, 2024), continue

to enhance the field. Although estimating abundance is the most effective assessment method because it directly measures the variable of interest, it is challenging in environments such as tropical forests, where access and observation of animals are more complex (Milner-Gulland and Rowcliffe, 2007).

An alternative, cheaper, and simpler way to measure the abundance of a prey population is through catch data, which can be obtained directly from hunters. This provides information not only on the relative abundance of species but also on the hunting system and, as seen below, in these times of increasing attention towards community-based management of tropical wildlife, it also provides a simple method of monitoring sustainability with minimal outside support (Rist *et al.*, 2010; Ingram, 2020). The use of catch data as an index of abundance is based on the following equation:

$$H = q \cdot E \cdot N$$

where H is the yield or number of animals removed by hunting, which depends on catchability q (a species-specific constant quantifying how difficult or easy it is to hunt the species), hunting effort E (a measure of time or other inputs that go into hunting), and population size N, i.e., if hunter effort or population size increases, the number of individuals killed will increase. In the same way, if the number of animals caught increases for the same hunting effort, it would be due to the rise in the population and, conversely, to a decrease ($H/E \propto N$). This ratio of yield to effort expended to achieve it is the catch per unit effort (CPUE). Thus, in principle, CPUE can act as an index of population abundance and could be monitored to detect declines in the same way as abundance itself (Milner-Gulland and Rowcliffe, 2007).

1.2.1.2.1 Shortcomings

Despite its widespread use in fisheries, the CPUE model has several shortcomings that must be considered. It has long been recognised that the assumption that catch is directly proportional to effort may only sometimes be valid (Beverton and Holt, 1957). CPUE may decline more slowly than abundance, giving a false picture of stability when it is not (Hyperstability) or may decline faster, indicating depletion when it is not (Hyperdepletion). This is because both exploiters and prey behaviour can influence this relationship. For example, suppose exploiters know where prey can be found. In that case, the effort will not be randomly distributed, and the catch may reflect abundance in a small number of high-density locations rather than the whole area, resulting in hyperstability (Salthaug and Aanes, 2003). The same would be true if hunters continually move to patches with the highest abundance. CPUE is calculated as total catch over total effort instead of the mean of local values weighted by area (Hilborn, 1992; Quinn, 1999). The increasing efficiency of harvest methods over time is an additional reason why the exploiter's behavior can lead to hyperstability (Hilborn, 1992). As for the animal's behaviour, if it is predictable and individuals or groups remain easy to find despite reduced abundance, or individuals become more clustered as depletion progresses (due to habitat selection or conspecific attraction), hyperstability will also be shown (Fréon *et al.*, 1993; Milner-Gulland, 1998). Some of the most well-known fisheries collapses in the world have been ascribed to hyperstability, such as the Northern Cod (Rose and Kulka, 1999; Shelton, 2005). Hyperdepletion occurs more rarely but has also been reported (Hilborn, 1992). It may occur when the prey learns to

avoid capture, when the effectiveness of the exploitation method decreases over time or due to high handling time rather than searching. It may also occur when exploiters remain in heavily depleted localities, and CPUE is calculated for a wider area, including less depleted patches (for being less attractive for hunting). For a more detailed explanation of non-proportionality causes see Rist (2007).

Consequently, to use CPUE as an index of abundance, it is essential to understand the behaviour of both the harvesters (e.g., their movement patterns, any changes in technology or any other factors that increases capture efficiency, and whether handling time is variable and exceeds capture time) and the prey (e.g., whether they learn to avoid capture or if group structure changes as depletion progresses) so that it is possible to control the influence of these factors on our measures and thus have a robust and unbiased index. This will allow us to determine to what extent hunting is responsible for population declines compared to other factors, thereby enabling the development of appropriate management measures.

1.2.1.2.2 Validation of CPUE use in wild meat harvesting systems

The use of CPUE as an index of abundance represents a central subject in the field of fisheries management science, where it is frequently the only available method for estimating abundance. However, this approach has been less explored and used in terrestrial systems (Rist, 2007). To assess the accuracy, power, and resolution of the use of CPUE for monitoring the abundance of tropical forest species, Rist (2007) uses a combination of fieldwork and modelling approaches and provides the first detailed exploration and test of CPUE in this context. Following Rist's evaluation, a number of studies have used CPUE to assess populations in bushmeat hunting systems (Peres and Nascimento, 2006; Parry *et al.*, 2009; Gill *et al.*, 2012; El Bizri *et al.*, 2018; Fonteyn *et al.*, 2024). However, new assessments have yet to be conducted on its accuracy as an abundance index.

Rist (2007) first investigated and explicitly quantified the sources of bias that exist between different hunting effort measures used in the wild meat hunting literature (such as time spent hunting or units of hunting equipment) that may or may not reflect the actual biological impact of hunting (in terms of the strength of correlation with prey mortality). Her results show that the reliability of the different effort measures can vary according to hunting method, hunting location and the species being hunted; absolute time measures must therefore be adjusted, and trapping effort will be best measured in terms of trap numbers and composition (see Rist *et al.*, 2008 for details). This study also shows that catch measures taken from the hunter's perspective are made up of what is caught and do not include discarded animals (e.g. wounded and escaped or rotten), which nevertheless form part of the total number of animals killed. It is therefore also necessary to adjust the measurement of catches to consider this ‘wastage’. While Rist *et al.* (2008) argue that the generality of their findings to other sites may depend on the type of hunting system in place, their analysis guides other researchers in collecting catch-effort data that more accurately represent the true biological impact of hunting.

In second place, using unbiased data on CPUE (from weekly hunter interviews) and independent abundance estimates (from line transect surveys), Rist (2007) investigates the CPUE-abundance relationship for several species (four primates and one duiker).

She found a significant positive relationship for the trap-hunted duiker (blue duiker) and one of the four gun-hunted species of primates (black colobus). Both species comprised a large proportion of the hunting offtake. For CPUE to be proportional to abundance, prey must be taken on every encounter; otherwise, the catch would underestimate population size (Alvard 1993; Alvard 1995). The black colobus was a preferred monkey species among hunters in Equatorial Guinea (Kümpel 2006), which, according to Rist (2007) suggests that it was shot at every encounter, unlike the other less preferred species, which could be discarded in favour of this one.

The study by Rist (2007) therefore, finds encouraging support for the potential of CPUE as an index of abundance, with a proportional relationship between CPUE and abundance demonstrated for some of the principal wild meat prey species (see also Puertas and Bodmer, 2004). However, evidence that hunter-prey selection can potentially affect the observed relationship between CPUE and abundance, together with the possible additional influence of species biology, means that their results cannot be generalised to other species. She, therefore, encourages further comparative studies in different locations and contexts. She also suggests that a useful approach might be using a few preferred prey species as 'indicators' of overall community status.

The CPUE model, as an index of abundance, can also be a useful tool for locally based monitoring. Rist *et al.* (2010) compared multispecies catch-effort data reported by locally based methods (hunting camp diaries and weekly interviews with hunters) with those provided by a professional technique (hunter follows of the same hunting trips) and found a strong correlation. Locally based methods were only slightly less accurate than the professional ones. Still, they had vastly lower financial and time costs and were much more cost-effective overall (and had the advantage of involving resource users in monitoring). What they did consider necessary (after running a series of simulations) to maximize the power of the monitoring program to detect changes in CPUE, was that hunter participation rates should be high to capture different levels of efficiencies (based on the varying ability of hunters). Noss *et al.* (2004) also investigated the possibility of using CPUE for hunter self-monitoring in the Bolivian Chaco and found it feasible if accompanied by some independent and complementary research (monthly activity records, participant-observation of hunting activities, household surveys of resource use, informal interviews or questionnaires, and focused research on species). Kümpel *et al.* (2010a) also supports using CPUE as a community management tool to monitor actual sustainability elsewhere in Equatorial Guinea.

In summary, if CPUE is to be used for predictive purposes to estimate abundance, the above-mentioned sources of error must be identified and incorporated into the analysis. Considerable amounts of temporally and spatially stratified data would be required, which are, however, feasible to achieve using locally based methods (Rist, 2007).

1.2.1.2.3 Other considerations

When using the CPUE model, it is essential to bear in mind that, despite having controlled for possible sources of bias and having managed to collect data that accurately reflect abundance, there may be factors other than hunting also acting on abundance. For example, other anthropogenic threatening processes (Isaac and Cowlishaw, 2004), habitat factors (Peres, 1997), natural stochasticity (Beddington & May 1977) or species interactions (Karanth *et al.*, 2004). Although teasing these factors

apart is notoriously complicated (White *et al.*, 2007), it is necessary to use an approach that isolates their independent effects and considers the broader context of the hunting system and the biology of each prey species (Rist *et al.*, 2009).

We must also remember that population declines are not necessarily a clear indicator of unsustainable exploitation. For example, when a population is first exploited with sustainable effort, it initially declines until a new equilibrium is reached. This can take up to a decade in some cases (Milner-Gulland and Rowcliffe, 2007). Conversely, a stable population does not necessarily indicate sustainability since an overexploited population may be stable but small and as such at risk (Milner-Gulland and Rowcliffe, 2007).

1.2.1.2.4 Species aggregated CPUE

Multi-species harvesting systems, where a single gear type targets multiple species simultaneously, are widely used in many ecosystems worldwide (Rist, 2007). Analysing species-aggregated relationships between effort and catch, such as Catch Per Unit Effort (CPUE), can provide valuable insights for resource management. These relationships offer a glimpse into exploitation's socioeconomic benefits and help understand ecosystem-level responses to harvesting pressure (Lorenzen *et al.*, 2006).

However, interpreting aggregated CPUE patterns requires caution. If catchability differs among the targeted species, CPUE may not reflect community abundance accurately (Maunder *et al.*, 2006). Moreover, even when the level of effort is high, community biomass can be maintained through the successive replacement of large, slow-growing predator species by smaller, faster-growing species (Lorenzen *et al.*, 2006). Consequently, aggregated CPUE should be used cautiously as an indicator of the impacts of exploitation on biological communities, as it may only partially capture the complex ecological dynamics at play (Lorenzen *et al.*, 2006).

1.2.1.3 Key population parameters from CPUE

Catch and effort data from intensive harvests over short periods (so that no natural mortality or recruitment occurs) can also be used to estimate the initial population size. The following hypothetical example from Kirkwood (2001) —quoted in Rist (2007)— illustrates the principle: suppose 1000 fish are caught quickly, and the CPUE before and after the harvest is 8.73 and 6.16 fish/hour, respectively. This would suggest that the harvest reduced the population by 8.73-6.16 / 8.73 = 29.4% so that the initial population size can be estimated as 1000/0.294 = 3396 fish. The problem is that in the case of offtake-based methods, even if collected over short periods, the removal can stimulate immigration by creating an unoccupied space attractive to colonising individuals, or the harvesting activity triggers emigration. This cannot be detected or controlled by using catch data alone. Thus, if there is any suspicion that migration might occur, results should be considered suspect. Alternatively, an open population model can be used, as discussed below (Milner-Gulland and Rowcliffe, 2007).

1.2.1.3.1 Dynamic models

Dynamic models do not assume that the population is at equilibrium and provide a way around these problems. The catch-effort time series models the underlying changes in population size from one time to the next by adding the population growth (*G*) and subtracting the catch (*C*). The basic idea is to take an initial estimate of the population size at the beginning of the data series available, then use the model to predict the whole time series:

$$N_{t+1} = N_t + G_t - C_t$$

growth can be given in any appropriate population growth model; the logistic model is frequently used as a default model in the absence of evidence for an alternative structure. In this case, Equation 1 becomes:

$$N_{t+1} = \frac{K}{1 + e^{-r_{\max}\frac{K - N_t}{N_t}}} - C_t$$

The parameter values (K, r_{max}, N and q) are adjusted to best fit the predicted-to-observed time series of abundance (CPUE) or catch data. Hilborn and Mangel (1997) provide an excellent introduction to model fitting, while the Catch Effort Data Analysis package (Kirkwood *et al.*, 2003) provides an accessible tool for such dynamic models. While this approach is potentially powerful, a reasonably long CPUE time series is needed to resolve all these parameters. Additionally, the data must exhibit strong contrasts, meaning there should be substantial variation in the underlying population size over time and in the amount of effort applied. Ideally, the system should experience recovery followed by further depletion, or vice versa. If the system remains in a steady state during monitoring, the data will provide no useful information, regardless of the time series length. Dynamic models often produce unrealistic parameter values with large standard errors when the data lacks sufficient variation. Results should be checked to ensure they are both intuitive and reasonably precise.

1.2.1.4 Early warning systems

Apart from the models above, other measures can indicate, but not demonstrate, whether wild meat hunting is sustainable (Fa *et al.*, 2022). These are more indirect approaches that provide a means to use various information when the information needed to carry out the more direct methods mentioned above is unavailable (Milner-Gulland and Rowcliffe, 2007). Collecting these data is essential as they can act as early warning systems, identifying situations where more detailed monitoring is urgently advisable (Fa *et al.*, 2022). They are also easier for local managers to understand and apply, and some authors have demonstrated their utility in local monitoring plans (see Marrocoli *et al.*, 2019). Although separately, some indicators may not be considered fully informative cumulatively and in combination with other information, they can gain considerable strength (Cowlishaw *et al.*, 2005a).

1.2.1.4.1 Changes in species composition

When several species can be subject to the same harvesting effort, species with lower intrinsic productivity will be overexploited first, partly because they tend to be larger and more profitable but also because they are simply more vulnerable (Pauly *et al.*, 1998; Milner-Gulland and Rowcliffe, 2007; Dirzo *et al.*, 2014). Thus, in principle, the species profile of offtake contains information on the state of the harvest system (Milner-Gulland and Rowcliffe, 2007). For example, the offtake of small rodents in places where large ungulates and primates were previously hunted almost certainly indicates over-exploitation (see Rowcliffe *et al.*, 2003; Koerner *et al.*, 2017). Studies such as Fa (2000), Albrechtsen *et al.* (2007) and Kümpel *et al.* (2010a) have used this indicator comparing two time periods, or Cronin *et al.* (2015a) assessing trends over a continuous 13-year period. More recently, Fonteyn *et al.* (2024) evaluated the effectiveness of 33 hunting offtake indicators, based on hunter reports, for monitoring wildlife degradation using camera trap surveys and faunal composition analysis data. The ratio of rodents to ungulates in offtake and the average body mass of all hunted species emerged as reliable and practical indicators of faunal degradation in hunting systems. A decrease in mean prey body mass has already been inferred to reflect a shift in the contribution of larger species in favour of smaller ones (see Ingram *et al.*, 2015). These indicators show significant promise for broader application in similar tropical forest settings.

The disadvantage of using these indicators is their generally low resolution, as they require drastic changes to be detected, so vulnerable species may already be heavily overexploited by the time they are detected. There may also be additional problems when the extraction profile is monitored at the market level or a remote endpoint of the trade rather than at the capture point. On the one hand, the original extraction profile may have been distorted after passing through the trade chain, e.g., protected species or species of low commercial value may be sold or eaten in the village, not reaching the market (Juste *et al.* 1995; Crookes *et al.* 2006 but see Allebone-Web *et al.* 2011). On the other hand, markets often have large catchment areas, which may mask local overharvesting problems. For example, hunters may move from depleted areas to less exploited areas and thus continue to hunt more vulnerable species. If additional information is available, for example, data on the origin of animals sold in the market, these changes can be detected (e.g. Albrechtsen *et al.*, 2007; Dupain *et al.*, 2012; Fa *et al.*, 2014). The more information on the hunting system there is, the better it is possible to interpret this, as well as other market and harvest indicators discussed below. The study by Cronin *et al.* (2015a) also shows the value of long-term studies of market dynamics (number and composition of species) combined with appropriately applied serial analyses.

1.2.1.4.2 Blue/Red Duiker index

Another indicator that is based on the empirically supported assumption that large, slow-reproducing species are more vulnerable to hunting and will decline or disappear more rapidly with increased hunting pressure (Wright, 2003) is the duiker index proposed by Yasuoka *et al.* (2015). It is calculated as the ratio of the (smaller) blue duikers (*Philantomba monticola*) to red duikers (a group consisting of several medium-

sized *Cephalophus* species). As hunting pressure increases, the number of red duikers, larger species more vulnerable to hunting, is expected to fall. In contrast, the number of blue duikers, a smaller, more hunting-resilient species, remains relatively constant. These predictions were fulfilled in Yasuoka *et al.'s* (2015) study on duiker densities in southeastern Cameroon.

Similarly, Hart's (2000) study on duiker densities in the Ituri forest, DRC, also found blue duikers better able to maintain their population under exploitation than red duikers. This study found that female blue duikers had a greater ability than red duiker females to accelerate sexual maturity (i.e. reach sexual maturity at an earlier age) in situations of increased hunting pressure; in addition, blue duikers were more tolerant to and thrive in human-modified landscapes. Other studies have used and discussed the duiker index (Marrocoli *et al.*, 2019; Breuer *et al.*, 2021), with Fonteyn *et al.* (2024) finding that the blue/red duiker index did not perform as well as other indicators.

1.2.1.4.3 Changes in population structure

If the harvest is sex or age-selective, the selected sex or ages will become less represented in the population (Milner-Gulland and Rowcliffe, 2007). For example, Hart's (2000) study in the Ituri forest showed how red duiker populations (a group consisting of four medium-sized *Cephalophus* species and the chevrotain *Hyemoschus aquaticus*) hunted with traps (which were selective towards adults) had more young animals and fewer adults in more heavily exploited areas, compared to less exploited or unexploited regions. The small blue duiker, however, did not show differences since, in heavily exploited areas, it counteracted the decrease in population density by reaching sexual maturity at an earlier age. If the harvest is unselective, the population may or may not become skewed towards juveniles, depending on the nature of density dependence (Milner-Gulland and Rowcliffe, 2007).

In Hart's (2000) study, red duikers were less capable than blue duikers of compensating for decreased population densities through increased reproduction when their numbers were depleted due to hunting. Similarly, in a study by El Bizri *et al.* (2020) on hunted pacas (*Cuniculus paca*) in the Amazon, a decrease in population density due to hunting was associated with higher pregnancy rates, which in turn led to a more significant proportion of juveniles in the population.

Given these findings, it is challenging to generalise the extent to which harvesting might alter the age structure of a population, if at all. Moreover, it is even more challenging to establish reference points for age structures that indicate overharvesting (Milner-Gulland and Rowcliffe, 2007). The variability in species' responses to population declines underscores the complexity of predicting and managing the impacts of hunting on age structure and overall population dynamics.

The study by Milner-Gulland *et al.* (2003) on saiga antelope (*Saiga tatarica*) demonstrated how the catastrophic decline in the number of adult males due to selective poaching for their horns led to a reproductive collapse within the population. However, in other cases, a highly skewed sex ratio may not necessarily impact population viability. Therefore, the sex structure of a harvest becomes a meaningful indicator of sustainability only when the natural sex structure is well understood and the potential

consequences of a skewed sex ratio on population viability can be accurately assessed (Milner-Gulland and Rowcliffe, 2007).

1.2.1.4.4 Spatial patterns of hunting yields

Changes in the distance travelled from base to reach hunting areas may be related to population depletion; hunters may deplete a closer or more accessible location and move to a more distant or inaccessible but less exploited area (Milner-Gulland and Clayton, 2002). However, this relationship is more complex, as other processes may cause people to move further afield to hunt. These must be considered before drawing conclusions (Milner-Gulland and Clayton 2002; Crookes et al. 2006).

This pattern may also reflect changes in species distribution. For instance, a vulnerable species may be extirpated locally within an actively hunted region where more resilient species are exploited, remaining only within distant areas (Ling & Milner-Gulland 2008; See also Hart 2000). When resilient prey species no longer satisfy hunter demand, hunters move to the more distant refuges of the vulnerable species. Again, factors other than hunting may also influence species distribution (e.g., changes in habitat) and need to be considered (see Rist *et al.*, 2009).

1.2.1.4.5 Prices and availability of wild meat and alternatives –Trends on harvesting costs

Trends in the price of wild meat on their own and combined with other information, such as quantity of species sold or prices of alternatives compared to wild meat, have also been used as indicators of the sustainability of bushmeat hunting (e.g. Albrechtsen *et al.* 2007, Cowlishaw *et al.* 2005a). If the price of wild meat increase can be considered an economic signal of diminished supply relative to demand (*Cowlishaw et al.* 2005, Weinbaum *et al.* 2013). The growing scarcity of wild meat will make it increasingly more expensive than its alternatives (Cowlishaw *et al.* 2005a). The increase in collection costs is also a significant factor, largely influenced by the distance travelled and transportation expenses (Cowlishaw *et al.*, 2005a, 2005b). Indeed, trends in harvest costs may be a more directly related indicator of resource abundance since market data on prices and quantities of species on sale can be influenced by multiple factors (e.g. taste preferences, law enforcement, environmental changes, technology changes), thereby confounding sustainability inference (Milner-Gulland and Clayton, 2002; Weinbaum *et al.*, 2013). Several authors have shown the importance of complementing market data with information on these other processes more directly related to resource abundance (e.g. spatial patterns of hunting yields and harvesting costs) to better infer sustainability (Milner-Gulland & Clayton 2002, Crooks et al 2006; see also Albrechtsen et al. 2007).

1.2.2 Understanding human setting to achieve social and financial sustainability

Once exploitation has been identified as unsustainable, interventions are needed to reverse the process. For these interventions to be successful, they must be socially acceptable and cost-effective. To do this, it is essential to understand the human setting in which the exploitation is taking place and to understand why this level of exploitation is occurring. The wild meat trade underpins many livelihoods and, in the case of forest-dependent communities, commonly acts as a safety net regarding protein and income in times of hardship (De Merode *et al.*, 2004; Allebone-Webb, 2009). We cannot, therefore, ignore the needs of the human population that uses this resource and develop actions that only guarantee biological sustainability (Milner-Gulland and Rowcliffe, 2007). To do so would only lead us to generate management recommendations that are inadequate or open to misuse (Ludwig, 1993; Gunderson, 1999). It is, therefore, necessary to seek solutions that satisfy both wildlife conservation objectives (encouraging regulations aimed at reducing the ecological impact of hunting) and human development objectives (considering the local need for sources of income and protein, as well as preserving cultural practices associated with hunting) (Coad *et al.*, 2019).

Therefore, understanding people's behavior towards natural resources is essential. This understanding requires a multidisciplinary approach. There is a wide range of fields addressing these relationships. These include history, politics, theology, cultural studies, development studies, ethics, economics, archaeology, ecology, and anthropology (Milner-Gulland and Rowcliffe, 2007). Each discipline offers unique insights into the complex interactions between human societies and natural resources.

Among these, the economic approach is critical when tackling the problem of wild meat overexploitation. When hunting is conducted as a commercial activity, wild meat becomes an economic commodity governed by the principles of supply and demand. Hunting systems operate as bio-economic systems, where biological and economic factors interplay. The population dynamics of harvested species, which represent the biological component of this bio-economic system, are closely linked to the economic incentives faced by harvesting households. These households must balance expected costs—opportunity costs and direct expenses—against the expected benefits, such as monetary income and food for the table (Milner-Gulland and Rowcliffe, 2007).The level of harvest mortality experienced by a population in a specific location and time is directly proportional to the harvesting effort exerted. This, in turn, determines the biological sustainability of the population.

This bio-economic perspective underscores the importance of integrating economic considerations into conservation strategies. By understanding the economic drivers behind hunting behaviour, interventions that align financial incentives with conservation goals can be designed to promote the sustainable use of wild meat resources.

While a comprehensive economic analysis is an optimal approach to evaluating the potential impact of conservation initiatives and the sustainability of hunting in the context of broader economic trends, it can be a challenging undertaking due to the sheer volume of data required (e.g., hunter profitability, quantity and price of the species of

interest, substitute goods, consumer income, inflation rate, etc.). For a detailed overview of the complexities involved, see Milner-Gulland (2001). However, one can focus on the various components of the system, which can be grouped into two categories (Milner-Gulland, 2001): the incentives faced by individual hunters (broadly speaking, the supply side) and market dynamics and consumer choice (broadly speaking, the demand side). Similarly, how individual incentives are translated to the market level is contingent upon the market structure, which must also be considered.

In the following sections, I will examine each of these components in greater detail, and the types of studies associated with them.

1.2.2.1 Consumers' decisions (demand)

Consumer behaviour in the context of wild meat consumption is a complex interplay of various factors, encompassing both economic and non-economic influences. On the economic side, consumer decisions are predominantly shaped by the price of wild meat, the cost of alternative protein sources, and household income levels. However, these decisions are not solely driven by economic considerations; cultural and political factors, such as preferences, taboos and government policies also play a crucial role.

A substantial body of research has focused on understanding the economic determinants of wild meat consumption, recognizing them as primary factors influencing consumer behaviour. Household surveys have been a key tool in this research, allowing for estimating how variables such as wealth, income, and the prices of wild meat and alternative foods impact consumption patterns. These surveys have provided insights into the dynamics of wild meat demand and have informed policy recommendations to regulate consumption and preserve wildlife.

For instance, policies that seek to limit the production or consumption of wild meat, whether through enforcement measures or taxation along the commodity chain, can be effective if they result in a significant shift in demand. However, such policies' success is contingent upon affordable alternative protein sources and the degree to which demand for wild meat is sensitive to changes in its availability and price. If consumers have limited access to substitutes or wild meat holds a strong cultural or economic value that outweighs price considerations, such policies may be less effective in the long run (Wilkie and Godoy, 2001).

Another policy approach that has been explored is the promotion of alternative, cheaper protein sources. This strategy assumes that wild meat and alternative proteins are substitute goods—meaning that an increase in the availability or affordability of one will lead to a decrease in the consumption of the other. This assumption is critical to the success of such interventions, as demonstrated in studies like those by Wilkie *et al.* (2005), which highlight the importance of economic substitution in reducing wild meat consumption. Additionally, improving consumer incomes will reduce wild meat consumption, as long as it is considered an inferior good—one for which demand decreases as income rises— within the target population.

These relationships are not universal and can vary significantly depending on the socio-economic and environmental context of the population. Generalisations about the effect of wealth on animal protein consumption may, therefore, be misleading (Fa *et al.*, 2009). Research in Gabon by Wilkie *et al.* (2005) and Starkey (2004) and in Rio Muni (Equatorial Guinea) by Fa *et al.* (2009) highlights these variations, emphasising the need for localised analysis.

Beyond the influence of wealth and prices, consumer behaviour in the context of wild meat consumption is also significantly shaped by preferences —based on taste, culture or spirituality. These non-economic drivers can influence consumption patterns, sometimes even outweighing economic considerations like price and availability, and should be considered alongside economic factors when analysing consumption behaviour and designing policies (Milner-Gulland and Rowcliffe, 2007; Van Vliet *et al.*, 2012).

This has significant policy implications. For example, when wild meat consumption—or the consumption of specific species—is driven more by cultural preferences than by price, demand may not significantly respond to price fluctuations, and alternative protein sources like cattle or fish may be less acceptable (Fa *et al.*, 2009). Studies by Anstey (1991) in Liberia, Fa *et al.* (2002b), East *et al.* (2005), and Kümpel *et al.* (2007) in Equatorial Guinea provide convincing examples of this. These studies also illustrate how preferences can differ within the same community, depending on social or ethnic groupings.

Moreover, preferences traditionally viewed as static—those associated with deep-seated cultural or spiritual heritage—are not immune to change. This change can be gradual and influenced by various factors such as urbanisation, exposure to different cultures, and generational shifts. The study by Luiselli *et al.* (2019) across Togo, Nigeria, Burkina Faso, and Niger provides valuable insights into this phenomenon. The research found that wild meat consumption patterns differed significantly between rural and urban areas, with younger urban populations showing a marked tendency to avoid wild meat. This trend towards "Westernisation," particularly among younger generations in urban settings, suggests that cultural preferences can evolve, potentially reducing the demand for wild meat in specific contexts.

The distinction between different species of wild meat is another important factor influencing consumer behaviour. The study by Schenck *et al.* (2006) in Gabon illustrates that demand for wild meat is not homogeneous; consumers differentiate between species based on factors such as taste, price, familiarity, tradition, and prestige. This differentiation affects the acceptability of substitutes like fish and chicken, which may be desirable depending on the species of wild meat they are meant to replace. The research by East *et al.* (2005) further complicates this picture by introducing the concept of "state" in their analysis, showing that for consumers in Bata, Rio Muni, the distinction between fresh and frozen products was more significant than that between wild and domestic meats. This finding indicates that consumer preferences are also influenced by the state of the food, with wealthier households tending to consume more fresh meat. In contrast, less affluent consumers opt for frozen products, often due to cost considerations.

East *et al.* (2005) also found that the most available species used as wild meat were often the most preferred and consumed, regardless of their price or size. This suggests that demand may not necessarily be biased towards the more vulnerable or larger-bodied species, as one might expect. Instead, the availability of species plays a crucial role in shaping consumption patterns. These insights are crucial for policy development, as they suggest that controlled demand for wild meat could be met through the sustainable harvesting of common, highly productive, and relatively resilient species. Additionally, promoting the development of domestic livestock as a viable alternative could help alleviate pressure on more vulnerable wildlife populations.

1.2.2.2 Producers' decisions (supply)

A similar scenario is presented for hunter's behaviour, the supply side. Hunters' incentives can be numerous and varied, and often interconnected (Lindsey *et al.*, 2013; Cawthorn and Hoffman, 2015). The individual's or household's economic situation and consumer demand are strong determinants, but there are also other social, cultural, political, and environmental factors that influence their behavior (Dobson *et al.*, 2019; Fa *et al.*, 2022).

We can divide hunters' behavior into two main blocks: first, the decision of whether to hunt, and second, if the decision is to hunt, how to do so. The latter includes a variety of decisions: hunting method, hunting area, and the spatial and temporal distribution of effort. Understanding as thoroughly as possible which external and internal factors influence these different decisions, and how they do so, will help to better predict the impact of hunting and its future trajectory, and to select more appropriate interventions to achieve the desired effect (Larrosa *et al.*, 2016; Dobson *et al.*, 2019).

For example, the likelihood that a given individual will 'abandon' hunting in favor of other economic activities may not be random, as younger or less efficient hunters are more likely to do so. This means that a decrease in the number of these hunters may not lead to an equivalent reduction in offtake (Coad *et al.*, 2013). Additionally, there may be personal circumstances related to the individual's skills or capacities that could prompt a change in behavior at any given time (Coad *et al.*, 2013). It is therefore necessary to identify the households that have a greater environmental impact and understand what their possibilities for change might be.

There are numerous studies that analyze hunters' behavior. Interviews, hunter follows and long-term offtake studies have been a key tool in these research. Dobson *et al.* (2019) review these studies and summarize the current understanding of these factors and the links between them. Their focus is on the factors influencing the selection of hunting methods and intensity (e.g., the temporal and spatial distribution of effort). Fa *et al.* (2022) also provide an interesting review of various studies focusing on non-economic factors such as taboos, preferences, or those associated with social status or reputation, which can bias prey selection contrary to the predictions of the optimal foraging theory. Although some very general patterns are evident, it is important to keep in mind that it is difficult to generalize, and that it is necessary to study the specific incentives driving our subjects of study.

Another study worth highlighting is that of McNamara *et al.* (2016) in Kumasi, Ghana. This study not only focuses on the behavior of hunters but also examines consumer behavior and the status of the resource to characterise the dynamics of supply and demand in the wildlife trade market. It is, therefore, a broader study that covers all three market attributes and demonstrates that hunting is not always driven by demand. In the case of the Kumasi market, hunters entered and exited the market regardless of price signals, and consumption levels were not governed by consumer choice but by supply scarcity and the resulting price responses. The study is particularly useful as it underscores the importance of targeting management interventions primarily toward changing hunter behavior in such circumstances.

1.2.2.3 Importance of wild meat in sustaining livelihoods

Some research has adopted a broader perspective by examining the role of hunting in the livelihoods of rural households. This approach not only offers valuable insights for conservation efforts by revealing how household activities influence the sustainability of wildlife resources but also deepens the understanding of the socio-economic context within these communities, highlighting the rights and needs of households. This understanding is crucial for developing conservation initiatives that are not only ecologically effective but also socially and financially sustainable, ensuring that the well-being of local populations is integrated into environmental preservation strategies.

In Democratic Republic of Congo, De Merode *et al.* (2004) conducted a significant study that assessed the role of wild foods—including wild plants, meat, and fish—in rural households categorised according to different wealth brackets. However, all were classified as extremely poor. Their findings revealed that while wild foods were minor in overall consumption, they were crucial for income generation. Notably, the value of these resources, both in terms of consumption and sale, increased during the lean season, when agricultural production was low. This demonstrates that small-scale marketing of wild foods provides a vital source of income for households struggling with extreme poverty, mainly when other sources of income are scarce. Similarly, Kümpel *et al.* (2010b) conducted research in a village in Equatorial Guinea, which mirrored these findings. Their study showed that wild meat was consumed moderately, but hunting for trade in urban markets was a significant component of household income, particularly for households in the poor-to-middle-income range. However, hunting was primarily viewed as a fallback strategy rather than a high-prestige livelihood. This indicates that hunting may not be the most prestigious occupation, but it is a crucial economic activity for many households.

These studies highlight the complexity of integrating conservation goals with the economic realities of local communities. Policies aimed at wildlife conservation must consider the significant role that hunting and wild food resources play in the livelihoods of these households. Effective conservation strategies should, therefore, not only focus on limiting hunting but also seek to enhance the economic alternatives available to these communities. For instance, policies that aim to reduce hunting pressures should also explore ways to increase the opportunity cost of hunting, perhaps through the development of sustainable alternative income sources or by improving access to other forms of livelihood.

1.2.3 Implementing appropriate management interventions

Once the dynamics of the socio-ecological system are understood, the most appropriate management measures can be selected. As discussed above, the objective is to identify measures that mitigate the effects of unsustainable trade while ensuring that they do not compromise the needs of the human population that relies on the resource. Instead, these measures should facilitate the development of the human population (Adams *et al.*, 2004; Kümpel, 2006; Bennett *et al.*, 2007). Additionally, such measures must be pragmatic and tailored to the country's institutional, ecological, and developmental context to be effectively implemented (Adams *et al.*, 2004).

The control of wild meat hunting is one of the most challenging problems for policymakers because it is a multi-species, widespread and informal activity, making it very difficult to regulate (Milner-Gulland *et al.*, 2003). According to Milner-Gulland and Rowcliffe (2007), some essential distinctions about possible management approaches are as follows. If the aim is to change people's behaviour, there are two ways to do this: directly, by controlling their resource use (prohibiting or restricting it), or indirectly, by changing their attitudes and opportunities to change their use themselves (e.g., promoting goodwill, alternative livelihoods, direct payments). If use control can be made economically, socially and ecologically sustainable, it can be considered a conservation solution. However, this is usually impossible, and other strategies, like those aimed at indirect control, must be used. In other words, in practice, both approaches are often used simultaneously.

Within the actions included in the two approaches, a variety of intervention types can be directed at different target groups—such as hunters, traders, and consumers. Milner-Gulland and Rowcliffe (2007) provide an excellent overview of a range of such interventions and discuss their pros and cons using real case examples.

Another essential aspect to consider is who has the authority to implement the different types of interventions. To effectively enforce regulations, top-down management by the government is typically required, though NGOs may assist, or, in some cases, the responsibility may fall on the community itself. This approach demands a stable and well-developed institutional structure capable of implementation and supported by a government that recognises the value of the resource. When this situation does not exist, the NGO or conservation project team will need to conduct preliminary awareness-raising and capacity-building efforts with the government. Depending on the development of institutions and legislation, more or fewer steps may be required. For instance, if there are already regulations and institutions with specific mandates to enforce them but insufficient resources, less groundwork will be needed. This is the situation in Equatorial Guinea, where, following an initial phase focused on developing legislation and institutions (as detailed in Section 2.1.7), the current task is to promote adequate funding and support from the government, as well as backing from NGOs and scientists, to select and implement appropriate interventions.

At the same time, the NGO or the conservation project team can develop indirect measures within their competencies in collaboration with the relevant institutions and communities in each case. This is also a way to involve, raise awareness, and build capacity as preliminary steps toward achieving a more robust governance regime that also allows for top-down management. Ultimately, developing a management plan

involves combining aspects of both approaches (direct an indirect), various interventions and stakeholders, and considering different phases.

Coad *et al.* (2019) propose different wild meat management strategies tailored to specific socio-economic contexts. Other reports and reviews that can assist researchers and conservationists in selecting the most appropriate livelihood-focused interventions include Evans *et al.* (2011), SCDB (2011), Roe *et al.* (2015) and Wicander and Coad (2018) among others. The former, which focuses on mainland Equatorial Guinea, is of relevance to this thesis.

Once the management plan is in place, a monitoring and evaluation process must be devised to enable continuous learning and adjustment of the interventions. This approach is known as adaptive management. Various studies, such as those by Coad *et al.* (2019), Cronin *et al.* (2021), Stuart-Hill *et al.* (2005) and Van Vliet *et al.* (2017b) address this topic and propose specific types of adaptive management depending on the context.

1.3 Main aims of the thesis

1.3.1 Interest of the study area

The island of Bioko has long been recognised as a globally significant conservation area, due to its high level of biodiversity and faunal and floral taxonomic uniqueness and the significant threats it faces as detailed in Section 2.1.5.

Most of the island's natural wealth is concentrated in two protected areas, the Pico Basilé National Park (PBNP) and the Gran Caldera de Luba Scientific Reserve (GCSR), which together cover approximately 42% of the island. The PBNP, located in the northern half of the island, encompasses an area of approximately 330 km^2, with elevations ranging from 800 m above sea level to the summit of Pico Basilé, the highest point on the island (3,011 m) (Figure 1.3-1). The altitudinal gradient gives rise to a wide variety of habitats, ranging from submontane and montane forests to subalpine grasslands (see Section 2.1.5.2). This heterogeneity of habitats within a relatively small geographic area contributes to a high level of biodiversity. An example of this is the presence of six of the seven anthropoid primate species found on the island, considered to be endemic subspecies, as well as the presence of the four galago species, of which one or possibly two are considered subspecies.

This co-occurrence of geographically restricted and threatened species (see Section 2.1.5.3) has led to the PBNP being designated as a Key Biodiversity Area (KBA) in 2018 (Site ID 6379; KBA 2024), under the global KBA criteria A1e.B2 (IUCN, 2016).

The recognised importance of Bioko and of PBNP for conservation efforts has not been translated into actual conservation. Despite been declared as protected area in 1988 and a National Park in 2000, PBNP has not received the management or protection typically afforded to such a designation. Since the emergence of the wild meat market on Bioko Island in the 1980s, studies have shown unsustainable levels of wild meat harvesting, with evidence of more significant depletion in Pico Basilé compared to the more

inaccessible southern regions of the island. Its proximity to the capital, Malabo, and to major roads has made it easily accessible, leading to an increase in bushmeat hunting. However, this same accessibility and the beauty of its landscapes are an advantage for the development of ecotourism, as well as for adaptive management supported by research led by the National University of Equatorial Guinea and INDFOR-AP, both based in Malabo.

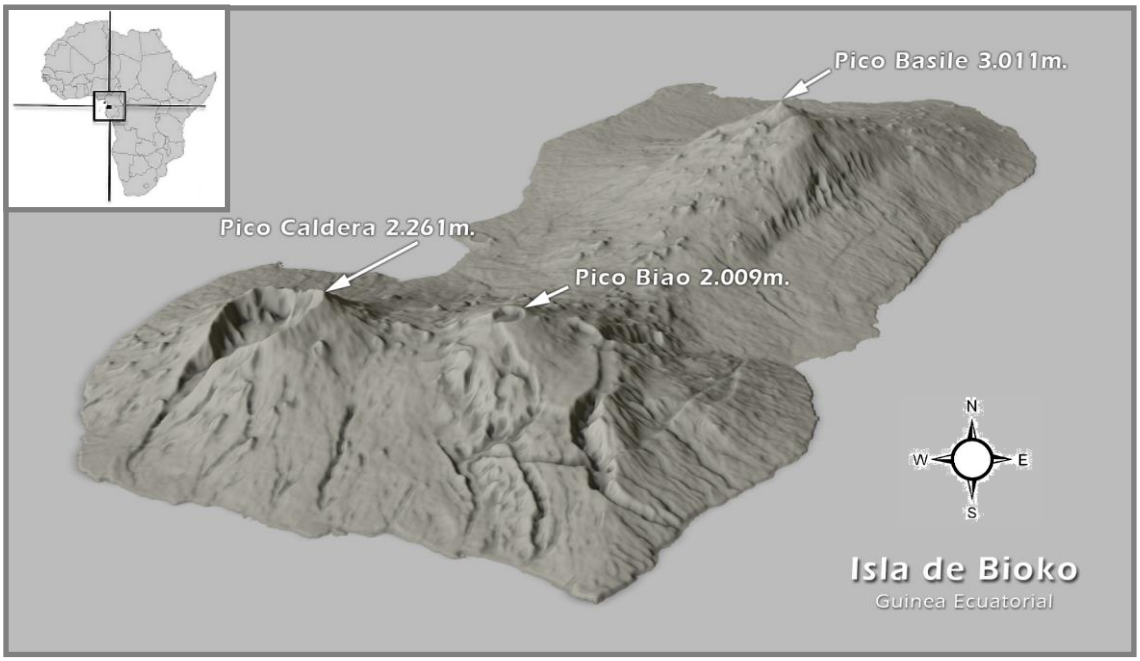


Figure 1.3-1 Three-dimensional map of Bioko Island. A) View of the Island including protected areas, main roads, and the locations of villages (dots) and the capital, Malabo. B) Perspective view showing the three highest peaks on the island. The insets show Bioko's location on the African continent. The inset in B) also shows the mainland region of Equatorial Guinea (for a more detailed view of the continental and insular regions of Equatorial Guinea see Figure 2.1-1). Source: adapted from Alfonso García Ávila (Unpubl.)

1.3.2 General and specific objectives

Successful conservation requires consideration of both the biological and human components of the hunting system. Ignoring the needs of local people and focusing solely on biological sustainability could lead to inappropriate management recommendations or practices vulnerable to abuse.

On Bioko Island, efforts should be directed at reducing the ecological impact of hunting while preserving the sources of income, protein and cultural practices of those who depend on wildlife.

This thesis aims to understand the role of wild meat in the lives of the people who rely on it and to discuss conservation strategies that support both wildlife conservation and human development.

The ultimate goal is to support policymakers, and in particular INDEFOR-AP staff, in crafting and implementing practical conservation strategies for the Pico Basilé region, while also addressing the development needs of the local communities.

The specific objectives (detailed in the following Sections 1.3.3. and 1.3.4) are:

1. Understand the role of wild meat as a source of protein and income for the villagers living around PBNP.

2. Enhance the biological and ecological knowledge of the most heavily hunted species (the blue duiker) to better assess its sustainability and demonstrate the effectiveness of monitoring Pico Basilé populations through participatory research, which may support future monitoring and adaptive management.

3. Based on this research and previous studies, and considering the current institutional context, capabilities, and development potential of the country: discuss conservation strategies that could be most suitable for the Pico Basilé region (i.e., PBNP and its surroundings, where the majority of Bioko’s population resides).

1.3.3 Scientific contribution

1.3.3.1 Research on the social and economic drivers of wild meat hunting and consumption

In addition to understanding the biological impact of hunting, it is crucial to examine the social and economic factors driving unsustainable hunting practices. While previous studies have documented the expansion of hunting and its impact on wildlife populations (see next section), they have yet to investigate the underlying social and economic drivers thoroughly. Cronin *et al.* (2015a) provided some insights by analysing the long-term dynamics of the wild meat market on Bioko Island in response to economic development and government legislation. However, this regional analysis has not delved into the factors influencing individual hunting and consumption behaviours.
Two studies on Bioko—Fa *et al.* (2022) and Albrechtsen *et al.* (2006)—have explored wild meat consumption preferences and the importance of wild meat as a protein source in urban areas, but similar research is lacking in rural areas. Additionally, the contribution of wild meat to livelihoods (as a source of income) on Bioko has never been quantified, unlike in mainland regions where studies have examined this aspect.

This thesis presents the first comprehensive quantitative analysis of dietary habits, protein intake, and livelihood strategies in rural Bioko, focusing on the role of wild meat. The study includes 155 households from 10 rural settlements.The thesis also compares two communities with distinct hunting practices—Basilé Fang, who engages in commercial hunting[1], and Basilé Bubi, who practices subsistence hunting[2]—to assess the role of wild meat in diets and livelihoods according to the type of hunting. In these two villages, the thesis examines total protein intake, including animal and plant-based sources, to provide a more accurate food security assessment. This approach is relatively novel in studies of wild meat overexploitation, which often overlook the contribution of plant-based protein.

1.3.3.2 Research on reproductive parameters and body condition for hunting sustainability assessments

As early as 1986, primate (Butynski and Koster, 1994) and duiker (Butynski *et al.*, 2001) encounter rates were found to be lower on Pico Basilé (the northern massif) than on Pico Biao and Caldera de Luba (the southern massif), a much more uninhabited and inaccessible area (see Figure 1.3-1). Several studies have since found evidence of unsustainable exploitation of wild meat on the island (see also Section 2.1.6.3). These studies have consisted mainly of field research in the south, focused on primates (Cronin *et al.*, 2016; Branch *et al.*, 2022) and studies in the island's largest wild meat market in Malabo, the country's capital (Fa *et al.*, 2000; Albrechtsen *et al.*, 2007; Cronin *et al.*, 2016). By monitoring the number of animals for sale, species composition, price trends or other indicators, as wildlife source distance, these market studies have shown evidence of increasing impact and unsustainable hunting for larger-bodied species. That

[1] Commercial hunting of wild meat involves harvesting wildlife primarily for sale in local, national, or international markets, driven by economic incentives rather than subsistence needs
[2] Subsistence hunting is the practice of hunting wildlife primarily to meet basic survival needs, such as food and materials, often rooted in cultural traditions and local sustainability

of Albrechtsen *et al.* (2007) captured the expansion of hunting in the south of the island, which supplied the market with a higher volume of primates and ungulates compared to the north, which, on the contrary, supplied to a lesser extent but with much higher quantities of rodents, indicating the better state of the fauna in the south and how the north had been heavily hunted earlier as suggested by Butynski and Koster (1994). More recently, Grande‐Vega *et al.* (2016) collected data on blue duiker captures and hunting effort in an area of Pico Basilé over a 33-month period (between 2010 and 2013) and observed a significant decline in CPUE, demonstrating for the first time that a supposedly abundant and hunting-resistant species has experienced a significant population decline due to hunting.

Since these studies, no further research has been conducted on the status of wildlife populations in Pico Basilé despite increasing pressures from the wild meat market driven by the economic boom from the oil industry (Cronin *et al.* 2015). Assessing the sustainability of hunting is essential for species conservation, particularly for those exploited for wild meat, which is a resource that must be maintained.

On Bioko Island, the blue duiker (*Philantomba monticola melanorheus*) is the most hunted and consumed species, playing a significant role in local diets and economies. The species is also extensively hunted for wild meat throughout its range (IUCN SSC Antelope Specialist Group, 2016). Duikers, in general, are the most economically and ecologically important wild ungulates in sub-Saharan Africa (Wilson, 2001; Van Vliet and Nasi, 2018).

The blue duiker is believed to withstand much higher hunting pressure than most larger duikers. Moreover, unlike many other forest duikers, blue duikers can tolerate and even thrive in a variety of human-modified habitats, including areas near settlements, and often persist well in small habitat patches (Hart and Kingdon 2013; Yasuoka 2015). Despite this adaptability, some local populations may be subject to declines or extirpation due to overhunting or habitat loss (e.g. Hart, 2000; Lawes *et al.*, 2000; Grande‐Vega *et al.*, 2016).

It is therefore essential to assess the sustainability of the blue duiker, and, in our case, the Bioko blue duiker. The study by Grande-Vega et al. (2016) in Bioko uses catch per unit effort over time to assess the impact of hunting and demonstrates, for the fist time, the sharp decline in hunting yields of a species otherwise presumed abundant.

As detailed in Section 1.2.1.1, another straightforward approach to assess hunting sustainabiltity is the use of models that rely on biological parameters, which have generally been one of the most commonly used methods. However, as Van Vliet and Nasi (2008) illustrated, the difficulty in obtaining accurate demographic or reproductive data for tropical species in their natural habitats has hindered the reliability of these assessments. One such model, the Potential Biological Removal index (PBR), is particularly recommended by several authors for its superior performance in simulations compared to other models, as it accounts for uncertainty (Milner-Gulland and Akçakaya, 2001; Weinbaum *et al.*, 2013). This model requires calculating the maximum intrinsic rate of population increase (r_{max}).

Only three studies, conducted over two decades ago, have collected data on pregnancy rates—basic information required to estimate r_{max}— in wild blue duikers, none of which were conducted on Bioko Island. As a result, sustainability assessments for the blue duiker, including the Bioko subspecies, have often relied on productivity data from captive or non-local populations. Similarly, information on other key parameters critical for the species' sustainable management remains limited. Studies such as those by Mockrin (2010) and Van Vliet and Nasi (2018) highlight the paucity of research on parameters influencing demographic patterns, including reproduction, dispersal, home range characteristics, mortality, longevity, and seasonal variation.

Enhanced knowledge of the ecology and biology of the blue duiker is therefore essential for its sustainable management. The Bioko blue duiker is of particular interest, as this subspecies is endemic to the island and coexists with only one other ungulate species, the Ogilby's duiker. Understanding its interactios with the environment and its reproductive potential in the wild is essential not only for making informed management decisions on Bioko but also for advancing general knowledge of the species across its range and in diverse anthropogenic contexts, as recommended by researchers (e.g. Van Vliet and Nasi, 2018).

This thesis addresses this gap by providing new data on the reproductive performance and body condition of the Bioko blue duiker, with body condition referring to the amount of energy reserves in the animal, which are influenced by the environment and affect reproductive performance (as detailed in Section 3.3.3.4). The research uses histological analysis to detect early pregnancies and examines individuals captured across the island's altitudinal range. Additionally, the thesis evaluates the validity of the Kidney Fat Index (KFI) as a measure of body condition in the blue duiker and examines how different hunting methods affect KFI values. Furthermore, this thesis employs a participatory research methodology, enabling the collection of large datasets that will serve as the foundation for future wildlife monitoring. It discusses and demonstrates how long-term monitoring is both feasible and essential for accurately assessing the sustainability of hunting.

1.3.4 Contribution to conservation

This thesis is significant for the conservation of biodiversity on Bioko Island, not only for what it proposes but also for what has already been achieved during its execution (see Sections 2.1.7.3 and 2.1.7.4), which undoubtedly serves as a guarantee that new proposals could be well received and may come to be implemented.

As detailed in Section 2.1.7, Equatorial Guinea has made many strides toward conservation; however, these have not translated into effective management of protected areas. Although the National Protected Areas System (NPAS) is considered well-designed and ecologically representative, and there is an adequate legal and institutional framework, there is still a lack of training, scientific basis, and resources. As Fernández de Velasco (2019) states, “NPAS has the potential to contribute tremendously to global conservation and to reinforce the natural resource foundation of Equatorial Guinea’s economic, social, and cultural prosperity – but socioeconomic, policy, legal, administrative, and capacity barriers currently block the achievement of this potential”.

This thesis presents the first comprehensive quantitative information on dietary habits, protein intake, and livelihood strategies in rural Bioko, with a particular focus on the role of wild meat in these practices. It also includes a thorough analysis of the legal and institutional context, the successes and failures of other conservation and development projects and assesses the limits and potential of possible conservation actions. This information is essential for developing conservation strategies that are also linked to human population development, which I address in the final section of my thesis by discussing a series of proposals based on all the information gathered. These proposals can assist in the conservation and management of the PBNP contributing to the revision and expansion of the current management plan. This will ensure that it remains both practical and feasible, while achieving more effective outcomes, supported by a strong scientific foundation.

Furthermore, the thesis compiles essential scientific information for the sustainable management of the blue duiker—the most hunted and consumed species and of greatest economic importance in the wild meat market—using a participatory methodology that sets a precedent for future monitoring of hunting practices and population dynamics of this species as part of adaptive management in Pico Basilé.

Chapter 2: STUDY AREA

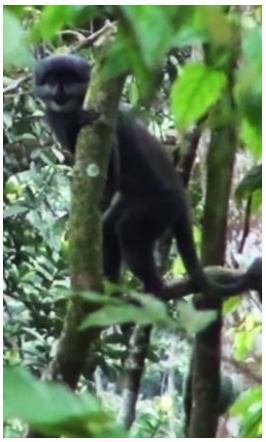


Photo captions in Appendix P

2.1 Bioko Island

2.1.1 Geography and population

Bioko Island is part of Equatorial Guinea (28,051 km^2), one of Africa's smallest and least populated countries, located in the central-western part of the continent within the Gulf of Guinea. The country comprises a continental part, Rio Muni (26,000 km^2), situated between Cameroon and Gabon, and an insular part consisting of three small islets of Rio Muni's coast - Corisco (15 km^2), Elobey Grande (2.27 km2) and Elobey Chico (0.19 km^2) - as well as two larger volcanic islands —Bioko (2,017 km²), of continental origin, located 32 km off Cameroon's coast and 200 km north of Rio Muni, and Annobón (17 km²), of oceanic origin, located 600 km from Bioko (Font Tullot 1951) (Figure 2.1-1). The maritime territory (Exclusive Economic Zone) of Equatorial Guinea covers approximately 314,000 km² (Pigeonnière *et al.*, 2001; Ross Salazar *et al.*, 2020).

Bioko Island is the largest and most politically important island, housing the capital, Malabo. The country's total population is around 836,180 people, with an annual growth rate of 2.35% (CIA, 2021). This estimate is considerably lower than available census data, which placed the population at 1,222,442 in 2015, with 27.8% residing in the insular region and 72.2% in the continental area (MEPIP, 2015). Kümpel (2006) suggests that this estimate might be artificially inflated to secure greater international aid and recognition for the country, though the proportions may be accurate. The population of Equatorial Guinea is predominantly urban (73.1% of the total population), with an annual urbanisation rate estimated at 4.28% (CIA 2021). It is concentrated in two main cities: Bata in the continental region and Malabo, the capital, in the insular region. Malabo concentrates most of the population of Bioko Island, with 297,000 inhabitants in 2018 (CIA 2021). The rest of the island's population resides in small villages and towns scattered along the main roads, which loop around Pico Basilé at lower elevations and extend along the northern slopes of the southern massifs. Ureka, the southernmost village and the only one entirely within a Bioko protected area, remained inaccessible by road until 2014, when a new road was completed. This road, spanning 35 kilometres, connects Ureka to Bioko's road network and runs through the southern protected area (Figure 1.3-1).

According to the national census, other significant towns include Baney in the north and Luba in the south, with populations of 20,000 and 30,000 inhabitants, respectively. Rebola, near the capital, and Riaba, in the south, have a population between 8,000 and 9,000 inhabitants (MEPIP 2015). The remaining villages on the island range from 44 to 363 inhabitants, with most having around 100 inhabitants (Mas *et al.*, 1995). This data is consistent with our 2009 census of 20 villages around Pico Basile. Most of them are in the northern part of the Island, where the population density is around 93 inhab/km^2, dramatically decreasing towards the south to less than 10 people/km^2 (Fa, 2000). Almost all villages are located inland rather than on the coast. According to Aymemi (1942), after initially living near the sea, as evidenced from archaeological discoveries from Carboneras beach (Clist and de Maret, 2021), the original inhabitants moved inland to avoid slave traders who could reach their coasts.

Figure 2.1 2 Satellite image of Central Africa showing Rio Muni and the islands of Bioko, Annobon and Corisco and Elobeyes. The islands between Bioko and Annobon are part of the state of São Tomé and Príncipe. Source: Kümpel (2006), adapted from Global Forest Watch (2003).

2.1.2 Ethnic groups

When the Portuguese explorer Fernando Po discovered Bioko in 1471, Bantu-speaking Bubi inhabited the island. According to Martínez García (1968), the Bubi are not the descendants of a single migrant people, but the result of successive migrations from the coasts of the Gulf of Biafra, which began in the Palaeolithic period, though the exact date of the first migrations is unknown (Liniger-Goumaz, 1989). In the continental region, the first inhabitants were considered Pygmies (hunter-gatherers), of whom only isolated individuals may remain in northern Río Muni (Olivero *et al.*, 2016). In Rio Muni, the Pygmies were primarily displaced by waves of Bantu migrations (farmers) between the 12th and 13th centuries, first by several coastal tribes (Ndowes and others) and five centuries later (19th century) by the Fang (Liniger-Goumaz, 1989; Rondo Igambo, 2006). Since the 1930s, the Fang have also migrated from the mainland to Bioko to work in agriculture during the Spanish colonial period (Fa, 2000). Currently, Bubi and Fang are the two main ethnic groups on the island. The Fang constitute 86% of the overall population of Equatorial Guinea (CIA, 2021) and are politically dominant, having been in power since independence from Spain in 1968. On Bioko, the Fang are the majority in Malabo, but the population has increasingly mixed with a growing number of foreigners (about 18% in 2015 according to the national census, including Cameroonians, Nigerians, French, Spanish, and Americans) arriving in response to economic growth. The Bubi make up most of the population outside Malabo. Several other tribes, including the Ndowe, Bissio and Annobonese, are present in the country, though primarily reside outside Bioko (see Rondo Igambo 2006 for a more detailed description of these five ethnicities that coexist in Equatorial Guinea).

On Bioko today, Bubi and Fang, although both Bantu-speaking, differ in their ways of life. The Bubi have had to adapt to the insular environment, transitioning from a hunting and migratory lifestyle on the continent to a sedentary one on the island (Crespo, 1949). Furthermore, since the migration to Bioko was one of the earliest branches of the Bantu expansion, the Bubi culture was purely Neolithic when the Portuguese arrived on the island: there was no mining, smelting, or use of metals until the 19th century, but were excellent pottery makers (Vansina, 1990). When Kingsley (1897) visited the island in the 1890s, she reported that the Bubi people cultivated yams, taro, plantains, and oil palm. They also hunted duikers, small monkeys, porcupines, and squirrels, fished and collected turtle eggs from the island beaches. At that time, the Bubi people manufactured various tools (sharpened stones, basket traps, slings, knobkerries, barbed spears, traps and nets) for hunting and fishing. They also kept domestic animals (cats, dogs, sheep, goats and poultry) (Kingsley, 1897), though in small numbers (Crespo, 1949).

The Fang, by contrast, had already introduced iron into their culture (Toledo, 1994), and their art included works in wood, ivory and iron (Tessmann, 2003). Like the Bubi, the Fang practised subsistence agriculture as a main activity. However, they were also renowned for their hunting skills, especially of large game like elephants and gorillas, thanks to the development of elaborate snares and traps that are part of their culture. Accustomed to constant migrations and nomadic lifestyles, the Fang, unlike the Bubi, did not develop the concept of stable settlements until their contact with Europeans. Even today, it is still common to find abandoned villages on Bioko or the mainland, whose inhabitants have joined another population or moved on to create a new one in a different municipality or region (Rondo Igambo, 2006).

From a socio-political point of view, the Bubi are matrilineal people, where women play a significant role in family organisation. Villages were administered by a "butucu" chief, assisted by a council of elders. Above the chiefs was the king, who could designate his successor from among his sons. The king also had a militia, comprising Bubi men from all villages, responsible for administering justice (Rondo Igambo, 2006). Some authors, such as Aymemí (1942), have compared the degree of socio-political organisation and development of the Bubi institutions to that of the European feudal monarchies. With the arrival of the European colonists, no succession was permitted. After the reign of Malabo Löepelo Melega (deceased in 1937), his son, Francisco Malabo (known as King Malabo II), did not rule but was recognised as a spiritual leader by the Bubi until his death in 2001 (Rondo Igambo, 2006).

The Fang's clan structure is rooted in a tribal framework, lacking the institutional complexity found within the Bubi's social organisation. The chiefs of the different clans, called Nsue, group all their descendants under their dominion, forming lineages of large families. The filiation is transmitted through the paternal line (Rondo Igambo, 2006).

The religious convictions of the Bubi and Fang differ in some respects. However, both ethnic groups share a common belief in the spirit world (the non-visible other world), where witchcraft, magic, divination techniques, and the activities of healers are all common. Dances and songs are also an essential part of the folklore and religiosity of both groups (Tessmann, 2003; Eteo Soriso, 2013). Many of these rich cultural elements

have gradually eroded due to the intense processes of evangelisation and acculturation that took place during the colonial era, giving rise to syncretism and the loss of the original orthodoxy (Sepa Boanaba, 2011). Nowadays, most citizens of Equatorial Guinea are Catholic. Even so, many rites and celebrations linked to belief in spirits are still observed on Bioko Island (Martín del Molino, 1989; Eteo Soriso, 2013).

2.1.3 History and politics

When discovered in 1472 by Europeans, Bioko Island was named “Fermosa” (beautiful in Portuguese). Later, the name was changed to Fernando Poo to honour the island’s discoverer Fernão do Pó. During that same voyage, Annobón Island was also discovered.

Spain had shown interest in Bioko Island as part of its African colonial ambitions. Under the Treaties of San Ildefonso (1777) and El Pardo (1778), Portugal ceded Bioko Island and Annobón, in addition to other territories in the Gulf of Guinea, to Spain in exchange for territories in the south of Brazil (Liniger-Goumaz, 1988). However, Spain's initial attempts to establish a permanent settlement on the island in October 1778 were unsuccessful. The primary reason for this failure was the outbreak of disease, particularly malaria, which decimated the Spanish settlers. The harsh tropical environment and lack of immunity among Europeans to local diseases made it extremely difficult to maintain a healthy population.

In 1827, the British established a presence on Bioko Island. Their primary motivation was to set up a base for the suppression of the transatlantic slave trade as part of broader British efforts to combat slavery. They founded the Port of Clarence, named after the Duke of Clarence (the future King William IV). This port would later become known as Santa Isabel, and today is the country’s capital, Malabo. The British used the island as a naval station and as a base for anti-slavery patrols. This move was part of Britain's broader strategy to use its naval power to enforce the abolition of the slave trade, which Britain had outlawed in 1807. The choice of Bioko Island was strategic due to its location in the Bight of Biafra, a region that was a major hub for the slave trade. Although the British established a settlement and influenced the island, they never claimed full sovereignty over Bioko. Spain retained nominal control, and the British presence was more of a protectorate arrangement focused on anti-slavery efforts. Over time, the British influence waned, and Spain reasserted its control over the island (Pardue, 2020).

During the British presence, small communities of Creole Africans arrived from Western African British settlements, referred to as Fernandinos (Campos, 2009). Spain took complete control over the island in 1858, and Rio Muni, the continental portion, became a protectorate in 1885 and a colony in 1900. Both territories (insular and continental) were united in 1926 as the colony of Spanish Guinea (TVE, 1982). In 1956, the Spanish government, under pressure from independence movements and the UN to maintain the colony, declared the insular and continental territories as provinces and later as autonomous regions within Spain (TVE, 1982).

Equatorial Guinea gained independence from Spain on October 12, 1968, with Francisco Macias Nguema as president, beginning one of Africa's most devastating

dictatorial regimes. From 1969-1979, it is estimated that a third of the population of Equatorial Guinea was killed, exiled, or fled. Macias was overthrown and executed in 1979 in a military coup led by his nephew, Teodoro Obiang Nguema Mbasogo (Kümpel, 2006). President Obiang has been in power since, making him the world's longest-serving (non-monarchical) political leader (42 years in power). The country is nominally a multiparty democracy (see BBC, 2021), with Obiang's party obtaining between 95% and 100% of the vote in all the elections held since the first one in 1997. Transparency International (2020) places Equatorial Guinea in the top 10 list of most corrupt states, and the Committee to Protect Journalists (CPJ, 2019) among the world's topmost censored countries.

2.1.4 Economy and development

The discovery of oil in Equatorial Guinea in the 1990s fundamentally transformed the country's economy, shifting its primary focus from agriculture and timber exports to hydrocarbon exploitation. Before this discovery, the economy was largely agricultural, with coffee and cocoa as key exports. The shift to oil production significantly increased the country's GDP and created numerous secondary jobs associated with the oil industry. Despite the substantial economic gains, the general population's living standards need to be improved.

2.1.4.1 Colonial era: economic boom

In 1854, cocoa was introduced to Bioko from São Tomé (Sundiata, 1996), significantly transforming the island's economy from a subsistence-based system to one oriented towards commercial production and exploitation. This shift focused on cocoa cultivation, while earlier agrarian activities had centred on palm oil production. By the late 19th century, cocoa emerged as the dominant crop, particularly on Bioko Island, while coffee and timber exploitation became prominent in Rio Muni (TVE, 1982; Bolekia, 2005; Carnero and Díaz de la Paz, 2009).

By 1901, cocoa production in Equatorial Guinea was around 1,000 tonnes but surged to over 40,000 tons by the 1967/68 season, with 38,000 tonnes just from Bioko (MAEUEC, 1998). This impressive growth helped Equatorial Guinea achieve Africa's highest per capita income, reaching $332 in 1968. However, the wealth generated was unevenly distributed, primarily benefiting landowners who controlled 85% of the farms, while workers saw much less economic advantages (TVE, 1982).

During this period, Equatorial Guinea enjoyed one of Africa's highest literacy rates and well-developed educational and health systems. The infrastructure and social services, especially on Bioko Island, were notably advanced compared to the mainland (TVE, 1982).

2.1.4.2 Macías Nguema's dictatorship: economic ruin

After independence in 1968, the economic splendour on the island ended with the regime of terror imposed by Macías Nguema Biyogo (Falcón, 2007). Shortly after coming to power, Macías ordered the execution of dissidents and political opponents, as well as many others, especially intellectuals. In early 1969, relations with Spain rapidly

deteriorated, and almost all the 8,000 Spanish residents who owned most of the major businesses (cocoa plantations, forestry concessions, oil palm and coffee plantations) left the island. Cocoa exports dropped to 22,000 tonnes in 1971 and 10,000 tons in 1974, and other industries suffered the same fate. Timber production, for example, fell from 325,000 m^3 in 1967 to 20,000 m^3 in 1972 and even less (Goytisolo, 1979). Coffee production was reduced from 9,000 tonnes in 1968 to virtually nothing one decade later (World Bank, 1985). Fishing (mostly undertaken at a small scale using dugout canoes or "cayucos") disappeared completely when Macías banned it and ordered all boats destroyed for fear that more people would flee by sea (Goytisolo, 1979). While in 1968 the country was meeting its needs for meat and dairy products, its livestock production dwindled in the 1970s due to the indiscriminate slaughter of most cattle, sheep, and goats.

The worsening treatment of the large number of Nigerian workers (who, since the end of the 19th century, had been essential to the functioning of the cocoa plantations) led to their departure in 1976. The workforce shortage led President Macias's government to set up a domestic forced labour system by enacting a Presidential Decree that requested 2,500 people from each district to work in the plantations. This mandate only increased the number of exiles and failed to improve the situation. In 1975, the GDP had fallen from $332 per capita in 1967 (TVE, 1982) to $70 in 1975 (Liniger-Goumaz, 1989). The population ended up living on subsistence (World Bank, 1985). The educational system also came to a complete standstill after the closing of secondary schools and the flight or assassination of numerous teachers (Liniger-Goumaz, 1989). The education system was largely diminished to the teaching and learning of anti-Spanish and anti-capitalist slogans, lacking pedagogical or ethical value (Negrín, 2011). Similarly, the medical staff and health system experienced a total collapse, leading to the reemergence of previously eradicated diseases (Nsí, 2014).

2.1.4.3 Obiang's government: recovery and foreign aid, oil boom and recession

2.1.4.3.1 Recovery and foreign aid

On August 3, 1979, Lt.-Col. Teodoro Obiang Nguema Mbasogo led a coup d'état that overthrew President Macias Nguema, becoming the second President of Equatorial Guinea since independence. The new government began to rebuild the economy and social institutions (Nsí, 2014).

In those years, as Campos (2009) points out, multilateral aid flowed to the country, and bilateralism with Spain was in place. A friendship and cooperation agreement was signed between Spain and Equatorial Guinea, and numerous Spanish technicians were sent to the old colony during the 1980s. The United Nations helped organise two conferences in 1982 and 1988 with a Round Table of Donor Countries, where they adopted an economic development program. Equatorial Guinea entered the Central African CFA Franc (CFA or XAF)[3] zone in 1988. Finally, the government accepted an

[3] The XAF is used by six countries in the Economic and Monetary Community of Central Africa (CEMAC). These countries are Cameroon, Central African Republic, Chad, Republic of Congo, Equatorial Guinea, and Gabon.

IMF proposal for a Structural Adjustment Facility in 1988. During those years, external aid became the main resource for the state.

Some of this external aid was allocated towards the re-establishment of cocoa production. First, in the 1980s, institutions such as the Organization of Petroleum Exporting Countries (OPEC), the International Development Association (IDA) and the Arab Bank for Economic Development in Africa (BADEA), and then, in the 1990s, the European Commission and the Spanish Cooperation, allocated large amounts of funds for this purpose (see reports of these projects in World Bank 1985 and MAEUEC 1998, respectively). By the end of the latter project, 2000 hectares of cocoa had been replanted on Bioko (MAEUEC, 1998). However, chronic issues such as labour shortages and the departure of experienced landowners (Liniger-Goumaz, 1989), along with the creation of inefficient public institutions, dysfunctional credit systems, and politically sensitive land tenure issues (MAEUEC 1998), severely hindered the recovery of Equatorial Guinea's cocoa sector. Additionally, the centralisation of the national economy around oil has exacerbated these problems, leading to a significant decline in cocoa production from 5,000 tons annually in 1989 to less than 1,000 tons since 2007 (INEGE, 2015b).

In contrast, the forestry industry expanded its production, becoming a cornerstone of the national economy (CARPE, 1998). Between 1985 and 1992, it was the top foreign exchange earner through exports. In 1990, with a production of 158,000 m^3, the forestry sector contributed 16.25% to the primary sector GDP, and by 1996 (with a production of 471,000 m^3), it represented 24.7%. This industry has been developed in the continental region since Law No. 1 of 1997 on the Use and Management of Forests explicitly excludes any industrial logging activity in the country's islands (Art. 34).

2.1.4.3.2 Oil boom and recession

Oil was discovered within the Exclusive Economic Zone of Equatorial Guinea in the mid-1990s, marking a drastic change in the country's economic trend, making it the main source of income (CARPE, 1998). Between 1995 and 2006, oil production grew 60 times, and the sector represented approximately 95% of GDP and exports (MAB and WRI, 2013). Equatorial Guinea became the third-largest oil exporter in sub-Saharan Africa, after Nigeria and Angola, with 360,000 barrels a day in 2004, when it reached its maximum production (Kümpel, 2006). Since 1995, per capita GDP has grown annually, reaching a peak of $38,400 in 2008 and remaining above $30,000 until 2014 (World Bank, 2019). However, despite this macroeconomic data, Equatorial Guinea has been ranked lowest in the Human Development Index (HDI) (e.g., the121st out of 177 countries in 2005, 144th in 2013, or 145 out of 189 in 2019) (UPND, 2020). Oil money has been directed toward large-scale infrastructure development at the national level (roads, bridges, ports, airports, public buildings) but not for establishing the much needed quiality education and health systems (Negrín, 2011; ASODEGUE, 2018). As Mba Ncony (2010) explains, oil rentierism is the cause of galloping inflation. As rents rise, consumption tends to increase, but essential goods and services are imported due to the scarce domestic production since among the consequences of oil rentierism is the atrophy of the other sectors of economic activity. Thus, Equatorial Guinea relies heavily on imports to meet most of its basic needs, and domestic trade in agricultural products or fish is minimal.

Even though in 2014, the Government of Equatorial Guinea was committed to diversify its economy, in what corresponds to the second phase of the "National Economic and Social Development Plan for the Emergency of Equatorial Guinea towards Horizon 2020", adopted after the Second National Economic Conference, held in Bata in 2007, the changes in this regard have been minimal. In the same year, declining hydrocarbon production combined with falling fuel prices initiated a recession, leading to continuous negative GDP growth since 2014 (World Bank 2021). COVID-19 has further aggravated the country's serious growth problems recently (AFDB, 2021). In 2020, Equatorial Guinea's GDP had further decreased to $10.02 billion, the lowest it has been since 2006 (World Bank, 2021) and is forecast to amount to just US$10.84bn in 2024 (Trading Economics, 2024). The unemployment rate, which was at 8% in 2014, began to rise until reaching its peak in 2021 (9.2%). Although it has declined in the following years, it remained at 8.7% in 2023 (World Bank, 2024).

2.1.5 Biogeography and biodiversity

2.1.5.1 Biogeographic history and conservation importance

Bioko Island is part of the Cameroon volcanic line (CVL), an extensive chain of volcanoes that stretches approximately 1,000 km from Lake Chad along a SE-NW axis, including the Gulf of Guinea Islands: Bioko, Príncipe, São Tomé, and Annobón (Marzoli *et al.*, 2000; Burke, 2001; Tsafack *et al.*, 2009). Rising to 4,095 m in elevation, Mount Cameroon is the tallest peak and the only active volcano in West Africa, with its last eruption in 2000. Together with Pico Basilé (3,001 m) on Bioko, which is somewhat less active (minor eruptions occurring in 1903 and 1923), these two peaks are currently the most active part of the line (Piper and Richardson, 1972). The CVL is geologically unusual because it extends along the ocean and continental crust (Burke, 2001; Tsafack *et al.*, 2009). Bioko Island is the southernmost continental formation, differing from the outer Gulf of Guinea islands, which are oceanic in origin and have relatively low elevations (Jones, 1994; Burke, 2001; Tsafack *et al.*, 2009). Bioko is separated from Cameroon by a 37-km-wide ocean shelf, which is less than 100 m deep and has formed a land bridge with the African mainland in different geological periods, the most recent during the last glaciation, becoming isolated again with the thaws that raised the sea level about 10,000 years ago (Jones, 1994; Oates *et al.*, 2004).

As a result of its connections with the African continent, Bioko has climatic, lithological, edaphological, orographic and other similarities with the adjacent land mass. Bioko's vegetation is similar to that of (i) the lowland and coastal forests of southeastern Nigeria and southwestern Cameroon —with which it forms the Cross-Sanaga-Bioko Coastal Forests ecoregion (Olson *et al.*, 2001)— and, because of the island's high elevation comparable to (ii) the mountains and highland areas of the border region between Nigeria and Cameroon, especially Mount Cameroon (with which it forms the Mount Cameroon and Bioko montane forests ecoregion) (Jones, 1994; Dinerstein *et al.*, 2017; WWF, 2021; One Earth, 2023).

Bergl *et al.* (2007) identified the region between the Cross and Sanaga Rivers, including Bioko, as the Biafran forests and highlands (BFH). The BFH's distinct geological and biogeographic history has made it a significant Pleistocene refuge, contributing to its rich biodiversity and high levels of endemism (Haffer, 1969; Hart *et al.*, 1989; Oates *et*

al., 2004; Anthony *et al.*, 2007; Cronin *et al.*, 2014). The region has been considered a centre of biodiversity on a continental (Brooks *et al.*, 2001; Oates *et al.*, 2004) and global scale (Myers *et al.*, 2000; Olson *et al.*, 2001). Plant species diversity in the BFH is the highest in tropical Africa (Barthlott *et al.*, 1996); with Mount Cameroon being an exceptionally biodiverse centre. The Mount Cameroon and Bioko montane forests ecoregion is among the most important for the conservation of forest-dependent bird species (Buchanan *et al.*, 2011), and Bioko Island has been ranked as the single most important place in Africa for the conservation of primate diversity (Oates, 1996). In addition, the southern coast of island is considered among the most important marine turtle nesting sites in the Gulf of Guinea (Butynski, 1996; Fretey *et al.*, 2007; Tomás *et al.*, 2010).

The recognised importance of Bioko for conservation efforts stems not only from its rich biodiversity but also from the significant threats it faces. The threat to biological diversity in West Africa is exceptionally high compared to other regions in sub-Saharan Africa, mainly due to the region's dense and rapidly growing human population, coupled with an accelerated rate of habitat loss (Brashares *et al.*, 2001; Wittemyer *et al.*, 2008). Bioko's Forests and Highlands (BFH) are part of the West African Forests biodiversity hotspot, which spans the southern part of West Africa and extends into Central Africa, north of the Congo Wilderness Area (Achard *et al.*, 1998; Myers *et al.*, 2000; Oates *et al.*, 2004). Among the most pressing threats to the biodiversity and fragile ecosystems of the BFH are deforestation and the hunting of wildlife for meat. These human activities have increasingly harmful effects, exacerbating the degradation of these ecosystems and pushing many species closer to extinction (Achard *et al.*, 1998; Myers *et al.*, 2000; Oates *et al.*, 2004).

2.1.5.2 Vegetation and climate

The island of Bioko falls within the Guinea-Congolese floristic region, which extends in an African Atlantic strip on both sides of the Equator from Sierra Leone to Gabon, extending inland to the great lakes of East Africa. Within it, the CVL is distinguished as belonging to the Afromontane archipelago-like regional centre of endemism, occurring primarily between 1200 and 2500 m.a.s.l. (White, 1983; Pérez del Val, 1996). Thus, the predominant vegetation formations in Bioko are the Guineo-Congolian rainforest with Afromontane elements in the higher zones (Fa, 2000; Perez del Val, 1996). Despite the great affinity of the plant species of Bioko with those of western Cameroon (Exell, 1973; see also above Section), Bioko has at least 40 endemic species (3.62% of its total number of species) (Figueiredo, 1994). This gives it a higher level of relative endemism than Mount Cameroon (2.01 %). but less than the other Gulf of Guinea islands (10% Annobon, 12% Príncipe, 16% Sao Tomé) (Jones 1994). However, its continental origin and elevation give it a greater species diversity than the other oceanic islands (Jones 1994).

The structure of the vegetation community on Bioko is highly dependent on elevation and localised climate variation (Oates *et al.*, 2004). It can be generally classified into altitudinal belts ranging from lowland rainforest to montane forests and subalpine grasslands in the higher elevations (Navarro-Cerrillo *et al.*, 2012) (Table 2.1-1). Bioko's climate is mainly determined by its insular nature, geographical location and orography. It is typically tropical equatorial, with distinct wet (April-October) and dry (November-March) seasons. The island is made up of two large volcanic massifs: the Pico Basilé

(3011 m), which makes up the northern half of the island, and the Luba Caldera (2260 m) and the Biao Peak (2009 m), which make up the southern massif (Perez del Val, 1996). Precipitation varies with altitude, reaching values of 4000 mm in the so-called fog belt, from 1000 to 1500 m approximately (the high temperature at this level, between 15ºC and 23ºC, together with the copious precipitations cause saturation of water in the atmosphere that gives rise to the characteristic almost permanent diurnal fogs), and then decreases to 3000 mm at the Pico de Basilé (Perez del Val, 1996). Bioko's three high volcanoes also intercept the prevailing southeastern trade winds, resulting in heavy rainfall along the southern coast of the island (11,000 mm yr^{-1}) and a rain shadow (2,300 mm yr^{-1}) along the northern coast where the capital city of Malabo is located (Nosti, 1942). This difference in rainfall creates additional microhabitats and leads to a substantially different vegetation community from the lowland forest in the south of the island, which is subclassified as monsoon forest (Butynski and Koster, 1989) (Table 2.1-1).

The average annual temperature is 25ºC but decreases with altitude (with an average of 27ºC at sea level and less than 5ºC at Pico Basilé) and towards the south of the island, where the annual average is 24.6ºC (Nosti, 1942). In general, there are no large thermal oscillations between day and night or throughout the year, the latter being smaller than the daily ones, with an oscillation of 2ºC to 10ºC (Capuz, 1961). Atmospheric humidity is high, with the annual average relative humidity of the air close to 90%, increasing towards the south and in the belt of mountain fogs and clouds, from 1000 to 1500 m approximately. Although it also depends on the season, it can be said that even in the driest months, the relative humidity never falls below 87% (Ocaña, 1960).

Since the mid-19th century, much of the island's lowland rainforest (except for the southern end) has been cleared or degraded mainly by the cocoa industry or other food plantations to a lesser extent (Perez del Val, 1996). Since independence, however, most plantations were abandoned and are now covered with secondary forest interspersed with small domestic crops, including malanga (*Colocasia esculentum*), plantain (*Musa* sp.), cassava (*Manihot esculenta*), pineapple (*Magnifera indica*), peanut (*Arachys hypogaea*), yams (family Dioscoreaceae), etc. (Perez del Val, 1996; pers. obs.). Roads and human settlements are also located on this vegetation floor but mostly in the island's northern part (as explained in Section 2.1.1.). Montane Forest, in contrast to lowland forest, has been less affected (due to its higher elevation and rather more inhospitable climate), but part of it in Pico Biao (southern zone) was deforested for cattle pastures in colonial times. Pastures and secondary Afromontane forests are still found (Navarro-Cerrillo, 2012; pers. obs.). See pictures in Figure 2.1-2.

Deforestation for timber extraction has not been a threat on the island, as industrial logging concessions are only allowed on the mainland (República de Guinea Ecuatorial, 1997). The exploitation of non-timber products is, however, permitted on the islands. On Bioko, between 1996 and 2004, large-scale extraction of the bark of the African cherry (*Prunus africana*), a tree found only in the Mossy Forest, occurred (Clemente-Muñoz et al. 2006). Impacts on the harvesting populations —one in Pico Basilé and the other in Pico Biao— were significant (Sunderland and Tako, 1999; Clemente-Muñoz *et al.*, 2006); still today, during the fieldwork of this thesis, numerous *P. africana* trees were observed dead on Pico Basilé. Much of Bioko's natural vegetation is found within two large blocks: Pico Basilé and the Southern Highlands (Butynski and Koster 1994; pers. obs.), both declared protected areas.

Table 2.1-1 Vegetation strata of Bioko Island, including altitudinal range and description. Summarised from Guinea (1951), Ocaña (1960), Juste and Fa (1994), Pérez del Val (1996), Clemente et al (2006) and Navarro et al (2012).

Altitudinal Range (m)	**Forest Type (Other nomenclature)**	**Description and common species**
0-20	Coastal Guinea-Congolian rainforest and mangroves (Coastal vegetation)	Narrow cordon that sometimes disappears when the cliffs reach the sea. In sandy areas we find *Cocos nucifera* (Arecaceae), *Terminalia catappa* (Combretaceae), and in their trunks epiphytic ferns such as *Platicycerium stemmaria* (Polypodiaceae). There are only two mangrove areas on the island (one in the Bahia de Venus and another on the west coast) with *Laguncularia racemosa and Avicennia nitida*. Another coastal formation, typical of marshlands at river mouths, is the pandanus (*Pandanus sp.*) swamp.
20-800	Guineo-Congolian rainforest (Lowland rainforest)	The physiognomy of this formation is typical of tropical evergreen forest with very tall trees, an irregular shrub stratum, and an herbaceous stratum with practically no graminoid and with numerous sub-frutescent plants (Perez del Val, 1999). Tree species include all palm species of the island, *Ficus sp*. *Piptadenia africana, Sterculia oblonga, Chrysophyllum africanun, Chlorophora excelsa, Ricinodendron africanus, Crotonogyne manniana, Allanblackia monticola.* Among the herbaceous vegetation *Costus engleranus*, *Piper* sp., *Peperomia* sp., *Palisota hirsute, Pollia condensate,* and numerous fern species as *Cyclosorus afer* and *Nephrolepsis biserrata*.
	Primary Guineo-Congolian rainforest (Monsoon forest)	In the approximate same range of the lowland rainforest but different from it due to the very high rainfall- five times higher. Due to the difficult access of the terrain, this type of forest is the least studied, and few species have been recognized that characterize it; among them: *Mapania amplivaginata* (Cyperaceae), *Costus dinklagei (Costaceae) and Pycanthus angolensis (*Myristicaceae**).**
800/1000-1400/1500	Lowland Afromontane forest (Montane forest)	Nearly permanent fog makes for high humidity and favours growth of epiphytic plants; largely mosses, ferns, orchids, and several species of *Begonia* sp. Canopy height is lower, the palm trees that thrive in the lowland forest disappear, and pure tree fern formations (*Alsophila camerooniana* and *A. manniana*) occur frequently. The understorey is relatively untangled, and often covered with Commelinaceae and Zingiberaceae (*Aframomum sp.*).
1400-2500	Highland Afromontane forest (Araliaceae) (Mossy forest)	Tree composition is characterized by species which are rarely or never found at lower levels such as the arborescent Araliaceae (*Schleffera*

		manii and *Schleffera hierniana*) as well as *Prunus Africana*. Tree ferns are also present (*Alsophila camerooniana* and *A. manniana*), although to a lesser extent than in the lowland afromontane forest. In the shrub coverage predominant species are *Mimulopsis solmssi* and *Crassocephalum mannii* while *Pteridum aquilinum*, *Anchomanes difformis* and *Piper guineense* occur on the herbaceous layer. The lower humidity and higher isolation of this vegetation floor prevents the proliferation of mosses and epiphytic liverworts, which are replaced by hanging lichens (*Usnea sp*.).
2500-2700	Afromontane heath forest (Ericaceous shrubbery) (Shrub formations)	Characterised by an ericoid vegetation like that can be found in Mount Cameroon and the high East African mountains. The Ericaceae *Agauria salicifolia*, *Blaeria mannii*, *Philippia mannii*, as well as *Hypericum revolutum*, *Lobelia columnaris*, and *Crassocephalum mannii* are the most common species here. Other species that occur in the heath forest are *Adenocarpus mannii*, *Pycnostachys volkensii*, and *Pittosporum mannii*.
2700-3011	Afromontane herbaceous vegetation (Subalpine meadows)	The presence of ericoid types of species begins to decrease and to alternate with grasses (*Festuca scimpeana*, *Eragrostis mokensis*) in association with lobelias (*Lobelia columnaris*) and orchids (e.g. *Lyssochylus pourpuratus*).

Shrub formations and subalpine meadows

Figure 2.1-2 Pictures of the various vegetation strata mentioned in the text and in Table 2.1-2.

2.1.5.3 Fauna

Relative to its size, Bioko's fauna is highly species-rich (Bocuma 2016). The island supports a more diverse fauna than other Gulf of Guinea islands. However, due to its origins and recent isolation, this fauna is essentially continental, and endemism is mostly limited to subspecies (UICN, 1991; Jones, 1994). (Bocuma, 2016) argues that although this endemism is less than in the other (oceanic) islands, they are far greater than what could evolve in 12,000 years (the time it has been separated from the mainland). This is because it could have been an island numerous times during the Pleistocene. While part of the mainland, it was a higher-elevation refuge, causing an island-like isolation.

Of the 65 mammal species reported for the island, 28% are endemic subspecies, particularly the Primates. Of the seven species of anthropoid primates found on Bioko Island, one (the Pennant's red colobus, *Piliocolobus pennantii pennantii*) is already considered endemic to Bioko (Groves, 2007), and five (the black colobus, *Colobus satanas satanas*; the Preuss's monkey, *Allochrocebus preussi insularis*; the red-eared monkey, *Cercopithecus erythrotis erythrotis*; the Bioko drill, *Mandrillus leucophaeus poensis*; the putty-nosed monkey, *Cercopithecus nictitans martini*) and possibly the crowned monkey (*Cercopithecus pogonias pogonias*) are endemic subspecies (Gautier-Hion *et al.*, 1999; Grubb *et al.*, 2003; Oates, 2011). In addition, Bioko has four Strepsirrhine taxa: Demidoff's dwarf galago (*Galagoides demidoff*), Thomas's dwarf galago (*Galagoides Thomasi*), Bioko needle-clawed galago (*Euoticus pallidus pallidus*), Bioko squirrel galago (*Sciurocheirus alleni alleni*). Grubb *et al.* (2003) identified the last two as endemic subspecies to Bioko, while Groves (2005) recognised only the Bioko squirrel galago as endemic to the island.

There are only two duikers found in Bioko: the blue duiker (*Philantomba monticola melanhoreus*), considered an endemic subspecies on Bioko (Ansell, 1968; Grubb and Groves, 2001), and Ogilby's duiker (*Cephalophus ogilbyi ogilbyi*), with two populations, one on Bioko Island and the other in the Cameroon/Nigeria borderlands. There is strong evidence that the African forest buffalo (*Syncerus caffer nanus*) was once widespread but overhunted to extinction from Bioko sometime between 1860 and 1910 (Butynski *et al.*, 1997). This would make it Bioko's first native species to be extirpated. However, Butynski *et al.* (1997) suspect that the buffalo was introduced to Bioko by Europeans. If so, there appears to be no example of the extinction of a native species from Bioko (Hoffmann *et al.*, 2015).

There is no evidence that other large mainland mammals occurred on Bioko. Thus, monkeys and duikers are the largest native mammals that remain on the island. Other medium-sized mammals found on Bioko include the rodents *Atherurus africanus* (porcupine), *Cricetomys emini* (forest giant pouched rat) and squirrels (Scuiridae, Anomaluridae); the hyrax *Dendrohyrax dorsalis* (Western tree hyrax); and a member of the scaly anteaters, Pholidota, *Phataginus tricuspis* (African white-bellied pangolin). Five Carnivora have been historically listed as occurring on Bioko. These include four viverrid species (Central African large-spotted genet, *Genetta maculate*; king genet, *Genetta poensis*; Central African oyan, *Poiana richardsonii*; African palm civet, *Nandinia binotata*) and one mustelid species (swamp otter, *Lutra poensis*) (Harrington *et al.*, 2002; Hoffmann *et al.*, 2015). However, there is strong evidence that *P. richardsonii* is the only mammalian carnivore (small or large) unequivocally recorded for Bioko and the other species must be rejected as part of Bioko's fauna (Hoffmann *et*

al., 2015). The remaining mammals of Bioko include 26 species of bats (the largest hammer-headed, straw-coloured and Angolan fruit bats) (Juste and Ibañez, 1994a; Juste and Ibáñez, 1994b; Juste *et al.*, 2000), smaller rodents than those mentioned above (including the endemic Father Basilio's striped mouse, *Hybomys Basilii*, and the Cameroon soft-furred mouse, *Praomys morio* only found in Mount Cameroon and Bioko; both listed as Endangered (IUCN, 2021), and shrews, including Eisentraut's mouse shrew (*Myosorex eisentrauti*) found only on Pico Basilé (Kennerley and Garcia-Ferrer Porras, 2016) .

Nearly 200 bird species can be found on Bioko Island (see Lepage, 2021). The first systematic list of Bioko's birds was by Perez del Val (1996), where 196 species are described in detail. Four new species were later added by Cooper *et al.* (2017). Of the total, 139 are residents, and of these, 46 are subspecies. One species, the Fernando Po Speriops, *Zosterops brunneus*, living only at 1,900 m.a.s.l in the Pico Basilé, and possibly the Bioko batis, *Batis poensis* (Borrow and Demey, 2014) are endemic to Bioko (Perez del Val 1996). Including the subspecies and endemic species this constitutes 34% endemism of the resident avifauna.

The herpetofauna of Bioko is varied, and the greatest abundance of both amphibians and reptiles occurs in the upland forests, possibly due to the high atmospheric humidity of these forest types (Pérez del Val, 1993). About 33 amphibian species (including one species and two endemic subspecies to Bioko) have been described. Among the reptiles, around 50 (including one endemic species) have been recorded (Jones, 1994). Notable iconic herptiles are the Bioko Squeaker Frog (*Arthroleptis bioko*), and the Bioko montane chameleon (*Trioceros feae*), both endemic to Bioko. The large predator, the Nile monitor (*Varanus niloticus*) is also found on the island (IUCN, 2021). Among the venomous snakes, three elapids stand out: the Jameson's Mamba (*Dendroaspis jamesoni*), the black cobra (*Naja melanoleuca*), the Goldie's tree cobra (*Pseudohaje goldii*); and three viperids: the African bush viper (*Atheris squamigera*), the rhinoceros viper (*Bitis nasicornis*) and the spotted night adder (*Causus maculates*) characteristic among the viperids of having rounded pupils (Chippaux, 2006). Two boids also coexist in Bioko: the Central African rock python (*Python sebae*) and the Calabar ground python (*Calabaria reinhardtii*) (Chippaux, 2006; IUCN, 2021). Four of the seven species of sea turtles in the world - the green turtle (*Chelonia mydas*), the leatherback turtle (*Dermochelys coriacea*), the olive ridley turtle (*Kepidochelys olivacea*) and the hawksbill turtle (*Eretmochelys imbricata*) - nest on the southern coast of Bioko (Cronin *et al.*, 2015a).

A significant number of invertebrates are present on the island. Molluscs are particularly important due to their high endemism level and nutritional importance. There are more than a hundred species of land snails on Bioko, 49 of which are endemic to the island (Gascoigne, 1994). The most consumed and preferred species is the Giant West African snail or banana rasp snail (*Archachatina marginata*) (Soriano and Villena, 1997; Zafra, 2008).

As many as 48 fish species have been recorded on and around Bioko; 17 are freshwater (with one endemic species), and 26 are saltwater and brackish water species (Castelo, 1994). There is a remarkable difference within Bioko between the northwest-draining and the rest of the island catchments. The former was once part of the same watershed as the adjacent volcanic region of Mount Cameroon and has a rich freshwater

ichthyofauna. However, the rest of the island is inhabited by salt-tolerant fishes, as found in Sao Tome, Principe and Annobon. Oeser's killifish (*Aphyosemion oeseri*), endemic to Bioko, has a distribution restricted to the small northern rivers and is in great danger of extinction (Castelo, 1994).

Knowledge of the biological diversity of the marine fauna of Bioko is still scarce and patchy, although Bioko is expected to show a lower level of endemism (Jones, 1994). As mentioned above, sea turtles are the best-studied group (Fitzgerald *et al.*, 2011). There is also a guide to the country's fish species (FAO, 2016). It is also known that the waters of Bioko are frequented by marine mammals such as the humpback whale (*Megaptera novaeangliae*), the common dolphin (*Delphinus delphis*), the spotted dolphin (*Stenella* sp.) and common bottlenose dolphin (*Tursips truncatus*) (Pers. obs.).

Although no other possible extirpations of terrestrial vertebrates other than buffalo have been documented on the island, most of Bioko's mammals, as well as some birds and reptiles, are currently hunted for consumption, and this activity affects many of them. In this thesis, I focus mainly on the mammals that are hunted. Table 2.1-2 shows their different degrees of threat according to the IUCN Red List.

Table 2.1-2 Species of mammals hunted for food on Bioko Island and their degree of threat status at the species and subspecies levels (IUCN 2021).

Taxon	English name	Local Spanish name	Sceintific name	Red list Category (species)	Red list category (subspecies)
Primates	Pennant's red colobus[a,b]	Colobo rojo	*Piliocolobus pennantii*	Critically endangered	
	Bioko black colobus[b]	Colobo negro	*Colobus satanas satanas*	Vulnerable	Critically endangered
	Bioko drill[b]	Dril	*Mandrillus leucophaeus poensis*	Endangered	Endangered
	Bioko Preuss's monkey[b]	Guenón/Mono de Preuss	*Allochrocebus preussi insularis*	Endangered	Endangered
	Bioko red-eared monkey[b]	Cola Roja	*Cercopithecus erythrotis erythrotis*	Vulnerable	Endangered
	Golden-bellied crowned monkey	Mono coronado	*Cercopithecus pogonias pogonias*	Near threatened	Vulnerable
	Bioko putty-nosed monkey	Nariz blanca	*Cercopithecus nictitans martini*	Near threatened	Vulnerable
	Bioko Allen's galago[b]	Gálago de Allen	*Sciurocheirus alleni alleni*	Near threatened	Endangered
	Bioko needle-clawed galago[b]	Gálago elegante del norte	*Euoticus pallidus pallidus*	Near threatened	Endangered
	Dwarf galago	Gálago enano	*Galagoides demidoff*	Least concern	
	Thomas's dwarf galago	Gálago de Thomas	*Galagoides thomasi*	Least concern	
Ungulates	Ogilby's duiker[c]	Venado	*Cephalophus ogilbyi ogilbyi*	Least concern	Vulnerable
	Blue duiker	Antílope/fritambo	*Philantomba monticola melanorheus*	Least concern	
Hyraxes	Western tree hyrax	Damán	*Dendrohyrax dorsalis*	Least concern	
Rodents	African brush-tailed porcupine	Puercoespín/Cuerpoespín	*Atherurus africanus*	Least concern	
	Emin's giant pouched rat	Rata de bosque	*Cricetomys emini*	Least concern	
	Squirrels	Ardillas	Sciuridae	Least concern	
Pangolins	White-bellied pangolin	Pangolín	*Phataginus tricuspis*	Endangered	
Carnivora	Central African oyan	Gato de bosque	*Poiana richardsonii*	Least concern	

[a]Recognised by Groves (2007) as a species endemic to Bioko. [b]Recognised by Grubb et al. (2003) as subspecies endemic to Bioko. [c]Recognised by Grubb and Groves (2001) as a subspecies endemic to Bioko; the threat level on the Red List has only been assessed at the species level.
All these species are present in the two protected areas, except the Pennant's red colobus, which is only found in the south.
Galagos have little commercial importance; they are not usually sold and are only consumed at home when they accidentally fall into a trap.

2.1.6 Wild meat hunting and trade

2.1.6.1 Socioeconomic and cultural drivers

Hunting has always been part of Bubi and Fang cultures. Initially, they used wooden darts or spears, plant nets and ingenious traps placed along animal transit paths (Kingsley, 1897; Crespo, 1949), but with the arrival of the Europeans, shotguns were also introduced. During the Spanish colony, they became numerous among the population of Bioko, mainly to control the squirrels in the cocoa plantations, but they were also used for hunting. Under the Macías dictatorship, their use was prohibited, but they became common again after this period. In 1986, hunters' use of shotguns and wire snares became common, and a commercial wild meat market appeared in Malabo (Butynski and Koster, 1994; Hearn *et al.*, 2006). At this time (and after the collapse of cocoa farming and livestock farming –except for households rearing a few animals as a form of reserve banking and to satisfy cultural needs- occurred during the Macias dictatorship), most of the protein consumed by Bioko's inhabitants came from the sea or the bush (Butynski and Koster, 1994). This fact, together with other factors that were occurring in the following years, such as: (1) the increase in population (arrival of Equatoguinean immigrants from the continent and immigrants from other countries), (2) the increase, therefore, in wild meat demand from the cities, (3) the improvement of the island's road system, which facilitates access to the forest and communication between the villages and the capital, (4) the improvement of the hunting techniques with greater use of guns (although not generalised because of costs and political control) and more varied and elaborated traps introduced by the Fang (with a more hunting culture than the Bubi people), favoured the growth of the bushmeat market (Butynski and Koster, 1994; Castroviejo, 1994; Colell *et al.*, 1994). This growth has continued steadily, concurrent with the economic boom caused by the discovery of oil in the 1990s (Cronin *et al.*, 2015b). Although alternative protein sources (imported meat and fish) were readily available during this economic boom, and people did not rely on bushmeat for food (Fa *et al.*, 2000; Albrechtsen *et al.*, 2007; Morra *et al.*, 2009; Grande-Vega *et al.*, 2013), it has remained virtually the only source of fresh meat (Albrechtsen *et al.*, 2006; Cronin *et al.*, 2017), as well as a cultural preference (Fa *et al.*, 2002b; East *et al.*, 2005; Morra *et al.*, 2009). The economic growth had entailed rising incomes and, with it, the demand for fresh meat (East *et al.*, 2005; Morra *et al.*, 2009), leading to higher prices and more significant potential profit for bushmeat carcasses (Fa *et al.*, 1995; Cronin *et al.*, 2015a). This, together with the willingness of Malabo consumers to pay a premium for wild meat over other sources of animal protein (East *et al.*, 2005; Reid *et al.*, 2005; Morra *et al.*, 2009), has caused the market for wild meat hunting to grow (Cronin *et al.*, 2015a).

2.1.6.2 Market structure and taxonomic profile

The market structure and taxonomic profile of animals sold for wild meat in Bioko are relatively similar to other regional markets (Cronin *et al.*, 2017; see also Table 2.1-2). Hunters take their quarry to intermediaries, who supply the end retailer in the city markets. Some meat stays in the village (where it is consumed in houses or bars), and some is hung on the roadside to sell to people passing by. Unlike in larger continental areas, in Bioko, distances are shorter, and the commercialisation of wild meat is less complicated. Fewer middle persons are involved, and a single primary market for wild meat (receiving a very high proportion of the game hunted throughout the island) is in

the capital (The Semu market). An essential result is that more fresh and less smoked meat appears in the island's market (Fa, 2000; Cronin *et al.*, 2015a). Most hunting on the island is carried out by itinerant Fang, who hunt for profit, though the Bubi (with an economy much more based on agriculture) may also significantly impact the prey population in some local areas (Juste, 1992; Colell *et al.*, 1994). While hunters are men in all cases, women are the market's principal processors and distributors of bushmeat (Fa, 2000).

Because Bioko contains an insular subset of the fauna found in the continental part of the Gulf of Guinea, the taxa that make up the bulk of the wild meat sold in the market are the same three groups of species found in markets in West and Central Africa: ungulates, rodents and primates (Albrechtsen *et al.*, 2007; Fa and Brown, 2009; Cronin *et al.*, 2015a). While ungulates and rodents are the most important taxa in all areas where the trade has been documented, primates constitute more than 20% of the trade (Robinson and Bennett, 2000; Fa and Brown, 2009). On Bioko, 89% of carcasses sold in the market were rodents (41%), ungulates (30%), or primates (18%). Reptiles (4%), pangolins (3%) and birds (2%) represented the other important groups in the market (Cronin et al. 2015). Previous market studies (Fa *et al.*, 2000; Albrechtsen *et al.*, 2007) reported percentages that are broadly like those observed in this long-term market study by Cronin *et al.*, (2015a). The most abundant species has always been the blue duiker (representing around 25% of all carcasses), followed by Emin's pouched rat (22.66%), the brush-tailed porcupine (12.34%), and the Bioko red-eared guenon (9.14%). In terms of biomass, the two duikers contribute by far the highest proportions (blue duiker 28% and Ogilby's duiker 21%), followed by the Bioko drill (8.16%) (Cronin et al. 2015).

2.1.6.3 Impact on hunted species

Multiple studies have documented unsustainable wild meat harvesting practices since the emergence of the wild meat market on Bioko Island. As early as 1991, Fa *et al.* (1995) identified that one ungulate, Ogilby's duiker, and five primate species, including the red-eared monkey, putty-nosed monkey, crowned monkey, Preuss's monkey, and Bioko drill, were being hunted at unsustainable rates. This conclusion was based on comparing potential harvest estimates derived from animal production rates (using the Robinson and Redford's (1991) model) and the number of these species found for market sale. By 1996, Fa *et al.* (2000) confirmed a drastic decline in the market presence of these larger species, including Ogilby's duiker and the seven diurnal primates, just five years later. In contrast, the market saw an increase in the number of smaller-bodied species, such as rodents and the blue duiker, with an overall rise in carcass numbers by 60% compared to 1991. This shift in species composition was attributed to the decline in larger species populations due to intense hunting pressure, as no significant changes were noted in hunting methods, the number of hunters, or consumer preferences for smaller animals. Albrechtsen *et al.* (2007) corroborated this trend in 1998. Later, Cronin *et al.* (2015a) conducted a comprehensive 13-year study (from October 1997 to September 2010) on wild meat market dynamics, which revealed that the Malabo wild meat market grew in tandem with Equatorial Guinea's socioeconomic transformation during the oil boom. Unlike earlier studies, Cronin *et al.* (2015a) observed a shift from trapping to shotgun hunting, which led to a significant increase in the volume of carcasses and the rates of larger taxa, such as Ogilby's duiker and primates, indicating intensified hunting pressure on these already threatened species.

Field surveys of primates conducted by the Bioko Biodiversity Protection Program (BBPP) have also confirmed the negative impact of hunting on these taxa. Using reconnaissance survey transects Cronin *et al.* (2016) assessed the relative abundance and species richness of diurnal primates among locations with different hunting pressure in southern Bioko. They found that both species abundance and diversity were highest in areas where gun hunting was minimal, but these parameters declined significantly with increasing evidence of gun hunting. To quantify species' vulnerability to hunting, Cronin *et al.* (2016) calculated a response index and discovered that *Procolobus pennatii* exhibited the highest vulnerability. This species was found to have the most restricted range, occurring only in a limited area of southwest Bioko (see also Cronin, 2013). Additionally, Branch *et al.* (2022) employed passive acoustic monitoring to explore the factors shaping hunting patterns within the GCSR by automatically detecting shotgun sounds. Their study revealed that the construction of the Belebú-Ureca road, completed in 2015 (see Figure 1.3-1 for its extension into the reserve), triggered a significant rise in hunting activity across the GCSR. Alarmingly, this included consistent hunting within the Caldera—one of Africa's most pristine forests, home to the densest populations of primates, including *P. pennatii*. The study highlights the road's impact on wildlife in this once remote and protected area. Previous non-systematic studies conducted by the Bioko Biodiversity Protection Program (BBPP), including those by Cronin *et al.* (2010) and Hearn *et al.* (2004, 2006), have also provided evidence of the negative impact of hunting on primate populations, further supporting these findings.

These studies have all been carried out in the southern part of the island. Only Butynski and Koster (1994) conducted a more extensive study in 1986 and 1990 throughout the island. They collected data on the distribution and abundance of primates in both the southern and northern parts of Bioko. By employing line transects walked by the authors, Butynski & Koster (1994) found that encounter rates were higher in the southern third (and exceptionally high on the Caldera de Luba floor) compared to the north (Pico Basilé). The southern region harboured the seven diurnal primates, whereas three species (*Procolobus pennanti, Cercopithecus nictitans, C. pogonias*) were absent in the island's northern part. The authors attributed these differences to the greater loss of primary lowland rainforest and the higher levels of human activity, including hunting, in the north of the island compared to the relatively undisturbed southern third. Additionally, during this study, the authors collected both systematic and opportunistic data on duikers, which were still widespread then; these findings were later published by Butynski *et al.* (2001). Despite the importance of this island-wide study, no further comprehensive studies or specific research focused on the northern zone have been conducted to assess the impact of hunting on primates or other species—except for the work by Grande‐Vega *et al.* (2016).

2.1.7 Conservation history

Most of the support for conservation on Equatorial Guinea has come from international conservation NGOs and bilateral or multilateral projects.

2.1.7.1 First conservation actions (1985-1992)

Contemporary conservation on Bioko Island began in 1985 with the Spanish NGO Asociación Amigos de Doñana (AAD), operating with support from the Spanish Co-operation Agency (AECI). At that time, Equatorial Guinea was recovering from a long dictatorship in which issues related to the environment, nature conservation, and sustainable use were neglected. Therefore, in coordination with the tutor organism, the Ministry of Culture and Tourism of Equatorial Guinea (MCT), AAD launched an extensive project called Research and Nature Conservation in Equatorial Guinea to bring the country in line with the times and integrate it into the international mainstream. One of the major achievements of the Project was the legal support and design of Law Nº8/1988 (December 31), regulating Hunting, Wildlife and Protected Areas. This law prohibited hunting in a new system of protected areas (the first system was established in colonial times and abandoned after independence), as well as the hunting of specific species.

Another critical achievement of the project was the integration of Equatorial Guinea into international environmental forums, which resulted in the signing of various international agreements (CBD, CITES, CMS, UNCCD) and the inclusion of Equatorial Guinea in the regional cooperation program financed by the European Development Fund (EDF) for the "*Conservation and Rational Use of Forest Ecosystems in Central Africa*". The first phase of this program consisted of a study of the status and use of the country's forest resources and the identification of a network of critical sites for biodiversity conservation, along with a series of recommendations (UICN, 1991). The following phases would lead to the ECOFAC and CUREF projects (see next section).

The NGO also promoted scientific research (Juste and Fa, 1994; Juste and Ibáñez, 1994b; Fa *et al.*, 1995; Juste *et al.*, 1995; Gonzalez-Kirchner, 1996a; GonzalezKirchner, 1996b; Gonzalez-Kirchner, 1996c; Fa *et al.*, 2000; Gonzalez Kirchner, 2004) and conducted important environmental education and training of Equatoguineans in management of natural areas (Castroviejo et al. 1994).

2.1.7.2 Consolidation of the Protected Areas System (1992-2003)

In 1992, only Monte Alén, one of the nine protected areas established by Law 8/88 and situated in the continental region, would benefit from adequate protection through the ECOFAC Project (Ecosistemas Forestales de África Central). This project, launched after the Earth Summit in Rio in 1992, was funded by the European Union within the framework of the above-mentioned program "*Conservation and Rational Use of Forest Ecosystems in Central Africa*". Monte Alen was chosen as a pilot area "*to establish the first National Park in Equatorial Guinea, with the goal of comprehensively protecting its fauna and flora while making the forest compatible with ecotourism*" (CSIC, 2024).

With the support of ECOFAC (and later also of AECI) and the exemplary direction of the biologist Luis Arranz, Monte Alén became a model of park management. It was officially declared the first National Park in Equatorial Guinea in 1997, achieving integral conservation of its biodiversity and developing and improving the quality of life in the region through initiatives such as building commissaries, transport infrastructure for agricultural products, and schools (Arranz, pers. comm.; Merino, 2002). Moreover,

it fostered ecotourism that generated sufficient income to construct several dispensaries in the villages surrounding the park.

In Bioko Island, AAD launched a new project in 1995 titled *'Conservation and Eco-Development in Southern Bioko Island.'* The project aimed to comprehensively manage the protected area in southern Bioko, later designated as the *Caldera de Luba* Scientific Reserve (Zafra, 2008). This initiative, carried out by AAD in collaboration with the local NGO *Amigos de la Naturaleza y el Desarrollo de Guinea Ecuatorial* (ANDEGE), was primarily funded by AECI. However, in 1998, the project's activities were significantly curtailed due to the political-ethnic uprising of January 21 in southern Bioko. Despite this setback, AAD remained active until December 2003. During this period, several key developments were achieved, including the construction of park management infrastructure, notably accommodation for scientists and tourists in Moka, the establishment of a surveillance team to monitor the protected area with a focus on sea turtle protection, as well as the creation of small stores (where food and other basic goods were sold at prices similar to those in the Malabo market) and experimental farms (for raising goats, snails, and pouched rats). A management plan for southern Bioko was also initiated but ultimately could not be completed (Castelo, pers. comm.).[4]

Coinciding with the decline of the AAD, in 1999, the Bioko Biodiversity Protection Program (BBPP) was established as an academic partnership between Arcadia University (USA) and the newly founded (1995) National University of Equatorial Guinea (UNGE). In 2003, AAD transferred its research projects to BBPP: (1) the study of sea turtles, led by PhD student Jesús Tomás from the University of Valencia, and (2) the study of the bushmeat market in Malabo, led by the Durrell Wildlife Conservation Trust under Prof Julia E. Fa (Cronin *et al.*, 2015b; Castelo, pers. comm.).

Additional European Union Development funds supported the project *Conservación y utilización racional de los recursos forestales de Guinea Ecuatorial* (CUREF) from 1996 until 2001 (Machado, 1998). Based on previous studies, the project developed the Draft Bill on Protected Areas of Equatorial Guinea, which established protection categories for 13 areas (2 Scientific Reserves, 3 National Parks, 2 Natural Monuments, and 6 Nature Reserves). Thus, the Provisional Network of Protected Areas, established by Law 8/1988 regulating Wildlife, Hunting, and Protected Areas, was incorporated — expanded and corrected— whose units (9 in total), except for Monte Alén National Park, lacked a formal and sufficient protection regime (Machado, 1998). In 2000, the Government issued Law No. 4/2000 on Protected Areas of Equatorial Guinea, which officially recognized these 13 protected areas proposed by the CUREF Project, covering a total of 591,000 hectares (see Figure 2.1-3).

In March 2002, Conservation International, BBPP, and UNGE co-sponsored an ambitious 'Bioko Biodiversity Roundtable' in Malabo. The three-day conference brought together 26 representatives from 13 different institutions, including Universidad de Alcalá (Spain), Free University of Brussels (Belgium), Duke University (USA), Dirección General de Bosques (Equatorial Guinea), CUREF (Equatorial Guinea), ECOFAC (Equatorial Guinea), Real Jardín Botánico-CSIC (Spain), Museo Nacional de Ciencias Naturales-CSIC (Spain), Durrell Wildlife Conservation Trust (UK), Tierra Viva (UK). One of the key actions recommended during the conference was the

[4] Ramón Castelo was the coordinator and project manager for the implementation of Asociación Amigos de Doñana (AAD) projects.

development of management plans for both of Bioko's protected areas (Declaración de Malabo sobre Preservación de la Biodiversidad de la Isla de Bioko, 2002); however, this recommendation would not be implemented until 2015 (see next section).

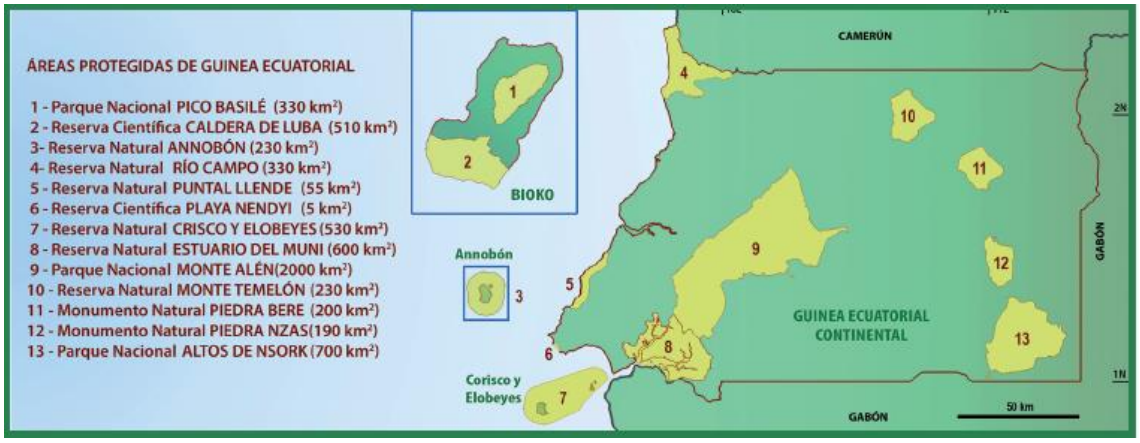


Figure 2.1-3 Map of Equatorial Guinea showing the current National System of Protected Areas of Equatorial Guinea established by Law 4/2000 (adapted from Rosas et al 2022).

Nevertheless, steps were taken towards this goal by implementing some short-term recommendations relating to training and research, awareness-raising and preliminary steps towards managing the areas, such as signage and patrolling (Cronin *et al.*, 2015b). However, most of these actions were mainly focused on the GCSR and were carried out by the BBPP. Meanwhile, the PBNP was left more unprotected and accessible to hunting, especially after the paving of the road to the summit in 2003, where Bioko's communications antenna is located.

In May 2002, in accordance with the provisions of Law 4/2000 and by Decree No. 60/2002 (República de Guinea Ecuatorial, 2000), the National Institute for Forest Development and Management of the Protected Areas System of Equatorial Guinea (INDEFOR-AP, its Spanish acronym) was established. INDEFOR-AP operates as an autonomous body of the Ministry of Agriculture and Forests, with the aim of overseeing the management of the forests and protected areas of the country.

The PBNP, as a protected area, falls under the jurisdiction of this institution. However, INDEFOR-AP's operational capacity would be achieved only gradually, and it would not begin to engage in the conservation of Bioko until 2013.

2.1.7.3 Conservation during the oil boom and early recession (2003-2015)

The period following the 'Bioko Biodiversity Roundtable' and up to 2015 is characterized by the consolidation of the institutional framework for environmental conservation, cooperation with NGOs, the adoption of commitments in international treaties, and, in the later period, financial support from UNDP/GEF. However, all these advances have yet to translate into effective management of the National System Protected Areas.

The exception, Monte Alén National Park, did not last. Starting in 2002, the management of the park was handed over to the Equatoguinean administration, and

funding from the ECOFAC project was reduced (as part of the planned phase-down after its initiation). The park had a hotel and a visitor center, as well as laboratories, offices, housing for workers and researchers, and camps within the park. The EU suggested privatizing the hotel, but this was not carried out. From that point, management of funds began to encounter serious problems, hindering activities. Tourism continued until 2006 but then disappeared completely. Activities were gradually reduced to just patrolling, ecological monitoring, awareness-raising, and support for agricultural development. In 2009, the fourth phase of the ECOFAC project ended, and Guinea was excluded from the program. Most of the infrastructure was lost, except for the hotel.

Despite this decline, the ECOFAC project demonstrated the success of effective management of a national park in Equatorial Guinea and left behind many trained and motivated individuals eager to work in conservation, many of whom became part of INDEFOR-AP, which was strengthened and had its functions further clarified.

INDEFOR-AP's activities focused on the continental region, where it implemented numerous projects in collaboration with international NGOs —Conservation International (CI), the Zoological Society of London (ZSL), the Wildlife Conservation Society (WCS), and others— as well as with the local NGO ANDEGE. While all these organizations contributed to conservation in various areas, CI focused on capacity building, conservation, and institutional support (such as the development of management plans, among other activities); ZSL (in collaboration with Imperial College London) worked on finding viable alternatives to hunting; and WCS concentrated on marine conservation (see Bocuma Meñe 2016 and Appendix 2.1-1).

The other governmental entity, other than INDEFOR-AP, responsible for biodiversity conservation and protected area management, the Ministry of Fisheries and Environment (MPyMA, in its Spanish acronym), concentrated on advancing the commitments made after the ratification of various international treaties (see Cronin *et al.,* 2015b and Doumenge *et al.,* 2015), promoting the enactment of decrees and strategies such as:

Decree No 171/2005 - Strategies and Biodiversity Conservation Action Plan
Decree No172/2005 Regulating the Trade of Endangered Species of Wildlife in Equatorial Guinea
Decree No72/2007 Prohibiting Hunting and Consumption of Primates in Equatorial Guinea
National Environmental Strategies 2010-20

In addition, the MPyMA was the governmental executive body in charge of implementing, together with CI, an ambitious project funded by the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF). The project, titled 'Strengthening the National System of Protected Areas in Equatorial Guinea for the Effective Conservation of Representative Ecosystems and Globally Significant Biodiversity,' was part of GEF's strategic program for sustainable forest management in the Congo Basin. The goal was to make Equatorial Guinea's protected areas system effective in protecting biodiversity at both species and ecosystem levels. To achieve this, the project focused on three key areas: 1) Improving environmental legislation, 2) Enhancing institutional and individual capacities in the environmental

sector, and 3) Demonstrating sustainable management in five protected areas (one of which is Pico Basilé National Park). The project, which began in 2008, had made some progress in areas 1 and 2 after facing many initial hurdles, but no progress had been made in area 3. The responsible entities organized a project-launch-seminar-workshop (April 25-28, Bata) in 2011, where governmental and non-governmental groups, both local and international, involved in conservation in Equatorial Guinea participated, including myself, to clarify the project's implementation strategy. However, this project still failed to translate into effective management of the protected areas, and in 2012 CI ceased its activities in Equatorial Guinea (see also Bocuma, 2016).

Consequently, on Bioko Island, conservation activities during this period were carried out solely by the BBPP (see Cronin *et al.*, 2015b), and later, from 2009 onwards, through the collaboration between UNGE and my work related to this thesis, which developed through the four projects described in Appendix 2.1-2. From the second project (2011), INDEFOR-AP also became involved, opening offices in Malabo in 2013 (its headquarters had previously been solely in Bata, on the mainland). These projects also involved other foreign institutions associated with me and my thesis supervisor, Prof. Julia E. Fa, as described in Appendix 2.1-2.

BBPP focuses its work on the GCSR, conducting research primarily on primates and marine turtles (see Cronin *et al.* 2015 and Section 2.1.6.3) while also developing numerous educational and training programs for the local community. They have established small cooperatives for crafting local artisan products in Ureka and Moka and have held communication sessions with government officials (Cronin *et al.* 2015b). A significant achievement resulting from these sessions was the approval of Decree No. 72/2007 which prohibits the hunting and consumption of primates in Equatorial Guinea (República de Guinea Ecuatorial, 2007). Many UNGE students also receive training and conduct final projects, including a doctoral thesis (e.g. Bocuma, 2016), with the support of BBPP.

The work described in this thesis and the associated projects focuses on Pico Basilé. The research aimed to understand the use of wild meat by peoples living around PBNP as well as investigate the biology of the most hunted species (the blue duiker) to provide a stronger scientific basis for future conservation actions. Throughout the four projects carried out between 2009 and 2015, numerous activities were developed, including training, awareness-raising, knowledge-sharing and institutional strengthening, and management support (see those of the final project in https://ecoguinea.com/). Numerous audiovisual materials were also produced to inform and raise awareness among the population and authorities (see Appendix 2.1-2). In the final project, a **'Program for the Implementation of Management Measures for Pico Basilé National Park'** was developed, previously discussed at a two-day workshop held in June 2015 (12-13 in Malabo) with INDEFOR-AP. The program consisted of a series of actions that, in the absence of a formally approved management plan for PBNP, could control, monitor, and manage activities in the area and address some of the challenges it faces. These actions were also intended to contribute to the future Management Plan for PBNP. The program was prepared by three members of the project team (including myself), following the guidelines for the management of Equatorial Guinea's Protected Areas Network, created under the CUREF Project (Machado, 1998). This program was eventually funded by the GEF/UNDP project and began implementation by the NGO

Ecoguinea (founded by the team from the final project related to my thesis) in November 2015.

In 2015, the BBPP organised a two-day participatory Science & Policy workshop in Malabo to discuss the future of the GCSR (Cronin *et al.*, 2015b). The workshop was attended by scientists, civil society members, policymakers, educators, NGOs (including ours), and government ministries. The aim of the symposium was to create a detailed framework for a management plan for the GCSR, develop a strategy to ensure its ministerial approval, and produce a document for the potential recognition of the GCSR as a UNESCO World Heritage Site and Biosphere Reserve.

2.1.7.4 Recent years (2015-2024)

The implementation of the program with the initial management measures for PBNP mentioned above, was carried out in two phases: November 2015–March 2016 and September 2016–October 2017, both funded by the GEF/UNDP project. This initiative achieved the following:

- Establishment of a team of Eco-guards[5] (previously trained and equipped) and a park director
- Marking the park boundaries
- Setting up trails and identifying points of interest for visitors and scientists
- Conducting patrol and surveillance missions
- Informing and raising awareness among the local population

From 2018 onwards, park staff continued working with financial support from the government, and in 2020, the local NGO ANDEGE prepared the "Participatory Management Plan Proposal for PBNP," funded by the Critical Ecosystem Partnership Fund (CEPF). The Covid pandemic caused a significant halt to activities, although they began to resume in 2023. In summary, management activities conducted from 2018 to the present can be summarized as:

1. Patrols for terrain reconnaissance, trail maintenance, identification of points of interest (touristic and scientific), and data collection on hunting and logging activities
2. Mapping of the terrain, trails, and points of interest in 2020
3. Collaboration with scientific studies (birds, primates)
4. Some enforcement actions (dismantling of hunting cabins and confiscation of captured animals)
5. Providing information to hunters and loggers

In the GCSR, the GEF/UNDP project supported BBPP in 2021 to carry out various alternative livelihood projects for those living in and around the area, as well as the construction of a management center/checkpoint for INDEFOR-AP in Ureka. That same

[5] Eco-guards are integral to biodiversity conservation in Africa, operationalising environmental policies across local, district, regional, and national levels. In partnership with local authorities they monitor ecosystems, mitigate potential threats on species and habitats, and notify relevant authorities of any indicators of environmental distress. Additionally, eco-guards can carry out an educational role within the communities they interact with (https://globalbiodiversityprotection.org/en/cause-view/eco-guards/).

year, the management plan for the GCSR was also validated; however, it has not yet been implemented (Montgomery, pers. comm.).

Although INDEFOR-AP's activities in the GCSR have been minimal, the presence of BBPP has had a positive impact by reducing hunting in areas where its personnel are present (Branch *et al.*, 2022). Unfortunately, BBPP nearly collapsed between 2020 and 2022 when Drexel University ceased its support, and expeditions were halted. It is currently in the process of slowly rebuilding, but it may not have a presence in the Caldera this 2024/25 dry season (Fernández, pers. comm.).

In the continental region, the situation is similar. Although at least seven management plans have been developed for the eleven protected areas (Doumenge *et al.*, 2015), none have been fully operational, and the level of management in areas where activities have taken place has been like that on the island.

The latest information I received indicates that the economic crisis (see Section 2.1.4.3) is affecting INDEFOR-AP's funding, which, at least on the island, has been reduced to a minimum. "The staff receive their salaries, but there is no funding for fieldwork or any form of protection" (Fernández, pers. comm.). Even so, INDEFOR-AP continues to work and is currently preparing an application for Bioko to be recognised as a biosphere reserve.

In Summary, the current situation in Bioko's protected areas is as follows:

- Little to no management activity by INDEFOR-AP
- No operational NGOs in Pico Basilé (work related to this thesis ended in 2015, and Ecoguinea's activities ceased in 2018), and limited BBPP activity in the GCSR
- Recognition in the 2023 PBNP Annual Report that, "Despite efforts to reduce poaching and wildlife trafficking within the PBNP, and despite having a barrier to prevent unauthorized personnel from entering, Basilé Fang remains one of the hotspots for illegal hunting, accounting for over 35% of recorded extractions during the year. While Basilé Fang remains a key hunting site, hunters are increasingly targeting other areas such as Bombe and Moeri."

2.2 Pico Basilé

This study focuses on the Pico Basilé, the highest mountain on Bioko Island (3,011 m), declared a national park from 800 m above sea level to the summit, and described in detail in Sections 1.3.1 (conservation importance), 2.1.1 (geography and population), 2.1.5.2 (vegetation and climate), 2.2.5.2 (fauna), and 2.2.6.3 (threats). On the slopes of Pico Basilé and around PBNP lie the island's main roads and most of Bioko's population and villages, including the capital, Malabo. In Sections 2.1.7 and 2.1.6.1, I detail how, despite conservation advances in the country and on Bioko, the PBNP is still not being managed as such. As a result, medium and large mammal species continue to be intensively hunted, even though many of them being threatened (Table 2.1-2).

To understand the importance of wild meat for the rural population of Pico Basilé, particularly those who depend on it as food, I studied food consumption and subsistence activities in a sample of 10 villages located in the northeastern part of the Pico Basilé (Figure 2.2-1). Here, hunting is most intense compared to other areas. Village selection and characteristics of the villages are given in Section 3.2.2.1 (see also Table 3.2-1).
In two of these 10 villages —Basilé Fang (engaged in commercial hunting) and Basilé Bubi (focused on subsistence hunting)—, I conducted a comparative analysis of consumption patterns, livelihoods, and offtake, due to the unique characteristics of these villages, as detailed in Section 3.2.2.2.

Finally, by working closely with Basilé Fang hunters, who have access to the entire altitudinal range of the Pico Basilé (see Section 3.3.1), I was able to collect data on the reproduction and body condition of the blue duiker throughout the peak.

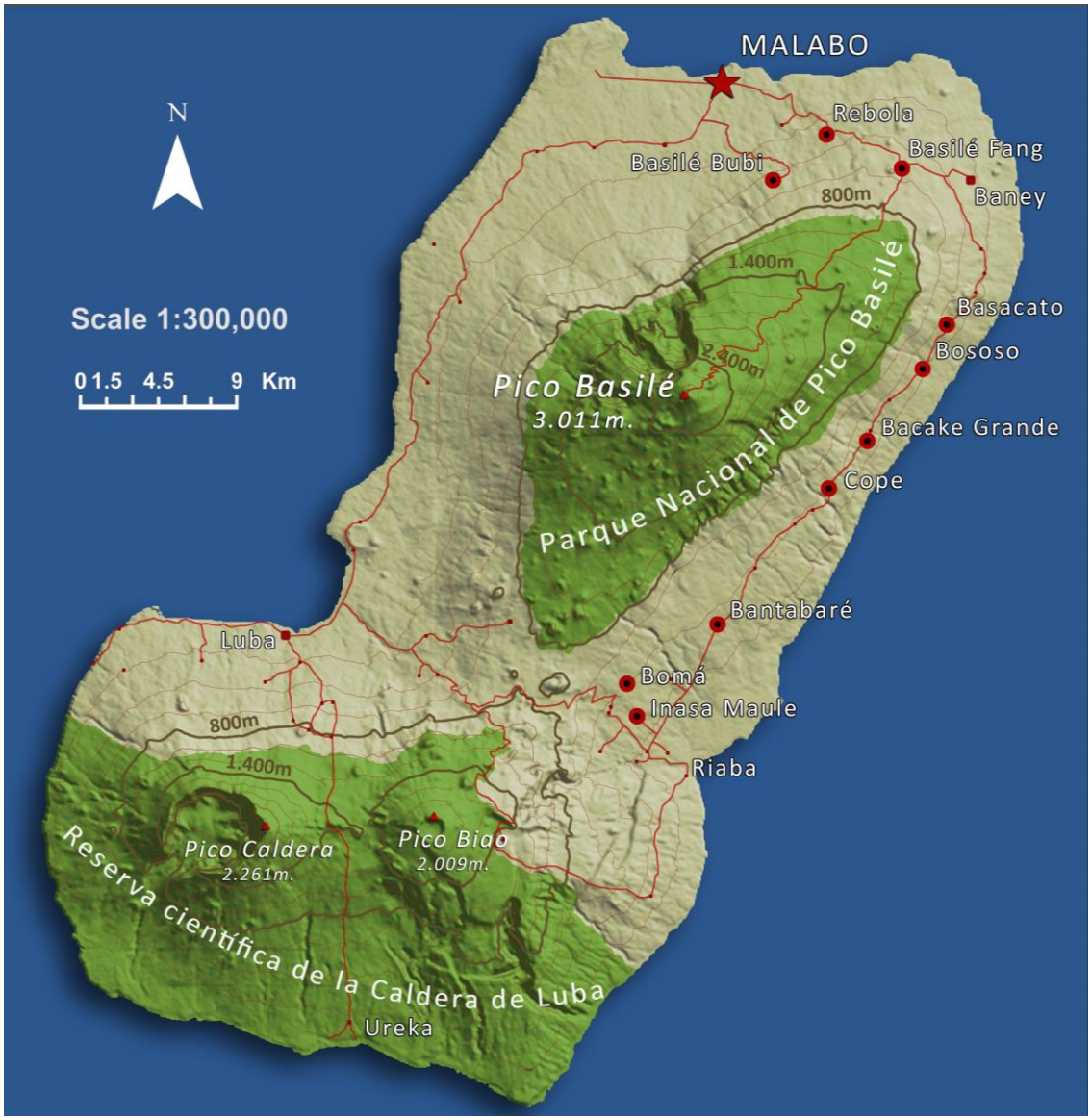


Figure 2.2-1 Map of Bioko Island showing study villages (large red/black dots), other villages (small red dots) and towns (red squares), the capital Malabo (red star), major roads (red lines), protected areas (green areas), altitudinal rings (in brown the approximate boundaries of the vegetation strata), and peaks (triangles).

Chapter 3: METHODOLOGY






Photo captions can be found in Appendix P

3.1 Setting the stage

Since this thesis is not merely academic research but a study linked to conservation in Equatorial Guinea, it was crucial to develop a strong cooperation framework with Equatoguinean institutions and local communities from the outset. It was essential for them to take ownership of the study's objectives, and the possible implementation of any activity related to its results. Additionally, my work also aimed to contribute to scientific training in the National University of Equatorial Guinea (UNGE), especially with the Faculty of Environment (FMA, in Spanish) and the University School of Agricultural, Fishing and Forestry Studies (EUEAPF, in Spanish).

Apart from the Ministry of Environment, in 2009 the UNGE was the only Equatoguinean governmental institution in the country working on conservation issues on Bioko Island. The National Institute for Forestry Development and Management of the Protected Areas System (INDEFOR-AP), the other major environment-related institution, had no representation on the island and conducted no work there. Partly encouraged by our work, INDEFOR-AP opened an office in Malabo in 2013 and began working on the island and collaborating closely with us (see Section 1.2.7.3).

The only other significant conservation project in Bioko was the joint program between Drexel University, Pennsylvania in the USA, and the UNGE which commenced in 1998. This program, known as the Bioko Biodiversity Protection Program (B) developed joint conservation activities in the southern part of the Island, specifically in the GCSR, the other protected area on Bioko apart from the PBNP (see Figure 3.1-1). However, no actions or programs had been undertaken in the PBNP until then.

Prior to starting my field work, all research protocols and questionnaires were discussed, finalized together and approved by the UNGE. It was also decided to involve several professors and students from FMA and EUEAPF in the research activities. I also presented the objectives and work plan to the BBPP program and spent several days at their Wildlife Research Center at Moka (in the south of the Island), getting to know the work of this organization. I contacted other environmental institutions and organizations not directly involved in conservation work at that time (Spanish Cooperation, USAID, UNDP, FAO, and some civil organizations). Interviews with their representatives were to discuss their projects (past, present and future) and to share insights about my own work.

The necessary permits were obtained from the Ministry of Tourism and Culture (the one that applied at the time) to work within the PBNP and with local communities adjacent to it.

3.2 Rural livelihoods and diets: understanding the contribution of wild meat

3.2.1 General approach

In this section, I describe the methods used to understand the nutritional and economic importance of wild meat for the population living around the PBNP, employing two different levels of study.

The first level focuses on a sample of ten villages and analyses two main aspects:

- *Livelihood Strategies:* This includes examining the population's livelihood strategies, emphasising hunting and identifying factors that influence greater engagement in this activity. Specifically, I examine the influence of paid work on hunting activity.
- *Protein Intake:* This involves assessing the contribution of wild meat, other meats, and fish to the daily animal protein intake and investigating factors that explain the varying consumption levels. Specifically, I examine the influence of access to alternative protein sources on the consumption of wild meat, other meats, and fish.

Additionally, I use data on household incomes collected in three of the 10 villages to understand the economic contribution of different livelihood strategies, particularly hunting, in contrast to other activities.

The second level delves into a more detailed comparative study of two villages—Basilé Bubi (BB) and Basilé Fang (BF). BB engages in subsistence hunting, where wild meat is primarily used for personal consumption, while BF exemplifies a village involved in commercial hunting, where wild meat is sold for income. In these two villages, I evaluate the nutritional and economic importance of wild meat according to the type of hunting practiced. Specifically, I analyse the contribution of wild meat and other protein sources to the daily total protein intake (both vegetable and animal). Additionally, I use quantitative socio-economic data from two sources:

- *Cross-Sectional Household Interviews*: These interviews provide income, expenses, and wealth data.
- *Long-Term Offtake Survey*: This survey includes data on hunting revenues.

I hypothesise that households in BF engaged in commercial hunting will exhibit greater nutritional benefits and higher economic advantages from wild meat than those in BB engaged in subsistence hunting due to increased income and enhanced access to wild-animal protein.

3.2.2 Selection of study villages

3.2.2.1 Villages around PBNP

Before starting the study, I visited 33 of the 57 villages (57%) around PBNP: 21 on the Malabo-Riaba Road, five on the Riaba-Luba Road, and seven on the Luba-Malabo Road. These villages, which are distributed across the two provinces (Bioko Norte and Bioko Sur) and four districts (Malabo, Baney, Riaba, and Luba) of the island, represent a significant portion of the area surrounding PBNP (see Figure 2.2-1). I was accompanied by the professor and Deputy Director of the EUEAPF, the late Dr. Claudio Posa Bohome[6], a Bioko native and connoisseur of its people and forests. During these visits, I met traditional chiefs, village presidents, and military personnel assigned to the area. I presented my permits and discussed the study's objectives. I also took the opportunity to gather valuable information on the characteristics and lifestyles of the villages, as well as their willingness to participate in the study.

These visits gave me insights into the rural population around PBNP and the various human settlements, which proved invaluable in designing my sampling strategy. Furthermore, I could ascertain the distances and travel times required to access each site, enabling me to evaluate the effort required for the study.

Villages around the eastern half of the PBNP are closer to the park's boundary (800 m.a.s.l.) than those on the western half, as shown in Figure 2.2-1. According to Dr. Posa and information gathered during our visits, the most significant commercial hunting activity is concentrated in the East. I selected 10 villages in this area to capture the range of human settlements around the PBNP, considering factors such as administrative importance, population size, predominant ethnic group, distance to Malabo, road accessibility and other factors (see Table 3.2-1).

Throughout my research, I applied clear Free, Prior and Informed Consent (FPIC) protocols to establish bottom-up participation and consultation before the beginning of all interviews and gathering data.

3.2.2.2 Basilé Bubi and Basilé Fang

Two of the ten villages in the sample, BB and BF, were selected for the comparative study mentioned in Section 3.2.1. These villages were chosen due to their shared characteristics—population size, access to protein sources and alternative livelihoods, and proximity to urban areas—and particularly their critical differences in subsistence and commercial hunting practices. These disparities allowed for the control of confounding variables, enabling a more precise determination of whether households engaged in commercial hunting derive greater nutritional and economic benefits from wild meat than those involved in subsistence hunting, due to increased income and enhanced access to wild animal protein. The key characteristics are as follows:

- *Type of hunting practice:* BB is an established community, probably dating back to the first settlements of Bubi peoples around 50 B.C. It is inhabited mainly by

[6] Dr Claudio Posa Bohome passed away at the age of 44 in 2010 due to a sudden illness that struck while he was participating in a scientific expedition to the Gran Caldera de Luba, organised by the National University and Drexel University (USA).

farming families who set traps around their farms to supply their households with some meat. In contrast, BF was founded in 2005 by traders from mainland Equatorial Guinea, Rio Muni (of Fang ethnicity), who were involved in commercial hunting as a means of earning income.

- *Geographical location and access*: Both villages are located at the foothills of Pico Basilé in the northeast, 10-15 km south of the country's capital, Malabo, which had a population of approximately 211,000 inhabitants in 2001 (Directorate General of Statistics and National Accounts, 2012) and are connected to it by a well-maintained asphalt road (see Figure 2.2-1). They also have similar distances to the PBNP. However, BF has greater access (than BB and any other village) due to its strategic location at the base of the only access road into the park.
- *Demographic characteristics*: The two villages have comparable population sizes (110 inhabitants in BB and 150 in BF), and regarding ethnicity and livelihood activities, both villages collectively display many of the characteristics of all sample villages (see Sections 2.1.1 and 2.1.2 for more details). Additionally, both villages had similar average employment rates relative to the total sample (see Section 4.1.3.7).

3.2.3 Data collection

3.2.3.1 Study period and UNGE participation

Interviews were conducted between May and October 2009 to gather information on household composition, livelihood activities, and food diaries. Socio-economic interviews focused on household income, expenditures, and wealth were conducted between August and December 2010.

All interviews were conducted by me and three students from the Environmental Faculty at UNGE (Mr. Eulogio Abeso, Ms. Lucrecia Bile, and Mr. Ricardo Oyono). Ricardo participated as part of his final Bachelor's thesis, while Eulogio and Lucrecia worked as interns. I trained all three and accompanied them during several interview sessions before they conducted interviews independently. Eulogio and Lucrecia collected data in Bososo, whereas Ricardo accompanied me to eight of the nine remaining settlements, conducting almost a third of the consumption interviews. I regularly checked the data quality of all interviews undertaken by the interns and student. Socioeconomic interviews were performed by me.

In addition to household interviews, hunting revenues were also estimated using data from the first 16 months of the offtake survey (October 2010–November 2011), as detailed in Section 3.2.3.6.

3.2.3.2 Household selection and sample size

In villages with around 40 households or less (all except Rebola and Basacato), all households were visited and encouraged to participate in the consumption study. In Rebola and Basacato, which had around 1700 and 160 households, respectively, a random sample of 30 households was selected for each. The team walked a zigzag route

through each village to accomplish this, timing the journey. This time was then divided by 30, resulting in several minutes designated as "X." A similar procedure involving stopping at regular intervals of "X" minutes would yield a random sample of 30 points/stops. At each stop, the nearest house was selected.

If any unoccupied household at the time or if the occupiers refused to participate in the study, the next closest household was chosen. The zig-zag approach ensured that houses off the street or main paths were also sampled.

A total of 214 households in 10 villages agreed to participate in the project and were first interviewed about their household composition (Section 3.2.3.3). Of these, 155 also provided information on their livelihood activities (Section 3.2.3.3), and 162 agreed to respond to the 24-hour recall consumption interview and complete the remaining six days of the consumption diary (Section 3.2.3.4). Subsequently, 57 consumption diaries had to be discarded as incomplete or unreliable. The final sample of one week-consumption diaries was, therefore, 105. In total, 798 days of consumption (mean [SD] = 7.51 d/household [1.19], range 6-16) in 10 villages were recorded. Table 3.2-1 summarises the number of final interviews included in the analyses.

The initial plan was to conduct socioeconomic interviews with all households that had previously participated in the consumption study. I started with pilot interviews in Rebola, Bakake Grande and Basacato. After these pilot interviews, I realised the significant effort and trust required to obtain reliable quantitative data. Given the available resources and time constraints, I decided that conducting these interviews in only some villages was feasible. Consequently, I focused on BB and BF, the two villages selected for an in-depth study (as explained in Section 3.2.1). I also used income data from Basacato (which was correctly collected) to have a larger sample to estimate the average annual household income from various subsistence activities. Despite my initial efforts to interview all families who had previously participated in the consumption study, some declined to participate or were unavailable. Ultimately, the analysis included 11 households from BF, eight from BB, and seven from Basacato (Table 3.2-1).

Table 3.2-1 Characteristics of surveyed villages and the number of household interviews in the final sample.

Village	Characteristics						Num. Of household Interviews			
Name	Settlement type[a]	Number of households (own census)	Ethnic group	Distance to Malabo (and to main road & type of connection) (km.)	Time to Malabo by car (min.)	Distance to the sea (km.)	Household composition	Liveli-hoods	Consumption	Income and wealth[b]
Rebola	Municipallity	1777	Bubi 100%	8,2 (0)	12	3,7	27	15	16	---
Basilé Bubi	Village	32	Bubi 100%	8,3 (0)	19	5,0	32	27	14	8
Basilé Fang	Patio/Village[c]	31	Fang 98%	13,5 (0)	17	5,0	31	31	13	11
Basacato[d]	Village	166	Bubi 100%	26,8 (0)	29	1,4	19	14	7	7
Bososo[d,e]	Village	40	Bubi 100%	31 (0,9 paved)	35	1,1	21	---	21	---
Bakake Grande[d]	Village	42	Bubi 95%	36,5 (0)	37	1,6	27	25	11	---
Cope	Grouping	10	Fang 75%	39,9 (0)	39	0,8	5	5	5	---
Bantabaré	Village	36	Fang 92%	52,8 (0)	49	2,5	36	23	10	---
Inasa Maule	Patio	13	Fang 100%	53,8 (1 dirt)	57	3,7	11	11	3	---
Bomá	Village	6	Fang/Bubi 50%	60,1 (0.55 dirt)	65	5,2	5	4	5	---
Total		2153					214	155	105	26

[a]The types of human settlements on Bioko Island include: formally recognised villages, many of which are originally Bubi or, in some cases former Fang settlements that have eventually been officially recognised as villages; and unofficial Fang settlements, which may be located in former cocoa plantation barracks (referred to as a 'patio' in Spanish) or organised as roadside groupings (see also Section 2.1.2).

[b]Quantitative socioeconomic data were collected in only three villages, as detailed in Section 3.2.3.2.

[c]Originally established in a former cacao plantation barrack (patio), Basilé Fang was officially recognized as a village in 2005.

[d]Fishing villages.

[e]Bososo was the first village interviewed, serving as a training ground for both me and the students who participated. Data on household composition (except education level) and meat and fish consumption were correctly collected and proved useful for the analysis. However, data on livelihoods were not adequately collected and therefore discarded, as indicated by the dashed line in the 'livelihoods' column.

3.2.3.3 Household composition and livelihood activities

A household census was conducted in the 214 households that agreed to participate in the project, recording each member's age, sex, relationship to the household head, origin, ethnicity, education level, and livelihood activities. However, only 32% of households provided accurate education information, and 72% provided accurate livelihood details, with no data collected in Bososo (See Table 3.2-1). The census data sheet, with a sample response, is shown in Appendix 3.2-1.

In all households that agreed to participate in the project, additional questions of interest were also explored informally. These included inquiries into the motivations behind their work, involvement in other current or past activities, livestock rearing, seasonal cropping, and details about their culture and traditions. If the interviewee held a relevant position in the village or was an elder who had lived there for many years, further questions were posed regarding village politics, popular festivals, land tenure, and perceptions of changes in various activities—including hunting if the interviewee was a hunter—or shifts in the village lifestyle over time.

In BF, motivations for current and past work were formally investigated through semi-structured interviews with heads of 24 households (see Appendix 3.2-2). Information on livestock rearing and cropping was also formally collected in BB, BF, Basacato, and Bakake Grande through semi-structured interviews as part of the socio-economic survey (see Appendix 3.2-3).

3.2.3.4 Food consumption and protein intake

3.2.3.4.1 Consumption data

There are two general ways to collect consumption data: through a recall interview (or a series of recall interviews of one or more days) or diary surveys where respondents are responsible for recording their food consumption (Oseni *et al.*, 2021). While a well-implemented diary (lasting 7 to 14 days and conducted at least twice a year, or once but with the sample spread over different seasons) is considered to be the most accurate way of collecting food consumption and expenditure data, there is ample evidence that in low-income settings with high illiteracy rates, diaries are often implemented as a series of short recall interviews (Oseni *et al.*, 2021).Consumption studies conducted in mainland Equatorial Guinea (Kümpel, 2006; Allebone-Webb, 2009; Fa *et al.*, 2009), as well as others conducted in other parts of Africa and the Neotropics (Wilkie *et al.*, 2005; Godoy *et al.*, 2010), exemplify this approach. Although some of these studies, such as that of Godoy *et al.* 2000 and Carvalho *et al.* (2015), use an interview with a recall period of one week, others have found that the respondents' ability to recall declined substantially after the third day (Jenkins *et al.*, 2011) or even after one day of recall (Kümpel, 2006).

On Bioko Island, literacy and proficiency in Spanish are higher than in the inland villages. Therefore, I based part of the household consumption interview format on those being conducted by Kümpel (2006) on the mainland (which in turn were based on those performed in Gabon by Wilkie *et al.* (2002) and Wilkie *et al.* (2005), but I used the

seven-day diary method (explained in detail in the next paragraph). My fieldwork period coincided with the rainy season. Although my budget at that time did not allow me to collect another seven days of consumption data during the dry season, interviews with villagers suggest that seasonal variation in food availability and consumption may not be significant. This was later verified for wild meat after my offtake surveys (where the results showed similarity in hunting for both seasons) and for domestic meat and fish (available in markets all year round). Kümpel *et al.* (2010b) also found no seasonal pattern in either wild meat or overall meat/fish consumption on the mainland.

To complete the one-week consumption diary, I asked the person in charge of cooking in the household (usually the female head of the family) for all products, natural resources and manufactured goods consumed (purchased, hunted, caught, or otherwise obtained) the previous day. This included the main meals—breakfast, lunch, and dinner—and any food consumed between meals. I also inquired about the number of people in the household (or guests, if any) who ate these foods, including their sex and age. Additionally, I asked about the condition of the product at the time of purchase (live, fresh, smoked, frozen, canned, etc.) and at the time of consumption (fried, cooked, smoked, raw), the quantity (kilograms, number, part/proportion of carcass, cup, sack, pile, etc.), where and how it was obtained (purchased, received as a gift, captured, farmed), and the total cost if purchased (in the local currency: Central African francs-CFA; code XAF). I also asked the interviewee how many meals were consumed outside the home and who ate them. They were included if these meals were few and could be well quantified; otherwise, the consumption diary was discarded.

Subsequently, I taught the respondent how to complete the next six days of consumption data (see Appendix 3.2-4 for an example of a food diary sheet). One week later, I would return to collect all the data. Usually, there were quantities or ingredients to clarify, but if the diary was complete and the person who had filled it in was present, it was easy to correct. If that person was absent, I would return another day. In cases where the food diary had not been completed, or important doubts were not resolved, the diary was discarded. If the interviewee had not completed the diary due to some external reason but showed willingness to do so, it was left for another week. There were also cases where the respondent collected more than one week of consumption data. In most cases, this extended to only a few more days, but in some cases, it extended to more than two weeks. In no case did I include more than 16 days in the analysis. However, I used these extended cases to examine if there were significant differences in meat and fish consumption between one week of data and more, and there were not.

3.2.3.4.2 Calculation of protein intake

To transform the quantities of food given in another type of unit into grams, I collected data on the weight of these units. For instance, if the amount was a cup of rice or a handful of local greens ("verdura"), I weighed several cups or handfuls, preferably in the same house or village. For purchase units linked to a price, such as a 500 XAF pile of chicken wings from the market, I would visit the market (or village shop) and, with the shopkeeper's permission, weigh multiple (>10) 500 XAF piles. This provided both the pile's average weight and an individual unit's average weight (e.g., a chicken wing). This method of selling by fixed-price piles was common, and the specific sale locations (two main markets in Malabo or village shops) ensured accurate quantity measurements.

While weighing local units, I also calculated the edible portion of many foods. For example, after cleaning a sample of medium-sized whole snails, I weighed the edible parts and the residues. My research assistant (A.O), whose uncles owned a bar, helped by weighing various wild animals whole or in pieces (of different sizes) before consumption and weighing the remains. For commonly consumed imported foods like chicken, turkey, pork, and fish, I referenced the edible portion data from literature sources, including the MAPA (2022) and the AESAN/BEDCA (2010).

Without a specific food composition database for Equatorial Guinea, the protein contents of all foods were taken from Vincent *et al.* (2020) and Stadlmayr *et al.* (2012) FAO/INFOODS food composition tables for West Africa. Data for foods not found in these tables were supplemented from various sources, including Oguntona and Akinyele (1995), Idris *et al.* (2011), and Latif and Müller (2015) for commonly eaten plant foods; Ejoh *et al.* (2007), Tongco *et al.* (2015), Jimoh *et al.* (2010), González *et al.* (2003), and Okeke *et al.* (2009) for wild edible plants; Malaisse and Parent (1982) and Ajayi and Tewe (1983), for wild meat species; and Oguntona and Akinyele (1995), Martínez *et al.* (2005), and AESAN/BEDCA (2010) for domestic meat and fish. Fish species and wild edible plants were identified in the field using the FAO (2016) guide and the book by Gómez-Marín and Merino-Cristobal (1989), respectively. Plants that could not be identified were photographed and dried, and specimens were taken to the UNGE. Dr. Maximiliano Fero Meñe (UNGE) and Ms. E. Gómez-Marín (Cooperación Española) later identified them.

I needed some household size measures to compare protein consumption across households. The most straightforward measure is the number of individuals in the household, but this does not consider the differences in energy needs based on sex and age (Sellen, 2003). To account for this, I used a measure of adult male equivalents, specifically Reference Adult (RA) units calculated according to the ILCA (1981) and FAO/WHO/UNU (2007). The RA represents the daily food energy requirements of an active African adult male, or 2530 kcal, based on the nutrient and energy intake recommended for African populations by FAO/WHO/UNU (1985) and FAO/WHO/UNU (1973). Thus, the food energy requirements for an adult male are taken as 1 RA, and the requirements of members of other population classes are expressed as proportions of this as follows:

Child	0 – 5 years	0.52 RA
Child	6 – 10 years	0.85 RA
Child	11 – 15 years	0.96 RA
Adult female	16 – 60 years	0.86 RA
Older female	> 60 years	0.85 RA
Older male	> 60 years	0.85 RA

Then, from the sex and age data of all persons eating each meal, I obtained the number of RAs at each meal. Daily animal and vegetable protein consumed per RA was determined by multiplying the amounts eaten of the different foods during each meal by their respective protein content. Hence,

$$\text{PIRA} = \sum (A_{a\ldots n} \times P_{a\ldots n})/\text{RA},$$

where PIRA is the protein intake per RA during a single meal, *A* is the total amount (in grams) consumed of food items *a . . . n*, and *P* is the protein content (grams of protein per gram of the food item), and RA is the total number of RAs consuming that meal. The total daily protein intake per RA was derived by adding all PIRAs for each sampled day.

The one-week consumption diaries technique was tedious at first, mainly because it was conducted in several villages simultaneously. After realising this, I concentrated on a single village at a time, which made the task much easier and efficient. In general, the people in the villages were welcoming and willing to cooperate after I explained the purpose of the work and assured them that I would thank them for their cooperation with food gifts (such as rice, oil, and soaps) at the end of the study.

3.2.3.5 Household income and wealth

3.2.3.5.1 Background and interview details

In all societies, monetary income and household wealth determine food consumption (Godoy *et al.*, 2010). They also influence hunter behaviour (Nielsen *et al.*, 2014). It is, therefore, relevant to understand and analyse their influence on wild meat production and consumption. In developed countries, there is a large amount of data on monetary income, but in the African rural context, where many respondents are self-employed farmers, these data may be more challenging to obtain. Reliable income measurement in these cases requires collecting information on all purchases and sales and thus requires considerable effort and trust with the respondents (Morris *et al.*, 2000).

To estimate annual monetary income, I conducted semi-structured interviews in Basacato, BF and BB households that had previously participated in the consumption survey. They were, therefore, households that had shown interest in the project and knew me well, as I knew them and their occupations. I am confident that the interview was answered thoroughly and arguably honestly. Additionally, I was able to triangulate with three other data sources: the household composition and livelihood activities survey (Section 3.2.3.3), the consumption survey (Section 3.2.3.4), and, in the case of BB and BF, with the wild meat offtake survey (Section 3.2.3.6). I asked all working household residents to recall the amount of income from salaries, wages, bonuses, pensions, donations, commercial activities (sale of forest goods or other goods), gifts, and remittances over the past year. To do so, I guided them step by step through each activity performed, calculating the net profit for each day, week or month, as appropriate, and finally, for the year. I used a "bottom-up" approach (as described in Crookes *et al.*, 2007), which, for activities such as hunting or farming, includes questions related to how many items are sold on a typical day, frequency of typical days, whether there are periods when sales are higher or lower, the average price of different products, etc. The socioeconomic interview data sheet in Appendix 3.2-3 (Section B) provides a detailed example of this approach and these steps.

To provide an alternative measure of income, I also calculated household expenditures, which can be used as a proxy for the income generated by resources available to the household (Morris *et al.*, 2000). In other words, this method assumes that a higher level of household expenditures measures a higher socioeconomic position (Deaton, 1997; Morris *et al.*, 2000). Morris *et al.* (2000) extended this approach by showing how this

can be assessed by developing a shortlist of key items that mirror total household expenditure when summed. Based on the key elements analysed by the author, those used in previous studies in Equatorial Guinea (e.g. Kümpel 2006; Allebone-Webb 2009), and on what my research assistants and I considered to be a significant or representative part of household expenditure in Bioko villages, I calculated annual household expenditure from the spending on education (tuition, school supplies, transport to school, accommodation), on immediate family members or other dependents (allowance, telephone, travel allowance, other), on electricity, fuel, phones, tv and/or internet, on regular meals away from home, on rent and other extraordinary or regular expenses (travel, renovations, workers, etc.) (see questionnaire in Appendix 3.2-3 Section A).

To assess the comparative wealth of each household, I followed an asset-based approach (see Morris *et al.* 2000). I asked the household head about the ownership of 23 items (including number and individual price or value) acquired within the last 5 years (see list of items in Appendix 3.2-3, Section C). Items were chosen after reviewing previous asset-based studies from rural areas of Equatorial Guinea (Kümpel, 2006; Allebone-Webb, 2009) and other parts of Africa (Wilkie *et al.*, 2005) and after discussing with villagers (not only from BB and BF but from other villages around PBNP) what they considered to be indicators of wealth. Items covered a wide range, from relatively cheap subsistence goods (such as cooking pots) to expensive items (e.g., refrigerators, music players, televisions, mobile phones, electric fans, air conditioners, and vehicles). Housing quality is also an important measure of wealth (as discussed by Morris *et al.* 2000). I determined the value of the household's dwelling(s) by asking the head of the household about the investments made for its construction or estimating its value based on the construction materials used and the size of the dwelling (as they were all built by the family themselves) (see an example in Appendix 3.2-3, Section C). The value of all items and properties was then summed to provide an overall figure for the household.

All values were collected and reported in local currency, in XAF. This facilitates comparison with several studies conducted in Equatorial Guinea and in other countries in the CFA franc zone that also report their results in the local currency (adjusting for inflation when necessary). In some cases, conversion into US dollars (USD, $) using the historical exchange rate for the period (1 USD = 508.82 XAF) was also indicated to facilitate comparison with other locations.

3.2.3.6 Hunting income

3.2.3.6.1 Data source: offtake survey complemented with hunter hunter-follows and interviews

Two independent data sources estimated income from hunting and the wild meat trade. The first source was the household socio-economic survey described above, which involved a single yet very detailed interview (as shown in Appendix 3.2-3) with a small sample of households (26 households in BB, BF, and Basacato, of which only eight hunted commercially: seven in BF and one in Basacato), recording net income for the year before the interview (i.e., 2009). The second source was a wild meat offtake survey that recorded almost daily transactions from a much larger sample of hunters (34 in BF and seven in BB) and traders (9 in BF) between August 2010 and November 2011.

This offtake study is part of a broader research project on the impact of hunting in the Pico Basilé region, which I am conducting but do not fully explore in this thesis. However, I analyse all relevant information concerning the hunting system and the socioeconomic benefits of its exploitation.

The complete offtake study collected daily species offtake and sales data over nearly three years in BB (Jul. 2011–Nov. 2014) and almost 3.5 years in BF (Aug. 2010–Sept. 2013), followed by an additional 2.5 years in BF (Nov. 2017–May. 2020). To estimate annual income from the wild meat trade, I used data from only the first 16 months (specifically Jul.–Dec. 2011 for BB and Aug. 2010–Nov. 2011 for BF), as this was the period when most of the hunters interviewed in the socio-economic survey were still active. This approach allowed me to work with the same sample of hunters in a period consecutive to the socio-economic interviews, ensuring no significant changes occurred, thereby enabling triangulation.

Biological data (species, age class, sex) and hunt/trade data (whether eaten or sold, where eaten/sold, state, carcass price to both intermediary and final buyer) were recorded for each animal caught, as well as information on the hunter (name, household code) and the hunting trip (number of hours/days, location, hunting methods used) (see Appendix 3.2-5 for an example of a data sheet). Two local male research assistants living in each village, a young man from BF (Ambrosio Ondo) and an elderly farmer from BB (Justo Sabana) were hired for this work. Both were already very familiar with the purpose of the study. Ambrosio O. had previously worked with me during a three-month pilot study (August-October 2009), collecting data on all the wild meat hunted and sold by a group of hunters and traders in the village. Justo S. was the president of BB and had provided significant assistance during the consumption study, providing valuable information about the village and meticulously filling out the consumption surveys. Therefore, both showed great interest in the project and were trustworthy and hard-working.

Because only seven hunters operated in BB, Justo S. could record all animals trapped by each hunter during the sampling period. In contrast, Ambrosio O. recorded most, but not all, hunting trips and transactions of most hunters and traders.

The wild meat offtake survey provided extensive information on the activity of hunting and trading, allowing me to distinguish between different types of commercial hunters and evaluate income from hunting in each case. This classification was based on their dedication (experienced and regular hunters, opportunistic or sporadic hunters, and visiting family members hunting with a relative) and their sales methods (selling alone, in collaboration with a female family member trader, or a combination of both). Additionally, this survey offered insights into the trade chain and the different roles of men and women, enabling me to assess the contribution to household hunting income by gender.

To complement the offtake study and verify the reliability of the data, a total of 21 hunter-follows were conducted with 18 hunters between March and October 2011 (three hunters had two different hunting areas and were followed twice). Specifically, 13 of the 25 active hunters in Basilé Fang and five of the six active hunters in Basilé Bubi were tracked. In Basilé Bubi, all the hunters were primarily farmers who set traps around their farms. In contrast, hunting in Basilé Fang was a professional, commercial activity that spanned areas from the village outskirts to the higher elevations near Pico Basilé's

summit. The selection of hunters in Basilé Fang was opportunistic, aiming to capture a representative sample that covered all hunting zones (near, mid-range, and distant) and methods (shotgun, trapping, and combined approaches).

The hunter follows involved accompanying hunters on their trips, during which spatial and temporal data relevant to the activity was recorded. This included tracking the route using GPS and marking key points and events, such as trap locations, gunshots, captures, animal sightings or tracks, shelters, entry and exit points, hunting circuits, rest periods, and trap setting or checking. I personally conducted 11 follows in BF and two in BB, while a colleague from Asociación Ecotono, Juan Gómez Soto, completed four in BF. Additionally, UNGE student David Ángel Ndong Bee conducted two follows in BF and two in BB.

During the follows, I interviewed the hunters during rest periods, using a format similar to the one employed the previous year to document their hunting activity—covering method, area, effort, and captures (see Appendix 3.2-6). However, this interview was more detailed and adapted to the specific techniques used by the hunter, whether shotgun, traps, or both (see Appendix 3.2-7). The aim was to ensure consistency between the responses from both interviews, the actual observations during the follows, and the data recorded in the offtake survey.

Triangulating these three data sources—hunter interviews, hunter follows, and the village offtake survey—enabled me to fill in gaps and gain a much more comprehensive understanding of hunting activity. As a result, the offtake survey was underestimating the actual number of primates killed. Since primate hunting is prohibited by Law No. 7/2007 (República de Guinea Ecuatorial, 2007), many hunters were reluctant to have their captures recorded in the offtake files and totally or partially concealed primates killed. However, during hunter-follows or in the semi-structured interviews, most hunters felt comfortable hunting primates in our presence during follows, explaining the number of primate captures, or at least admitting that they hunted primates. This allowed me to estimate the volume of unreported primates, and the additional income earned, as explained in the following section.

3.2.3.6.2 Calculation of hunting revenues

To estimate the total annual income from hunting, I first used the data collected by the two research assistants from BB and BF using the sheets provided in Appendix 3.2-5. As shown in the filled-in example, each batch of animals observed by the research assistant during a sampling day was attributed to an individual hunter's hunting trip. I derived the proportion of sample days during which incoming carcasses were recorded for each hunter. I then used this proportion to estimate the number of hunting trips undertaken by a particular individual in a year. Finally, I multiplied the estimated annual number of hunting trips per hunter by the average number of animals recorded per sampling day and by the average prey price for each hunter. These prices refer to what the hunter sells (either directly to the client or to a trader) or to what his wife or relative sells (in cases where she was also a trader and oversaw selling all or part of her husband's or relative's hunt).

Additionally, these women traders could buy animals independently from other hunters outside the household and sell these carcasses. Some women were traders without a hunter husband. Following the same steps as for the hunters, I also estimated the independent earnings of these women traders. All these calculations are detailed in Section 4.1.6.2.

Up to this point, the estimated incomes did not include the volume of unreported primates. To account for this, I used information from hunter follows and semi-structured interviews to estimate the number of primates of each species that an experienced shotgun hunter could kill during a hunting trip in specific areas of the Pico Basilé. Having personal knowledge of each hunter, his hunting area and the number of hunting trips per year, allowed me to estimate the number of primates hunted in a year. I subtracted the portion he reported in the offtake survey. By knowing the average selling price of these species for each hunter (based on reported primates), I could include these values and adjust the average prey price per hunter to account for unreported primates.

I applied the same method to the women traders. Knowing the number of days each trader bought carcasses from these experienced hunters, I estimated the number of primates the hunters would have sold to them that the women should have reported. From the reported primates, I estimated the average profit each trader made from each species and included this to recalculate the average profit per trader.

3.2.3.7 Feasibility of alternatives to commercial hunting

Hunters most likely to switch from hunting to a proposed alternative activity may not be those with the most significant impact on wildlife (Coad *et al.*, 2013). Therefore, when developing alternatives, it is essential to focus on the key individuals whose behaviour must change to make hunting more sustainable; otherwise, the activity substitution effect will not achieve the desired outcomes (Wicander *et al.*, 2014).

Although interviews on past activities and reasons for change (Section 3.2.3.3) had provided information about the preferences of hunting households regarding livelihoods, a more comprehensive examination of their motivations and the potential for change in response to alternative activities was needed. Therefore, I organised a seminar-workshop that included a meeting with the residents of Basilé Fang. This village, home to commercial hunters and strategically located on Pico Basilé, was identified as a priority for managing the PBNP.

The seminar-workshop also aimed to engage Equatoguinean and foreign governmental and non-governmental institutions in this discussion and share lessons learned. As detailed in Section 1.2.4.1.1, these steps are essential for successfully designing and implementing conservation actions. The seminar-workshop was divided into three sections. The first session, held at UNGE, involved presentations from national and international institutions regarding their projects and contributions to biodiversity conservation in Equatorial Guinea (13 national and international institutions were invited to participate, and 12 attended; see Appendix 3.2-8). This was followed by a series of debates in which the attendees (comprising students and professors from the FMA and the EUEAPF.) also participated. The second part of the seminar included a discussion with the main stakeholders i.e., wild meat hunters and traders in BF. The final part

comprised a working session with all participants, conducted in groups and then shared with the larger group to complete the drafting of the proposals discussed.

Before this seminar-workshop, I also reviewed the legislation and projects related to the environment and development in Equatorial Guinea (see Appendix 2.1-1). This review involved visiting the sites of previous initiatives and speaking with the local personnel and leaders involved. For instance, I participated in a meeting with INDEFOR-AP and hunters of Monte Alén National Park on the mainland, who had been recruited as Eco-guards in the successful ECOFAC project (see Section 2.1.7). The aim was to consider lessons learned and the level of legislative support, as well as information necessary to design alternatives.

The prior review and the collaborative session at UNGE with all involved groups significantly contributed to discussing potential alternatives to hunting with the hunters and traders from BF (see Appendix 3.2-8).

3.2.4 Research questions and statistical tests

3.2.4.1 General procedure

All statistical analyses were conducted using SPSS Statistics software, version 19.0 and 23.0, with an alpha level of 0.05. The normality of the data was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests. In the case of non-normal data, I performed a logarithmic transformation of the variables or appropriate nonparametric tests were used in each case. Central values were expressed as mean ± standard error for normally distributed data or median (interquartile range; or range, if indicated) for non-normal data. Both statistics were given in some cases to understand the data distribution better. I also carried out multivariate analyses as described below.

3.2.4.2 Demography and education

Before initiating the analyses to answer the research questions posed, I evaluated the demographic and social characteristics of the sampled households and villages. I described the household structure by describing the average number of people per household, the average number of adult men and women per household, and the child-to-adult ratio. I compared these with broader demographic trends in Equatorial Guinea. Additionally, I calculated the proportion of families belonging to specific ethnic groups or mixed ethnicities. I provide details on the characteristics of the settlements in this regard, noting their historical origins.

Finally, I described the educational level of the overall household sample. I examined whether there were differences between villages and ethnic groups using the Kruskal-Wallis test and the student's t-test, respectively. The differences were not statistically significant, and thus, the level of education was not included in the subsequent multivariate analyses. However, to ensure rigour, the variable was checked and determined to be non-significant.

3.2.4.3 Contribution of wild meat to rural livelihoods

3.2.4.3.1 Research question 1: Does the wild meat trade constitute an important source of income for rural households around the PBNP?

To answer this question, I first estimated the proportion of households engaged in commercial hunting and other livelihood activities within the total sample of 155 households across 10 villages. To better understand the varying contributions of different ethnic groups and villages, I analysed their involvement in commercial hunting and other livelihood activities. I used the Mann-Whitney U test to examine differences in employment rates between the Bubi and Fang ethnic groups.

Additionally, I estimated household revenues from commercial hunting for the subsample of households for which I had collected income data (n=26 households in 3 villages: BB, BF, and Basacato). Using analysis of variance (ANOVA) followed by a post hoc Tukey HSD test, I investigated differences in these revenues compared to the other three most prevalent alternative activities: paid work, bar-shop trade, and agriculture.

3.2.4.4 Factors influencing hunting activity

Having established that commercial hunting constituted a primary source of income, I proceeded to analyse the association between having a regular wage and the likelihood of engaging in hunting activities. As discussed in Section 5.1.3, existing literature indicates that in many cases, the possibility of having a regular salary increases the opportunity cost of hunting.

3.2.4.4.1 Research question 2: Does paid work increase the opportunity costs of hunting?

To test this hypothesis in the context of Bioko, I conducted univariate analyses at both the village and household levels. In the first case, a two-tailed Pearson correlation was conducted between the variables "percentage of households engaged in commercial hunting" and "percentage of households with employment". In the second case, a chi-square analysis was conducted with the variable "employment" (0 = households with no wage-earning members; 1 = households with one or more wage-earning members) and the variable "hunting" (0 = households that do not hunt; 1 = households where at least one member hunts or trades in wild meat).

Since the type of hunting (commercial or subsistence) and ethnicity (Fang or Bubi) were also correlated, I conducted further analyses at the household level, including these variables. First, I repeated the chi-square analysis, segregating the sample by ethnicity and adding one more level to the variable "hunting" to specify the type of hunting (0: households that do not hunt; 1: households that engage in subsistence hunting; 2: households that engage in commercial hunting). Additionally, I performed a multinomial logistic regression analysis where the dependent variable was "hunting" (comprising the three levels), and the predictors were employment (of one or more household members, 0=no, 1=yes) and ethnic group (0=Bubi, 1=Fang).

The findings of these analyses were then compared with the responses of hunters and traders obtained during interviews regarding their past activities and motivations for

change (Section 3.2.3.3). Furthermore, these findings were juxtaposed with the perspectives articulated at the seminar-workshop convened in Basilé Fang (Section 3.2.3.7).

3.2.4.5 Contribution of wild meat to protein intake

3.2.4.5.1 Research question 3: Is wild meat a major contributor to protein intake in rural households around the PBNP?

To address this question, I first detailed the diet of the households in my sample, comprising 105 households across 10 villages. Considering the total number of consumption days sampled (n=798), I estimated the frequency of wild meat consumption compared to other animal and plant-based foods. Subsequently, I calculated the contribution of wild meat to the average daily intake of animal protein per household (n=105 households across 10 villages) and to the total daily protein intake (both animal and plant-based) per household (n=27 households in 2 villages), relative to other protein sources.

3.2.4.6 Factors influencing consumption of wild meat and other meats/fish

After determining that wild meat was not a major contributor to animal protein for the entire sample but observing differences between villages (through a Kruskal-Wallis test), I further investigated these differences and the factors influencing them. It is important to understand rural consumption patterns and identify whether some villages are more dependent on wild meat than others and why, if effective management interventions appropriate to the population's needs are to be designed.

3.2.4.6.1 Research question 4: Does access (which includes availability and affordability) to alternative protein sources influence consumption of wild meat and other protein sources?

I postulated that although the villages around PBNP are connected to the city by a well-maintained road, their access to imported domestic meat and fish from Malabo may still be limited by other factors related to their distance from Malabo, such as the frequency of taxi service, the lack of electricity for the preservation of frozen foods, or the greater distance of some villages from the main road. A similar phenomenon could be expected regarding the distance to the sea, affecting accessibility and consumption of fresh fish, given the existing conditions on the island for transportation and preservation of this resource (World Bank 2019 and pers. obs.; see also Section 2.1.1).

Since access to alternative protein sources depends not only on their availability but also on whether people can afford them (Albrechtsen *et al.*, 2006), socio-economic characteristics and livelihoods of each village, as well as the differences in meat and fish prices at various villages and Malabo, were also considered in the analysis.

I first examined how meat and fish were obtained in different villages. I investigated where families purchased various types of products (frozen meat/fish, fresh fish, and wild meat)—whether in the city or village shops—and at what price and whether there

were differences between villages. Depending on the number of variables, I used either the Kruskal-Wallis or Mann-Whitney U tests.

Subsequently, I analysed the influence of the distance to Malabo (the main supply point for frozen domestic meat and frozen fish) and the sea (the primary source of fresh fish) on consuming wild meat protein and other animal protein sources. Distance was measured in time from Malabo to the village by car (or by car plus walking in cases where it was impossible to get there by car, as in Bomá during the rainy season). This considers the distance and the quality of the road, which ultimately conditions the access to food that must be transported to the villages (Carvalho *et al.*, 2015). The distance from the sea to the village was measured in a straight line from the coast to the village, as roads do not connect them, only footpaths, which I did not travel.

Specifically, I first calculated the proportion of households in each village (n=105 households across 10 villages) that reported consuming domestic meat (frozen and fresh), fish (frozen and fresh), or wild meat (hunted and harvested). I then investigated whether the variation in these proportions was correlated with the distance to Malabo or the distance to the sea. To analyse this, I used a two-tailed Pearson's correlation. Secondly, I investigated whether the differences in protein intake ($grams \cdot RA^{-1} \cdot day^{-1}$) from various types of meat and fish among villages and their respective contributions (%) were associated with the distance to Malabo or the sea. For this analysis, I used a two-tailed Pearson's correlation. Finally, I created a pie chart for each village, illustrating the contribution of each protein source to the total animal protein intake. These charts were arranged geographically and highlighted the socioeconomic characteristics of each village. This approach aimed to facilitate a more nuanced discussion of the observed patterns, considering the socioeconomic factors at play.

Additionally, I investigated the correlations between the various types of meats and fish. The graph mentioned above suggested that domestic meat protein intake –which varied between villages but was not correlated with distance from Malabo or to the sea- might be negatively associated with fish protein consumption, particularly in villages where both were more accessible (i.e. all except Copé, Inasa Maule, and Bomá). To test this hypothesis and to explore any other correlations between different types of meat and fish protein consumption, I analysed the correlations (two-tailed Pearson's) between the amounts (and proportions) of protein from various food types for both the subset of villages and the full sample.

3.2.4.6.2 Research question 5: Does income and wealth influence protein intake?

Although the above analyses took into account price variation and the characteristics and livelihoods of each village, which provided implicit information on their socioeconomic status, I also analysed the influence of income, expenditure, and wealth on the intake of wild meat protein and other alternative sources for the subsample of households for which quantitative socioeconomic data was collected (n=26 households in three villages: BB, BF, and Basacato). I used two-tailed Pearson correlations to compare each socioeconomic variable with each protein source.

3.2.4.7 Contrasts in livelihoods and protein intake between commercial and subsistence hunters

It is possible to make use of the fact that the sample of villages contains two that are comparable (thus controlling for possible confounding factors) but the one engaged in commercial hunting and with more access to wildlife (Basilé Fang), and the other practising subsistence hunting only (Basilé Bubi) (see more details in Section 3.2.2). This allows me to delve deeper into the study of the contribution of wild meat to diet and livelihoods according to the type of hunting and answer the following question.

3.2.4.7.1 Research question 6: Are households engaged in commercial hunting economically and nutritionally favoured over subsistence hunting due to higher income from the wild meat trade and greater access to wild meat protein?

I first tested for differences in household income, expenses (as an alternative measure of income), and wealth (assets) between the two villages. I employed either the student's t-test or the Mann-Whitney U test depending on the data distribution. Similarly, I examined differences in total protein intake and specific types of protein (animal, vegetable, total wild meat, hunted wild meat, and harvested wild meat) between the two populations. I also estimated the average annual income (both at the household level and the total village level) from each type of livelihood activity in each village and compared them using a bar chart.

To gain a deeper understanding of the economic contribution of commercial hunting, I also analysed hunting income using data from a source other than household interviews: the long-term offtake survey and the hunter follows conducted in Basilé Fang. For consistency, I used hunting sales data from the first 16 months of this survey, ensuring alignment with the sample of hunters interviewed in the household survey (as explained in Section 3.2.3.6.1).

This study provided detailed data on the hunting system, enabling the identification of distinct categories of hunters based on their level of involvement—regular hunters, visiting relatives, and occasional hunters—and allowing for the calculation of their income, both annually and per hunting trip. To investigate differences between these groups, I applied an analysis of variance (ANOVA) on the log-transformed incomes, followed by a Tukey HSD post-hoc test. This analysis also facilitated a comparison of income from regular hunting with other common regular activities, such as employment, shop/bar trade, and agriculture. Additionally, I estimated the annual income of women involved in the wild meat trade independently of the catches made by their husbands or relatives, enabling an assessment of their specific contribution to the income generated from hunting. Understanding the income levels of more experienced hunters and traders is crucial before proposing management measures.

3.3 Reproductive parameters and body condition of the Bioko blue duiker: implications for sustainability assesments

3.3.1 Village and Study area

Data on blue duiker reproduction and body condition were collected in Basilé Fang in collaboration with hunters and traders. I had previously worked closely with these individuals during the research activities on livelihood and diet research, and I was confident in their continued collaboration and support. Moreover, Basilé Fang is a key hunting village near Malabo, where a significant volume of animals is traded, ensuring an adequate sample size for the study. Additionally, as I explain next, the hunting area of Basilé Fang hunters added value to the study by providing a sample of animals captured across the full elevation range of Bioko Island.

Basilé Fang is located on the slopes of Pico Basilé, approximately 15 km from the capital, Malabo, at 507 m.a.s.l. This volcanic massif, which occupies the entire northern part of the island and reaches an altitude of 3,011 m.a.s.l. was declared a National Park in the late 1980s starting at 800 m.a.s.l. (Figure 2.2-1). Its altitudinal gradient gives it a climatic and vegetation gradient. Patches of lowland rainforest occur around 800 m., montane forests range between 800 and 1400 m, mossy forests are found between 1500 and 2500 m, and shrub formations and subalpine meadows appear above 2500 m (see a full description of the types of forests in Section 2.1.5.2 and Table 2.1-1). There is a paved road (approximately 30 km long) from Basilé Fang to the summit, hereafter referred to as the Pico Road. This road was originally built to facilitate maintenance access to the island's main communications antenna, located at the peak. Since then, maintenance companies have regularly serviced the road, resulting in a constant flow of vehicle traffic along this route. Hunters take advantage of these vehicles to reach various points on the mountain after making arrangements with the drivers. Other hunters, although fewer in number, own their own vehicles and access the road with prior approval from the military post that controls access; both drivers and military personnel are usually paid with carcasses. In conclusion, the Pico Road provides hunters with easy access to the park, allowing them to hunt along the elevation gradient.

3.3.2 General procedure and study participants

Prior to the commencement of fieldwork, my research assistant Ambrosio Ondo, UNGE student Pastor Cham, and I, received training in data collection techniques under the guidance of Dr Miguel Ángel Farfán Aguilar (Universidad de Málaga) and veterinarian and professor Kouassi Messan Ague (UNGE), collaborators on the project. Pastor Cham participated during six months as part of his final Bachelor's thesis. Subsequently, my research assistant and I trained the biologist Paloma Ferrer, from Spain, who started working as a volunteer and then became part of the staff of the project. She subsequently trained two UNGE students (Josefa Mikue and Inés Adá), who participated during the last three months of fieldwork as interns.

In collaboration with hunters and traders we examined blue duiker carcasses brought daily to Basilé Fang village between February 2013 and May 2014. We took advantage of the fact that they were brought in whole and then eviscerated for later sale. For each animal, we recorded sex and age (adult or juvenile), capture method (trap or gun), took standard body measurements and assessed body condition and reproductive status.

The macroscopic analysis of the carcasses was conducted in the field simultaneously with the preparation of sperm samples (fixing and staining them) and female genitalia samples (preserving them in formalin) for subsequent microscopic analysis. The microscopic analysis of the spermatozoa was carried out in Equatorial Guinea by myself and the UNGE students (previously trained by me), while that of the female reproductive organs was carried out in Spain by Prof. Manel López-Béjar and the Endocrinology, Reproductive Physiology and Animal Welfare Research Group of the Universitat Autònoma de Barcelona (UAB), which he heads.

Although most animals in our study were hunted in the Pico Basilé, we also examined blue duikers from the Riaba area (at the base of Pico Biao, see Figure 2.2-1) that were purchased by some women traders in the village. For animals hunted by the BF villagers, we were able to document the altitude and forest type where the animal was hunted by noting the kilometre on the road where the hunter entered the forest, and in many cases, by identifying the precise hunting area based on information collected during the hunter follows (described in Section 3.2.3.6.1). However, for animals brought from Riaba, the specific location of where they were hunted was not available.

3.3.3 Data collection and derived metrics

3.3.3.1 Body measurements

All animals were weighed (undressed body mass) to the nearest 10g using a digital hand dynamometer. Hereafter, W refers to the animal's weight. Body measurements were taken following Wilson (2001) using a tape measure (1 mm divisions) or a Vernier calliper (1 mm divisions) (see Figure 3.3-1).

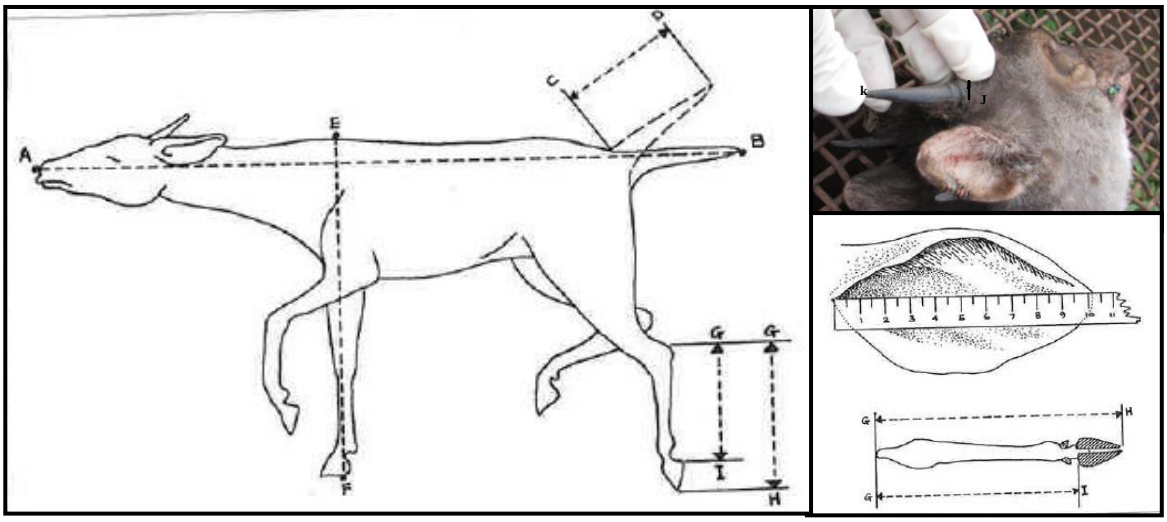


Figure 3.3-1 Procedure for taking blue duiker body measurements (adapted from Wilson 2001). A-B = Total length (TL): animal lying on its side and stretched out in a straight

line; C-C = Tail length (T): from fleshy tip of tail to junction with body. A-C = Head and body length (HB); E-F = Height at withers (i.e. shoulder height) (HS); G-I = Hindfoot length (Hf); I-H = Hoof length (Ho); J-K= Horn length (HL): from the base to the tip, including the grooves whose number was recorded (G). Ear length (E): as indicated in the drawing; Head length (H): from fleshy tip to the occipital bone with the neck in natural upright posture.

3.3.3.2 Reproductive stage

For females, lactation status was first determined by manually expressing the udders. Subsequently, during evisceration, the reproductive organs were examined to identify the presence of a conceptus. The mass and crown-rump length of the conceptus were measured (to the nearest 0.1 g and 0.1 mm, respectively), and classified according to the foetal developmental stages in Wilson (2001) (Figure 3.3-2). Accordingly, pregnant females were classified as being at the embryonic stage (embryo ≤ 45g) or at the foetal stage (foetus >45g). Genital organs were stored in a 4% formalin solution. Subsequently, ovaries and uterus were embedded in paraffin wax, cut into 3-µm sections and stained with haematoxylin and eosin for observation under the microscope. This allowed us to determine whether a female was pregnant from the presence of an embryo into the genital tract or a pregnancy corpus luteum (5.9 ± 1.8 mm of diameter on average) in the ovary.

For males, we extirpated the left testicle, weighed it to the nearest 0.2 g and measured its length to the nearest 1 mm. Testicles were then cut along the midline, smeared over a microscope slide, and dyed using a Diff–Quick stain (Gosalbez *et al.*, 1979) for examination under a light microscope. Males were considered reproductively active if mature sperm cells were present.

3.3.3.3 Age classification

Pregnant and/or lactating females were considered as adults. To classify the rest of the females, we used two criteria. First, we determined the minimum body size at which females were pregnant, taking into account body mass and the two most correlated body measurements with body mass: HB (r=0.758, p<0.001) and H (r=0.719, p<0.001). We then established minimum values for these variables: W=2.61 kg, HB=49.2 cm and H=11.9 cm. Females exceeding two of these three values were classified as adults, otherwise as juveniles. We also classed females as physiologically mature if there was evidence of antral follicle development and presence of corpora lutea and endometrial gland development from the microscopic examination of the ovaries and uterus, respectively. Both criteria, morphological and histological, were coincident in the classification of 94% of the females (n=121). Since we stored reproductive organs from only half of the females, those lacking them were classified according to morphological criteria.

Males that showed sperm cells in the testicular smears were classified as adults. For those for which we did not have a semen sample (n=50, 18%) we only used the morphological criteria. Most correlated body measurements with body mass were HB (r=0.630, p<0.001) and H (r=0.737, p<0.001). Minimum values for those measurements in an active male were: W=1.93 kg, HB=33 cm and H=11.2 cm. Males that exceeded at

least two of these values were regarded as adults, otherwise they were considered juveniles.

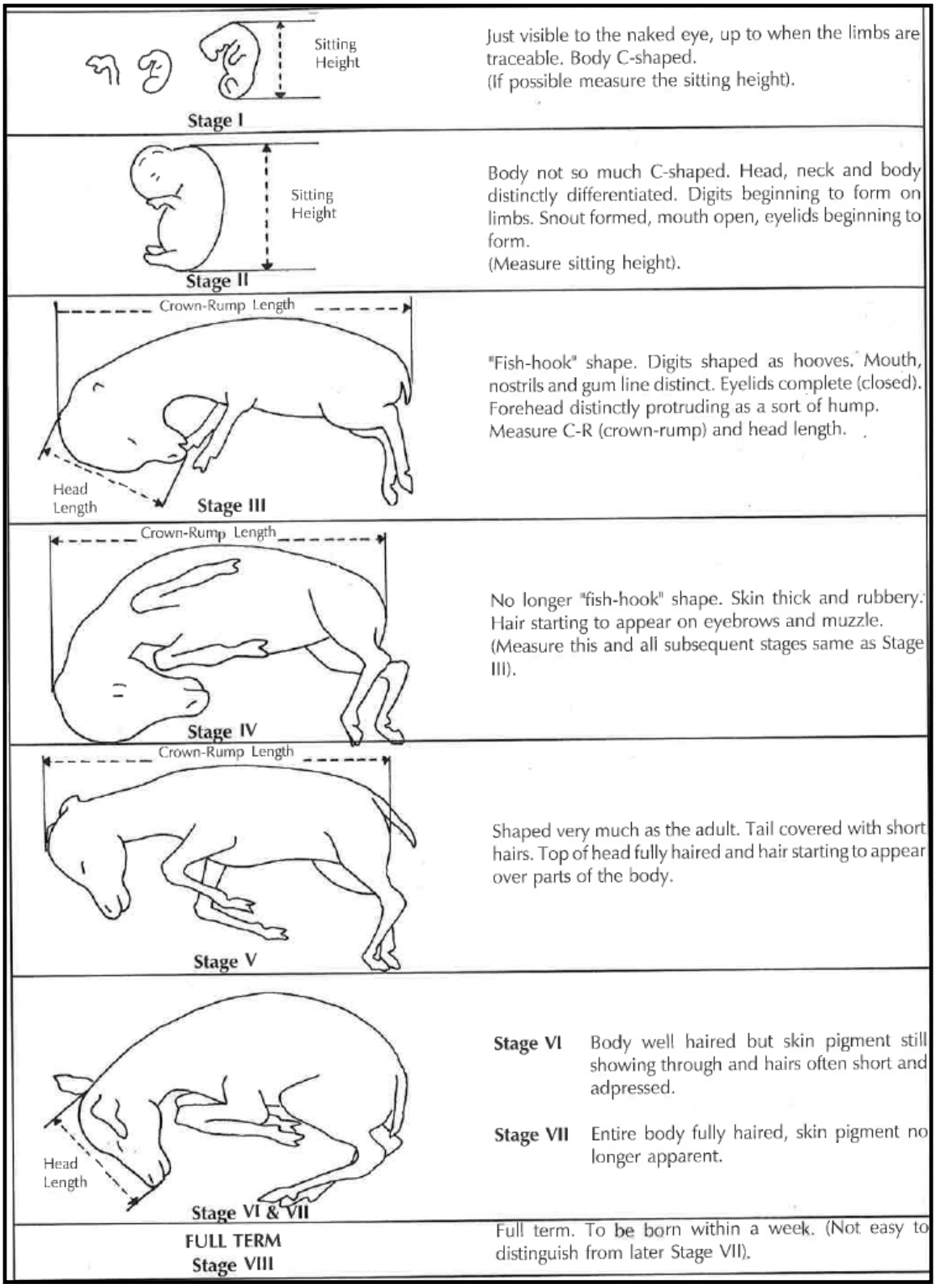


Figure 3.3-2 Classification of foetal duiker stages and procedures for measuring the foetus at each stage (from Wilson 2001: adapted from Ansell, 1965).

Figure 3.3-3 Photograph of the female reproductive system of the blue duiker, inside (left) and outside (right) the body, from a young female (top) and an adult female that has already given birth (bottom). Notice the bulging in the right uterine horn of the adult female, where the fetus is located during pregnancy.

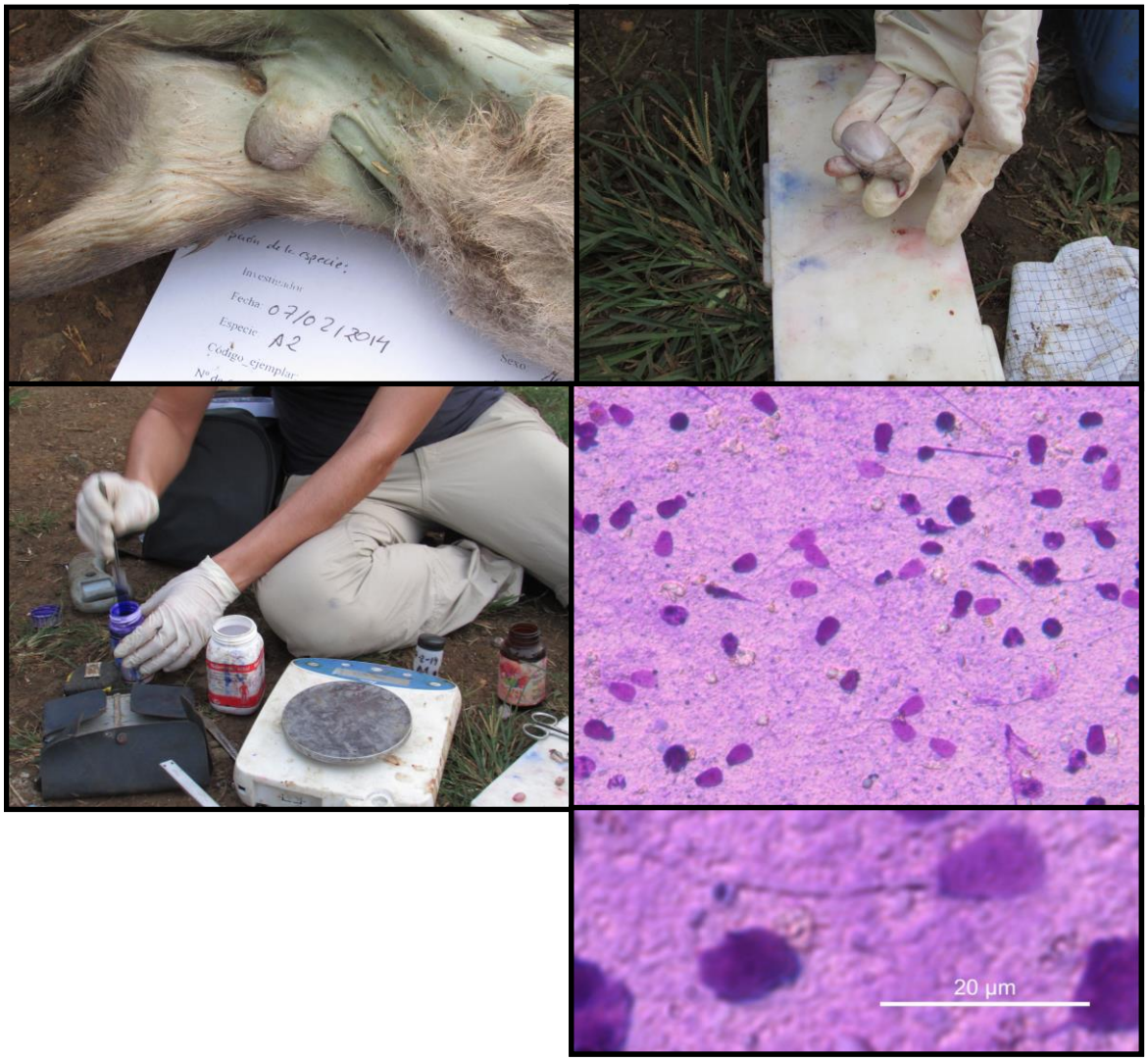


Figure 3.3-4 Photograph of the male reproductive system of the blue duiker (top left), the extracted testicle and epididymis (top right), the staining process in the field (bottom left), and the mature spermatozoa under the microscope (bottom right).

3.3.3.4 Body condition

Monitoring body condition (amount of energy stored in organs and tissues) is an essential tool in wildlife management as it provides information on the nutritional status, affecting both survival and reproduction (Cameron, 1994; Reading and Clarke, 1995; Flydal and Reimers, 2002; Parker *et al.*, 2009). Nutrition is linked to environmental and climatic variables (Cheney *et al.*, 1988). Therefore, measures of body condition allow for assessment of an animal's physiological adaptation to its environment (Riney, 1955), making it possible to determine intra- and interpopulation differences (Brooks, 1978). In other words, it describes the interaction between the population and its habitat (Morellet *et al.*, 2007) and offers a better understanding of the complex mechanisms that underpin the demography of wildlife populations (Bowyer *et al.*, 2014; Stephenson *et al.*, 2020).

Several indicators have been developed to assess body condition in wildlife (for reviews, see Franzmann *et al.*, 1995 and Kirkpatrick 1980). The most widely used indicators are based on fat reserves, and among these, the Kidney Fat Index (KFI) —the ratio of the

weight of perinephric fat to kidney weight (Riney 1955)— has been the most commonly applied to estimate ungulates' body condition over recent decades (Serrano *et al.*, 2008; Flores-Saavedra *et al.*, 2018). Its popularity is due to its strong correlation with whole-body constituents (Smith, 1970; Monro and Skinner, 1979; Rioux and Diouf, 2006) and the relative ease with which it can be obtained compared to other indices based on marrow fat, subcutaneous fat, or blood serum lipids (Monro and Skinner, 1979; Kie, 1988).

I assessed body condition using the Kidney Fat Index (KFI) developed by Riney (1955) and modified by Monson *et al.* (1974) to include total kidney perirenal fat: (perinephric fat mass/renal mass) x 100. Following the recommendations of Santos et al. (2013), I sampled only the left kidney. The kidney and surrounding fat were extracted from the peritoneal cavity and weighed on a digital balance with an accuracy of 0.1 g. The fat was then separated, often by removing the kidney capsule to facilitate complete fat removal, after which the kidney or fat was reweighed.

Before examining the effects of sex, age, local, and seasonal variations on body condition, I first assessed the validity of using the KFI in hunted blue duikers (see Section 3.3.9.1).

3.3.3.5 Reproductive performance

The reproductive performance of females was evaluated using the following parameters (Butynski, 1979; Dubost *et al.*, 2005; Mayor *et al.*, 2009): 1) Pregnancy rate =number of pregnant females/total adult females; 2) Number of parturitions per female per year= (365/gestation length)*Pregnancy rate; 3) Number of young per female per year (or Gross Productivity) = Parturitions per year*Litter size; 4) Annual birth rate of female offspring (or Gross Fecundity)= Gross productivity*ratio of female foetus; 5) Interbirth interval = gestation length/pregnancy rate; and 6) Parturition-conception interval = interbirth interval-gestation length. I used a gestation length of 205 days given by Wilson (2001) and consistent with the 204 days of Böhner *et al.* (1984); these two studies were chosen because of their experimental rigor.

Foetal age was calculated using Huggett and Widdas (1951) formula, using the mean weight of 525 g at birth from Wilson (2001), consistent with the weight of the most developed foetus in our sample (521g). I then determined patterns of conceptions and births by backdating and foredating embryos or foetus from the estimated age at the date of collection. I tested whether there were differences in monthly or seasonal birth rates (nº of births/reproductive females), conception rates (number of conceptions /reproductive females), and pregnancy rates; both for the entire sample and for each locality separately (Pico, Riaba and inside Pico in each of the tree habitats). For adult males, monthly and seasonal variations in testis weight were examined and related to conception rates.

3.3.3.6 Maximum ntrinsic rate of natural increase

The r_{max} was calculated for the entire Bioko sample, and for each separate locality (Riaba, Pico, and inside Pico for the three habitats: lowland, montane and mossy forest). I applied: 1) Cole's equation (1954) equation, $1=e^{-r\max} + be^{-r\max(a)} - be^{r\max(w+1)}$ (where *a*

is the age at first reproduction, *w* is the age at last reproduction, and *b* is the annual birth rate of female offspring), and 2) Caughley and Krebs' (1983) formula: $r_{max} = 1.5P^{(-0.36)}$ (where *P* is the mean population weight in kg). For the former, I used our estimates of *b* and values derived from the literature for *w* and *a* —7 years from Payne (1992) and 0.83 years from Wilson (2001) respectively—, and for the latter the mean adult weight. I compared my parameters and calculations with those from previous studies that have also determined r_{max} for this species.

3.3.4 Research questions and statistical analysis

3.3.4.1 General procedure

All statistical analyses were performed using SPSS Statistics, versions 19.0 and 23.0, with an alpha level set at 0.05. Trends were reported for alpha levels between 0.05 and 0.1. Normality was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests. For non-normal data, appropriate nonparametric tests were applied. Central values were expressed as mean ± standard deviation for normally distributed data or median (interquartile range, or range where indicated) for non-normal data.

3.3.4.2 Validity of the KFI as a measurement of body condition in hunted blue duikers

3.3.4.2.1 Research question 1: Is the kidney fat index (KFI) a valid index for measuring the body condition of the the blue duiker?

The use of the Kidney Fat Index (KFI) (see Section 3.3.3.4) assumes that kidney weight is a constant function of body size. This assumption supports its inclusion in the index, facilitating comparisons among animals of different sizes. However, some authors have identified seasonal variations in kidney weight that are not necessarily correlated with body size (Batcheler and Clarke, 1970; Dauphine, 1975; Van Vuren and Coblentz, 1985). Others, however, do not consider this effect to be a problem (Flux, 1971; Mitchell *et al.*, 1976; Finger *et al.*, 1981). Proposed solutions include using absolute perirenal fat for animals within the same age class (Dauphine, 1975; Warren and Kirkpatrick, 1982) or adjusting the KFI to account for seasonal differences in kidney weight (Dauphiné, 1975).

Before analysing seasonal and local variations in body condition within my sample, I first investigated whether kidney mass varied between seasons. To account for the effects of sex, age, and reproductive status, I conducted separate analyses for each group. I used Student's t-test as the data followed a normal distribution.

3.3.4.2.2 Research question 2: Does the capture method (ultimately the type of death of the animal) affect the KFI value?

The KFI has been generally used in shot ungulates. In my sample, 74% of specimens were caught using traps, while 26% were shot (out of 405 animals for which the capture method was recorded). The most active hunters stated that they usually checked their traps every three days. However, based on the offtake survey records and hunter-follows

data, I found that in many cases the time between hunting trips was much longer. In fact, hunters claimed that a blue duiker can survive in a trap for up to three days, but no longer. Despite this, 47% (18) of the duikers caught using traps during the hunter-follows (n=38) were already dead upon retrieval, and of these, 50% (9) were discarded due to an advanced state of decomposition. Duiker traps are leg-hold traps consisting of a noose placed over a camouflaged hole in the ground and tied to a bent-over stick, which acts as a spring. The safety catch, also made of sticks and camouflaged within the hole, is triggered when the animal steps on the noose. Therefore, when the animal is caught in the trap, it is usually left hanging by one leg, or sometimes, if branches are in the way, semi-hanging or with its leg raised.

Considering this information, I hypothesized that that a loss of body condition might occur in animals caught in traps due to the time spent trapped without food and under stress—factors that have been shown to cause reductions in perirenal fat in other species (Peris and Abd El-Latif, 2021). This is not expected in shot animals, which die quickly.

To test this hypothesis, I analyzed whether there were significant differences in KFI values between animals captured with traps and those captured with guns. To account for the influence of sex, age, and reproductive status, I analyzed these differences separately for each group. I used the Mann-Whitney U test as the data did not meet the assumption of normality.

3.3.4.3 Reproductive parameters and body condition of the Bioko blue duiker

3.3.4.3.1 Research question 3: What is the body condition of the blue duiker in Bioko?

As far as I know, no previous studies have been conducted on the body condition of the blue duiker; however, many studies have been carried out on other ungulate species. It is well-documented that, within the same population, factors such as age, sex, and reproductive status influence an animal's body condition, as energy demands often vary in each case (Brooks, 1978). Furthermore, as mentioned above (Section 3.3.3.4), body condition reflects the nutritional status of the animal and can therefore vary depending on external factors like the season and the habitat type.

Before investigating potential seasonal and local variations in the body condition of the blue duiker, I analyzed variations associated with age, sex, and reproductive status. I focused on animals hunted with shotguns, as the body condition of animals caught in traps may have been compromised (see Section 4.2.4.1). The sample was divided into seven groups: juvenile females, non-pregnant adult females, pregnant females at the embryonic stage, pregnant females at the foetal stage, lactating females, adult males, and juvenile males. The data were visualized using a stem-and-leaf plot, which clearly showed that pregnant females at both the embryonic and foetal stages exhibited similar and the highest KFI values, while lactating females showed the lowest. A subsequent Kruskal-Wallis H test with pairwise post hoc comparisons, grouping females at the embryonic and foetal stages, confirmed significant differences exclusively between pregnant and lactating females (see Section 4.2.4.2). To avoid the potential influence of an uneven distribution of these two groups across seasons or localities, I excluded them from the analysis of seasonal and local variations.

To analyze differences in body condition between the dry and wet seasons for the entire sample and for each locality separately, I applied either the Student's t-test or the Mann-Whitney U test, depending on whether the data met the assumption of normality. The localities included the two hunting sites (Pico and Riaba), and within Pico, the three distinct habitats (lowland forest, montane forest, and mossy forest). The analysis was conducted separately for males and females. The sample size was insufficient for analysis in the lowland and mossy forests, as most gun hunting was conducted in the montane forest, while trapping was more common in the other two habitats.

To analyze differences in body condition between the Pico and Riaba areas, I used the Mann-Whitney U test, as the data did not follow a normal distribution. The analysis was conducted separately for males and females. However, comparisons across the three Pico habitats were not possible due to insufficient sample size, even when both sexes were grouped together.

3.3.4.3.2 Research question 4: Are the pregnancy rates and reproductive cycle of the Bioko blue duiker as expected?

Although data on pregnancy rates and the reproductive cycle of the blue duiker in the wild are scarce, preliminary hypotheses can be formulated based on previous studies, which I discuss further in Section 5.2:

Hypothesis 1: The Bioko blue duiker is expected to have a single offspring per birth and to breed throughout the year. Due to the intense hunting pressure and high extraction rates in the Pico Basilé area (Grande‐Vega *et al.*, 2016), high pregnancy rates could be expected as a response to population decline (Bowyer *et al.*, 2014). To test these hypotheses, I recorded the number of offspring and calculated pregnancy rates for my sample based on macroscopic field analyses and histological laboratory analyses (Section 3.3.3.2). I also estimated the remaining reproductive parameters mentioned in Section 3.3.3.5, which are related to reproductive performance.

Hypothesis 2: Some researchers have identified birth peaks for groups of frugivorous species, including the blue duiker, which are suggested to be related to food quality and availability. Others have argued that food supply during fertilization and gestation stages could influence seasonality. To test whether there was any seasonal or local variation in reproductive parameters in my sample of blue duikers, I analyzed monthly and seasonal variations in birth rates, conception rates, and pregnancy rates, both for the entire sample and for each locality separately. I performed this analysis using the chi-square test and visualized the results with bar charts. I then examined whether there was any pattern consistent with the seasonal and local variations in body condition (as an indicator of nutritional status) observed in males and females.

3.3.4.4 Maximum intrinsic rate of natural increase

3.3.4.4.1 Research question 5: What are the implications of using local pregnancy rates for estimating r_{max}, instead of using rates from captive animals or populations from other areas?

To address this question, I conducted a literature review of previous studies that evaluated the sustainability of blue duiker hunting using r_{max} in their analyses. I identified a total of four studies. All of them used Cole's (1954) equation to calculate r_{max} (see Section 1.2.1.1), which required the following parameters: age at first reproduction (*a*), age at last reproduction (*w*), and the annual birth rate of female offspring (*b*). I reviewed how each of these parameters was calculated, focusing particularly on the calculation of *b*. None of the studies used data from populations in their study area to calculate this parameter, nor did all of them use the same formula.

Using the same values of *w* and *a* as each author, but employing my own productivity values to calculate *b* (based on gestation duration, pregnancy rates, and litter size; see Section 3.3.3.5), I compared my estimate of r_{max} with theirs. This approach allowed me to illustrate how different my estimate would have been if, instead of using the pregnancy rates from my study sample, I had used others to calculate r_{max} , and to discuss the implications for sustainability assessments. Additionally, it highlighted the various methods used to calculate *b*, and consequently, the limitations of comparing r_{max} values across different studies. This analysis is presented in Section 5.2.3.

Chapter 4: RESULTS

Photo captions can be found in Appendix P

4.1 Rural livelihoods and diets: understanding the contribution of wild meat

4.1.1 Demographic characteristics of the sampled villages

4.1.1.1 Ethnicity and origin

Overall, study villages were predominantly Bubi or Fang households (see Table 3.2-1). Of the 214 households interviewed across all sampled villages (n = 10), 62% were entirely Bubi and 36% Fang. The remaining 2% consisted of three mixed marriages (two Bubi/Fang and one Fang/Cameroonian) and one Nigerian living alone.

The long-established Bubi villages (see Section 2.1.2 for further details) have been known since pre-colonial times (cited by Terán 1962 and Martínez 1968). In contrast, Fang villages (whose inhabitants originated from the mainland and accustomed to constant migrations have a more nomadic lifestyle; see Section 2.1.2), occupied former cocoa plantation barracks (e.g., Inasa Maule and Basilé Fang), or founded roadside settlements (e.g. Copé); in some cases, been officially recognised as Bioko villages (e.g. Basilé Fang). All Bubi were born and lived in Bioko, with most remaining in the same village. Fang families had arrived from the mainland, although many had children born or raised on the island.

4.1.1.2 Household size

The average household size in the sampled villages was 4.5 members, ranging from 1 to 16 members per household. The mean number of adult males and females (over 16 years old) per household was 1.3 (ranging from 0 to 7) and 1.1 (ranging from 0 to 4), respectively. This demographic structure results in a high proportion of children under 16, accounting for 47% of the population. These figures align with the progressive population profile of Equatorial Guinea as depicted in the Statistical Yearbook of Equatorial Guinea (INEGE, 2018). The data for this study were drawn from the IV General Population and Housing Census (INEGE, 2015a), which reported an average household size of 4.3.

4.1.1.3 Educational level

The educational attainment of household heads in the sampled villages was generally low. A total of 81% of the respondents had pursued further education beyond the primary level (corresponding to up to 12 years of age in the Guinean education system (as defined by Education Act No. 14/1995, see Dyombe 2009). Specifically, 46% had completed primary school, while 34% had not (32% had attended some courses, and 2% had never attended school). Higher levels of education were rare, with only 6% of respondents having completed secondary school (corresponding to age 16), 7% high school (up to age 18), and 5% higher education. Among those with higher education, 4% were graduates or technicians, and 1% held a bachelor's degree. There were no significant differences in educational attainment levels between villages ($\chi 2$=10.87, df=8, p=0.209) or between Bubi and Fang households (t=-0.884, df=62, p=0.380).

4.1.2 Livelihood activities

4.1.2.1 General patterns

Out of the 214 households sampled, 155 households provided comprehensive information on the livelihood activities of all their members. The percentages of households engaged in each activity were calculated from fully completed interviews (see Table 4.1-1). The primary livelihood activities, ranked by the number of households engaged, were agriculture, trade, hunting, and paid work. Conversely, fishing, cocoa cultivation, and timber extraction (the latter limited on the island, as detailed below and in Section 2.1.5.2) were significantly less common.

Socio-economic surveys conducted in 26 households (11 in Basilé Fang, 8 in Basile Bubi, and 7 more during the pilot study in Basakato) allowed for estimating the average annual household income derived from the various livelihood activities. Despite the relatively small sample size for many activities, these results allow for some insights into the economic contribution of livelihoods in the rural population around the PBNP. The highest income-generating activities were timber extraction, salaried work, commercial hunting, and shop/bar trade (see Figure 4.1-1); Agriculture, on the other hand, was one of the lowest income-generating activities.

Table 4.1-1 Percentage of households in each village engaged in the main livelihood activities. The complete interviews related to each activity are presented in parentheses.

Village	Agriculture	Agricultural trade	Paid work	Hunting	Wild meat trade	Bar/shop trade	Fishing
Rebola	100% (14)	29% (14)	62% (13)	40% (15)	7% (15)	14% (14)	0% (14)
Basilé Bubi	93% (14)	57% (14)	36% (14)	33% (27)	0% (27)	14% (14)	0% (14)
Basilé Fang	74% (23)	35% (23)	26% (31)	87% (31)	77% (31)	29% (31)	0% (31)
Basacato	100% (14)	36% (14)	46% (13)	36% (14)	14% (14)	14% (14)	7% (14)
Bososo	NA	NA	NA	NA	NA	NA	10% (21)
Bakake Grande	100% (25)	56% (25)	48% (25)	60% (25)	20% (25)	24% (25)	40% (25)
Cope	80% (5)	20% (5)	0% (5)	80% (5)	80% (5)	0% (5)	0% (5)
Bantabaré	75% (12)	17% (12)	91% (22)	26% (23)	13% (23)	5% (23)	0% (22)
Inasa Maule	91% (11)	45% (11)	0% (9)	55% (11)	45% (11)	30% (10)	0% (11)
Bomá	75% (4)	60% (4)	0% (4)	75% (4)	50% (4)	0% (4)	0% (4)
All	**84% (130)**	**41% (122)**	**43% (136)**	**52% (155)**	**30% (155)**	**18% (140)**	**8% (160)**

Note: NA refers to not applicable.

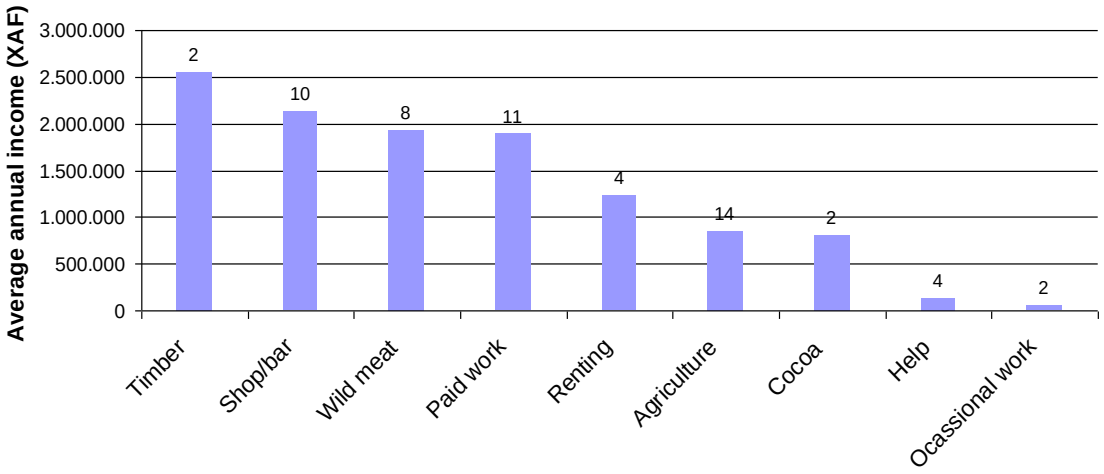


Figure. 4.1-1 Average annual household income from the various livelihood activities in the three quantitatively sampled villages (BF, BB and BC, 26 households interviewed). The number of households engaged in each activity is at the top of the bars. The analysis of variance (ANOVA) on the $\log_{10}$ income generated by the four livelihoods with the largest sample size ($n \geq 8$) revealed significant differences between agriculture and the other three - shop/bar trade, wild meat trade and paid work - which did not differ from each other (analysis details are provided in the text).

4.1.2.2 Agriculture

With 84% of households (out of 130 interviewed) producing local products for their own consumption, agriculture was the predominant activity. Of these, 41% also sold part of their produce to generate income. Mean annual income from the sale of agricultural products was 844,785 ± 272,950 XAF [median= 681,250, range 60,000 - 4,183,000 XAF, n=14]. In general, households were also engaged in other income-generating activities. On average, sales of agricultural products contributed 36.3% (range 7-10%) of total household income.

Cocoa cultivation, once a dominant activity during the colonial period, has declined dramatically since independence (see Section 2.1.4). Consequently, only 4% of households (3 in Rebola, 1 in Inasa Maule, 1 in Basacato and 1 in Basilé Bubi) were engaged in this activity, working either for the Casa Mallo[7] company or IMPAGE[8]. In Basilé Bubi and Basacato (where income data were collected), this contributed 4% to total annual village income, compared to 17.6% from home-produced products. For the two households growing cocoa, I estimated an average annual income of 805,550 ± 205,550 XAF, corresponding to 27% of their total annual income.

[7] *Casa Mallo S.A.* is the sole remaining private company in the cocoa sector on the island.

[8] The *Instituto Nacional de Promoción Agropecuaria de Guinea Ecuatorial* (INPAGE), the National Institute of Agricultural Promotion of Equatorial Guinea, is the administrative body within the Ministry of Agriculture and Forestry responsible for managing cocoa production on Bioko Island.

Besides the two types of agriculture, only one small vegetable garden was reported in Basilé Bubi, cultivated by three or four individuals from two households. This garden produced a variety of crops, including cabbage, parsley, celery, tomatoes, beans, and lettuce. These crops were not typically grown by other households near the PBNP. These products were intended for both own consumption and trade, which started with the cooperative project, "Granja de Basilé," discussed in more detail in Appendix 2.1-1.

4.1.2.3 Livestock

Unlike agriculture, livestock contributed little to household consumption or income. Therefore, respondents often overlooked livestock information in the livelihood interviews. To address this, I included specific questions on livestock production in socio-economic interviews in Basilé Bubi and Basilé Fang (and in Basakato and Bakake Grande during the pilot study). Of the 34 households interviewed across these four villages, 59% kept domestic animals, and the rest did not. A total of 259 animals were recorded: 89% chickens, 4% pigs, 4% ducks and 3% goats. All households with domestic animals kept domestic fowl (an average of 11 chickens per family). In Basilé Fang, three households also kept pigs (3.3 pigs on average per family), two households had ducks (3.5 ducks on average per family), and in Basacato, two households kept goats (4 goats on average per family).

Chickens were primarily kept for special occasions (celebrations, arrival of guests, etc.). Additional reasons included a food reserve (33%), for sale (27%), and for medicinal or traditional purposes (20%). Goats and pigs were kept for consumption on special occasions or for sale when offspring were born.

Generally, pigs were kept in enclosures and goats tethered, while chickens roamed freely, resulting in many being run over by road traffic and killed; this was also common for the pigs if they escaped from their enclosures. The care and feeding of animals were generally poor, with animals often left to fend for themselves. Consequently, eggs were rarely collected; only 21% of the households that kept chickens collected eggs regularly, 57% never collected them, and 21% did so occasionally when needed or found.

Informal observations in other villages confirmed the presence of these four types of animals, with chickens being the most common. I observed Zebu cattle only twice, and they appeared to be a market controlled by individuals with government connections, likely due to high investment costs. Additionally, a minister had taken over the abandoned Basilé Bubi Farm to raise pigs for sale. No other forms of livestock farming were noted in the island's northern part. These findings align with Albrechtsen et al. (2006), which reported similar species, including sheep in the Malabo market, during a study from 2003 to 2004.

4.1.2.4 Fishing

Fishing was not widespread and recorded only in Bakake Grande, Basacato, and Bososo. In the first two villages, 40% and 7% of households (out of 25 and 14 respectively) practised sea fishing, using hook and line from the shore or canoe and net at sea. In Bososo, data from the consumption interviews (21) revealed that 10% of households fished. About 8% of the sample households (n=160) engaged in fishing, limited to these three villages. The proximity to the sea and the settlement's historical context likely

contributed to this higher involvement in this activity. This is also reflected in the higher consumption of fresh fish and seafood in these villages (Section 4.1.5.2).

No women in the livelihood interviews currently fished, though some Fang women mentioned past fishing activities on the mainland, their place of origin. However, consumption interviews revealed two Bubi women—one in Bakake Grande and one in Rebola—who fished for crayfish in rivers, with one selling the catch. River fishing by women was thus rare and anecdotal. These findings align with Albrechtsen et al. (2006), who reported that all fresh fish in the Malabo market are marine (and mostly imported), with no freshwater fish, reflecting the island's unsuitable estuaries for fishing.

No families in the socio-economic interviews fished, so no income data from this activity was available.

4.1.2.5 Hunting

Fifty-two per cent of the households interviewed had at least one male engaged in hunting: 28% in commercial hunting, 17% in subsistence hunting, and 7% unspecified (n=155). In addition, in three Fang households (2%), despite the lack of male hunters, the woman traded wild meat purchased from others.

Of the 200 adult males (>16 years) in the 155 sample households, 51% hunted (26% commercially, 14% for subsistence, 10% unspecified). Hunters were almost evenly split between Fang (52.4%) and Bubi (47.5%). Commercial hunting was predominantly Fang (79%), while subsistence hunting was mostly Bubi (78%). Both hunting types were identified in all villages, apart from Basilé Bubi, where only subsistence hunting was observed, and Copé, where all hunting was of a commercial nature.

Subsistence hunters primarily used traps, with some also using spikes, spears (12%), dogs (8%), or smoke (4%) to harass animals in burrows. Commercial hunters used shotguns (15%), traps (53%), or both (33%). Some trap users also employed spikes, spears (7%), and smoke (2%). Most shotgun hunters were Fang (89%).

In Basilé Fang and Basacato, where income was quantified, the mean annual household income from commercial hunting was 1,935,850 ± 551,799 XAF (median = 1,453,400 XAF, range 607,400 to 5,330,000) for households engaging in this practice (8 in Basilé Fang and 1 in Basacato, out of 26 interviewed), constituting about 62% of household income (range 28% to 100%). This was one of the most profitable activities, along with shop/bar trade and salaried work, and was surpassed only by logging, which is rare due to its limitations on the island (Section 4.1.3.8). A detailed profitability analysis of commercial versus subsistence hunting is provided in Section 4.1.7.

4.1.2.6 Trade

Trade was a pervasive activity involving self-produced goods (such as agricultural, fishing, or gathered products) and purchased items (like food, clothing, and household goods). Sixty-eight per cent of families participated in some form of trade. Specifically, 41% traded agricultural products, 30% wild meat, 20% purchased products, 5% fish, and 1.5% snails. I did not consider sales that generated less than 100,000 XAF per year to the household as a commercial activity.

Wild animals and fish were typically caught by men, who sold them either directly to customers (individuals or bar/restaurant owners) or to female intermediaries who then sold them in villages or city markets. Agricultural products were usually sold by women in village or city markets. Purchased products were sold within villages, often through small shop-bars operated by women or both heads of household. Some of these bars also sold cooked wild meat. On average, 18% of households ran a shop or bar. Villages with higher mean annual household incomes had a higher percentage of shops/bars: Basacato (3,843,981 XAF, 57%), Basilé Fang (3,684,544 XAF, 45%), and Basilé Bubi (1,750,817 XAF, 25%). This suggests that running a shop/bar requires more initial investment and was, therefore, less common than wage labour and hunting, consistent with Kümpel's (2006) findings in the mainland region.

Bubi families were more likely to trade agricultural products (49%) and less likely to trade wild meat (8%) or other products (10%). In contrast, Fang families traded both agricultural products (24%) and wild meat (29%), with lower involvement in other products (9%).

The income from each type of trade has been previously discussed and will be elaborated on in the following section (see also Fig. 4.1-1).

4.1.2.7 Paid work

The proportion of households with at least one member in salaried employment was 43% (n=136). Most salaried positions were with large companies, particularly in construction, while others worked for smaller businesses or as self-employed individuals. Job roles included computer technician, driver, mechanic, carpenter, machinist, cook, blacksmith, welder, waitress, dishwasher, and road hand. Several women were employed by a school in BB and an oven run by nuns in Basacato. Civil servants interviewed included the deputy mayor of Rebola, a Basacato councillor, teachers, and military personnel.

The employment rates exhibited considerable variation across the villages, as illustrated in Table 4.1-1. The villages of Boma, Inasa Maule, and Cope had no employees due to their small, transient populations and distance from Malabo. Bantabaré, also distant from Malabo, had the highest employment rate (91%) due to the presence of the construction company SOGECO, which operated a local quarry and employed most households. Originally inhabited by the Bubi, Bantabaré had become predominantly Fang during the study period, likely due to job opportunities. Other villages with notable employment rates were Rebola (62%), Basacato (46%), and Bakake Grande (48%); the first two due to their larger populations and proximity to the capital, while Bakake Grande's employment was boosted by the BASICS construction company, which was upgrading a local road. Basilé Bubi and Basilé Fang had intermediate employment rates (36% and 26%, respectively). They are moderately populated and close to the capital but lack large enterprises; Basilé Fang had a Chinese construction company, though it employed relatively few locals, as most employees were Chinese.

There were no significant differences in employment rates between the Bubi and Fang ethnicities ($X^2 = 0.990$, p=0.373).

In Basilé Fang, Basilé Bubi, and Basacato, where income was quantified, paid work brought a mean annual income of 1,895,075 XAF (range 600,000 – 3,912,506) to households engaged in it (3 in Basilé Fang, 4 in Basilé Bubi, and 4 in Basacato), representing about 64% of household income (range 17% to 99%). This income is comparable to the wild meat trade (see above) and the shop-bar trade (average of 2,122,710 XAF, range 607,400 to 5,330,000, n=10). However, these incomes are higher than those of the agricultural trade (see above) (see also Figure 4.1-1).

A one-way ANOVA on Log_{10}-transformed incomes from these four activities showed significant differences ($F_{(3,42)} = 5.876$, $p = 0.002$). A post hoc Tukey HSD test revealed that income from agricultural trade was significantly lower than from the other three activities ($p=0.027$ for commercial hunting, $p=0.007$ for shop/bar trade, and $p=0.011$ for paid work), which did not significantly differ from each other ($p>0.9$ in all cases). Although paid work did not exceed commercial hunting in income, rural populations preferred paid work when available, as discussed in Section 4.1.4.

4.1.2.8 Timber

Nine households in six villages engaged in logging and timber sales. This activity was conducted at a limited scale due to the restrictions imposed by Law No. 1 of 1997 on the Use and Management of Forests, which explicitly prohibits any industrial logging activity in the country's islands (Art. 34). Consequently, this activity was carried out by individuals in Bioko who sold locally yet yielded considerable profits. Two households were identified through socioeconomic interviews as being engaged in this activity. One family in Basilé Fang and one in Basacato earned annual incomes of 2,100,000 XAF and 3,000,000 XAF, respectively (see Figure 4.1-1).

4.1.2.9 House rentals

During the livelihood activities interviews (Section 3.2.2.3), renting houses was initially declared as something other than a livelihood activity. However, the socioeconomic interviews (Section 3.2.2.5) revealed that some households did derive income from this source. Specifically, four out of 26 households reported renting a second home. The mean annual income from renting was 1,230,000 XAF, ranging from 300,000 to 2,100,000 XAF. No other undisclosed activities were identified during the livelihood interviews.

4.1.3 Influence of paid work and ethnicity on hunting activity

The descriptive results in Table 4.1-1 and Figure 4.1-2 indicate a negative association between employment and hunting. This relationship was confirmed through univariate and multivariate analyses. Villages with a higher percentage of households having one or more employed members had a lower rate of households engaged in hunting (r= -0.761, p= 0.017, Figure 4.1-2).

Among households with at least one member in paid employment, 29.6% (54) were also engaged in hunting. In contrast, 69.4% (72) of households without employed members were involved in hunting. These differences were statistically significant ($\chi^2 = 19.61$, $p <$

0.0001), indicating that households without salaried members were more likely to hunt than those with salaried members.

To understand the type of hunting involved, I re-ran the chi-square analysis specifying commercial and subsistence hunting. I segmented the sample by ethnicity due to the different hunting practices of the Fang and Bubi (Section 4.1.3.5). The results showed significant differences. Fang households had a significant ($p < 0.0005$) and strong (Vcramer= 0.48) association with commercial hunting, while Bubi households had a significant ($p = 0.046$) but weak (Vcramer = 0.26) association with subsistence hunting (Figure 4.1-3). Thus, the absence of salaried employment in a household was associated with an increased likelihood of hunting, especially in Fang households, which were more inclined towards commercial hunting. In contrast, Bubi households showed a weaker tendency towards subsistence hunting.

Using multinomial logistic regression, with hunting activity as the dependent variable (0= no hunting, 1= subsistence, 2= commercial) and predictors as employment status (0= no, 1= yes) and ethnic group (0= Bubi, 1= Fang), the results indicated that ethnicity did not predict the likelihood of engaging in subsistence hunting but did predict commercial hunting. Fang households were 1.7 times more likely to engage in commercial hunting than Bubi households. Employment predicted the likelihood of engaging in both types of hunting. Unemployed households had five times greater odds of engaging in subsistence hunting and 5.7 times greater odds of engaging in commercial hunting than employed households (Table 4.1-2).

These findings confirm that lack of salaried employment increases the likelihood of hunting, with distinct patterns observed between Fang and Bubi households.

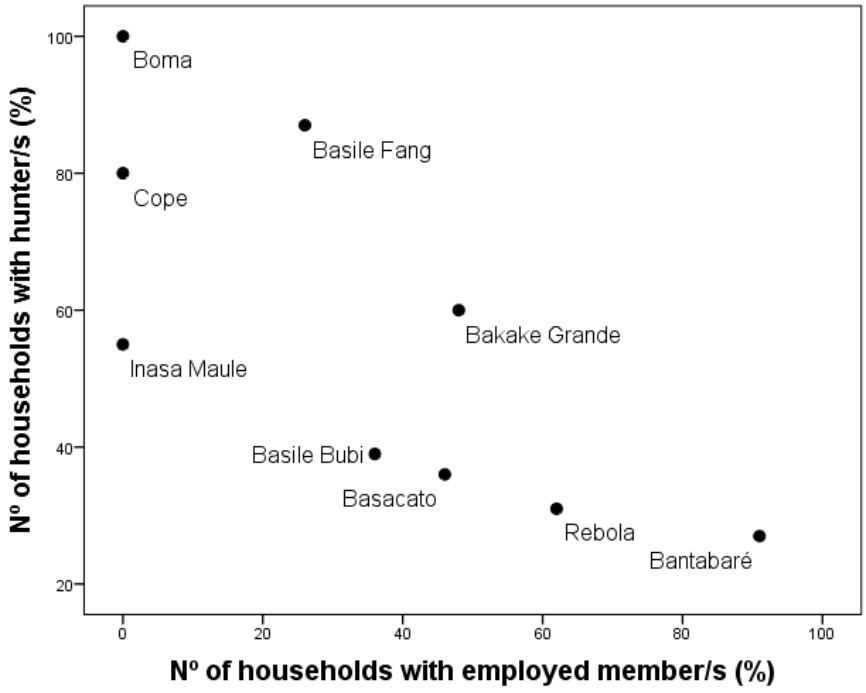


Figure 4.1-2 Proportion of households with employed members vs. the proportion of households engaged in hunting across study villages.

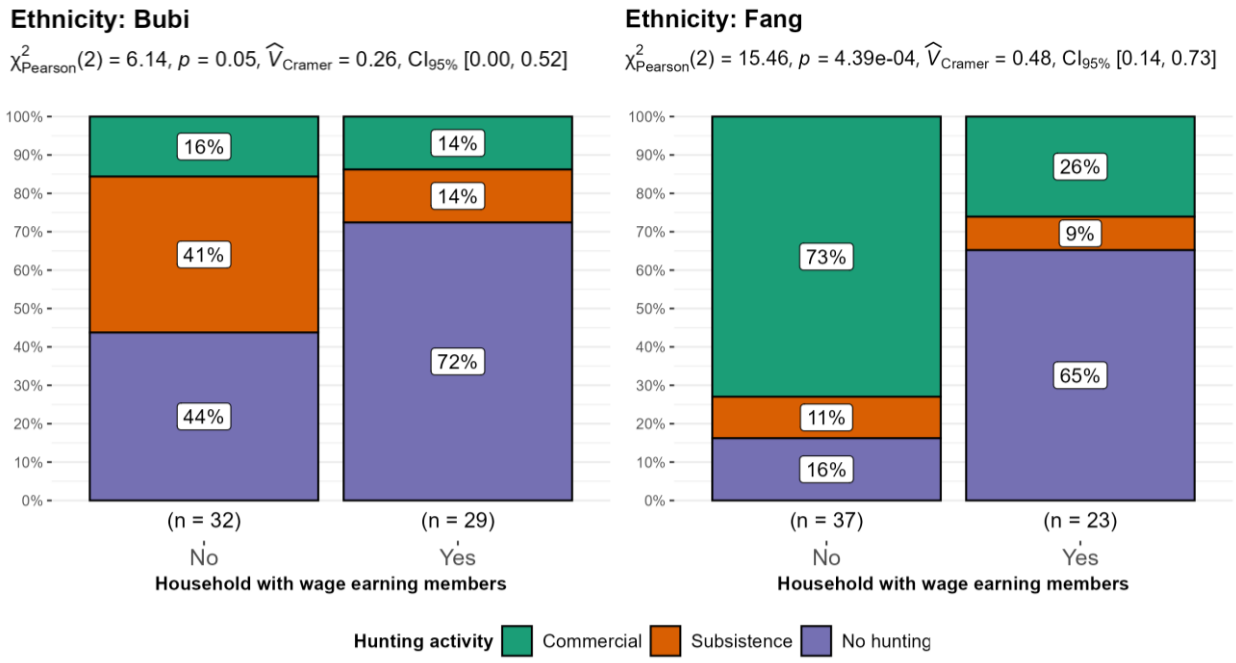


Figure 4.1-3 Differences in hunting activity between households with and without wage-earning members for the Bubi and Fang ethnic groups.

Table 4.1-2 Multinomial Logistic Regression Analysis of Hunting activity

		95% CI for OR		
	B(ES)	Inferior	Odds Ratio	Superior
No hunting Vs. subsistence hunting				
Intercept	-2.150 (0.61)			
Ethnicity[a]	0.525 (0.57)	0.55	1.69	5.21
Employment	1.628 (0.55)*	1.72	5.09	15.05
No hunting Vs. commercial hunting				
Intercept	-0.542 (0.41)*			
Ethnicity	-1.816 (0.50)***	0.06	0.16	0.43
Employment	1.757 (0.49)***	2.21	5.80	15.21

Pseudo R^2= 0.30 (Cox and Snell), 0.34 (Magelkerke).
Model X^2= 42.39, p<0.001.
*p<0.05; **p<0.01; ***p<0.001
[a]Ethnicity was coded as 0=Bubi and 1= Fang, and employment so that 0=no and 1=yes

4.1.4 Feasibility of alternatives to hunting

The results of the analyses above (previous section) are consistent with responses from interviews conducted with commercial hunters in Basilé Fang about their past activities and reasons for change. A total of 18 of the 33 hunters active in this village during the study period responded. All were mainland Fang hunters. Fifty per cent of hunters had come to the island to work, 28% to study, 11% to hunt, and another 11% for family

reasons (e.g., to look after an inheritance or to accompany a relative). All but three individuals (83%) had previously held occupations other than hunting: 44% reported having a salaried position in a company, 17% indicated having worked in the cocoa industry, 11% had pursued studies, 6% had engaged in the trade of purchased goods, and the remaining 6% selling snails. The reason they engaged in hunting was due to the loss of employment or the inability to continue their studies. Only those involved in cocoa production and trading indicated that they had left their previous occupations voluntarily, citing the difficulty and unprofitability of these roles.

In total, 56% of the hunters said they would stop hunting if they could secure employment, while 44% said they preferred to continue hunting. The latter were all hunters who had been dedicated exclusively to hunting for a long time and were earning good incomes from it (six owned shotguns, and two only used traps, but one of them was very successful with traps). Among those who preferred a salaried job, half were also regular and experienced hunters, and the other half were sporadic hunters or visiting family members.

On the other hand, when we conducted the seminar-workshop in Basilé Fang (Section 3.2.3.7), two perspectives emerged. On the one hand, there were hunters and women traders who were willing to engage in alternative activities if they were offered a higher profit margin. Conversely, a group of hunters asserted that they would not engage in any other profitable activity unless it also aligned with their interests and skills. These were the more experienced hunters, those who derived the most financial returns from hunting and those who had the greatest impact on wildlife. These hunters expressed a desire to maintain their connection to the forest. Consequently, among all the activities discussed (see table in Appendix 3.2-8) they opted for the role of eco-guard or park guide as an alternative. This information, together with their annual income data, is essential for the design of attractive alternatives for this higher-impact group.

4.1.5 Total food consumption and the contribution of wild meat

As stated in Section 1.1.1, 'wild meat' refers to terrestrial wild animals consumed as food, encompassing both hunted vertebrates and harvested invertebrates. In this thesis, I primarily focus on hunted wild meat; however, when discussing consumption patterns, I distinguish between hunted and harvested wild meat. On Bioko Island, the latter is primarily limited to snails, which are an important component of the rural diet.

4.1.5.1 Staple foods and frequency of consumption

Considering the total number of recorded consumption days (n= 798, mean 7.5 ± 1.2 per household), the most frequently consumed foods were rice (361 days), plantain (299 d.), taro (298 d.) and bread (296 d.), followed slightly behind by mackerel (181 d.), milk (170 d.), chicken (168 d.) and banana (148 d.). Of these, only plantain, taro and banana are local products. Bread is produced on the island, but the flour is imported. The most consumed condiments were bouillon cube (618 d.), soybean or olive oil (553 d.), onion (412 d.), tomato (mostly canned; 296 d.), palm oil (186 d.), garlic (199 d.), chilli (149 d.) and canned sardine (usually added to boiled rice to give it some flavour) (102 d.). Of

these, only palm oil and chilli are local products. All these foods and condiments were consumed in all villages by many families (Table 4.1-3).

"Verduras" (leafy greens in Spanish) were widely (80 families in the 10 villages) and frequently (268 days) consumed. “Verduras" refers to various species of wild edible herbaceous plants, which are semi-domesticated (planted and maintained near homes) and to the leaves of some agricultural plants, such as taro, eggplant, sweet potato and cassava, usually cooked with meat and fish, (or plantain and taro when there is no meat or fish). Wild edible plants were most frequently consumed (243 days in 78 families in 10 villages) and included as many as 23 species (Table 4.1-3). Leaves of the four cultivated plants were less frequently consumed (52 d., 40 f., 10 villages).

Hunted wild meat consumption was less frequent (50 families; 109 days) but occurred in all sample villages. The most hunted and consumed wild meat species were the forest giant pouched rat (35 families; 70 days) and the blue duiker (21 families; 25 days), followed by the brush-tailed porcupine (5 families; 8 days), squirrels (4 families; 7 days), the African white-bellied pangolin (1 day), and snakes (1 day). The consumption of harvested wild meat, particularly snails, was higher (47 families; 88 days) than that of the pouched rat and not much lower than the total hunted wild meat (Table 4.1-3).

Table 4.1-3 Total Food Items recorded in Basilé Fang, Basilé Bubi and the remaining eight villages, categorized in 15 groups according to the classification by Oguntona & Akinyele (1995) and the FAO/INFOODS food composition tables (Vincent et al 2020; Stadlmayur et al 2012). The villages of Basilé Bubi (BB) and Basilé Fang (BF) are presented separately from the other eight villages to better visualize their representativeness in terms of the products consumed relative to the total sample of villages. The dashed lines help to visualize the foods that are uncommon between BB/BF and the other villages. The means of procurement are classified as either produced (or harvested) by the household itself (P) or acquired by other means (A). The table highlights in bold the most widely and frequently consumed products in each group. Note that animal products are included in M, P&E, F&MF, and M&MP, while the rest are vegetable. M, P&E is composed of domestic meat and wild meat (hunted and harvested). F&MF is composed of fish and marine invertebrates.

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	**VILLAGES WHERE IT IS CONSUMED**					**ORIGIN**	**SCIENTIFIC NAME (only local products)**
		BB	**BF**	**Other villages (n=8)**	**Num. households (n=105)**	**Procu-rement**		
BEVERAGES AND SOFT DRINKS (B&SD)								
Lemon grass	Contritί	x	x	6	16	A/P	Local	*Cymbopogon citratus*
Coke/Fanta	Coca Cola[a]/Fanta[a]	x		4	16	A	Imported	
Chocolate	Colacao[a]	x	x	4	13	A	Imported	
Juice	Zumo		x	3	9	A	Imported	
Coffe	Café	x		2	4	A	Imported	
Malt	Malta	----	----	2	2	A	Imported	
CEREAL AND CEREAL PRODUCTS (C&CP)								
Rice	**Arroz**	**x**	**x**	**8**	**95**	A	**Imported**	
Bread	**Pan**	**x**	**x**	**7**	**82**	A	**Imported**	
Pasta	Pasta	x	x	7	23	A	Imported	
Biscuits	Galletas	x	x	5	20	A	Imported	
Pastries	Bollería	x	x	4	6	A	Imported	
Doughnuts	Buñuelos		x	4	27	A	Imported	
Corn flour	Harina de maíz/Kuni		x	2	5	A	Imported	
CONDIMENTS AND SPICES (C&S)								
Bouillon cube	**Caldo**	**x**	**x**	**8**	**103**	A	**Imported**	

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED					ORIGIN	SCIENTIFIC NAME (only local products)
		BB	BF	Other villages (n=8)	Num. households (n=105)	Procu-rement		
Ginger	Cocobianco (jengibre)		x	0	4	A	Local	*Zingiber officinale*
African basil	Mesep (orégano)		x	1	2	A/P	Local	*Ocimum gratissimum*
Hoary basil	Osim (orégano)		x	1	1	A	Local	*Ocimum americanum*
Bay leaves	Hoja de sopa (laurel)	----	----	1	3	A	Imported	
Vinegar	Vinagre	----	----	1	1	A	Imported	Astacoidea
River shrimp	Langostino/grafis	----	----	1	3	A/P	Local	
Fruits (F)								
Banana	**Banana**	**x**	**x**	**8**	**59**	**P**	**Local**	***Musa sp.***
Avocado	Aguacate		x	6	24	P	Local	*Persea americana*
Papaya	Papaya		x	5	9	P	Local	*Carica papaya*
Orange	Naranja	x	x	3	9	P	Local	*Citrus sinensis*
Pineapple	Piña	x	x	2	4	P	Local	*Ananas comosus*
Jack fuit	Fruto pan / Yaca	x		2	4	P	Local	*Artocarpus heterophyllus*
Mango	Mango	----	----	3	21	P	Local	*Magnifera indica*
Coconut	Coco	----	----	2	5	P	Local	*Cocos nucifera*
Cocoa	Cacao	----	----	1	1	P	Local	*Theobroma cacao*
Guava	Guayaba / Casamanga	----	----	1	2	P	Local	*Psidium guajava*
Apple	Manzana		x	0	1	A	Imported	
FISH AND OTHER MARINE FOODS (F&MF)								
FROZEN								
Horse mackerel	**Chicharro / Jurel**	**x**	**x**	**8**	**77**	A	**Imported**	
Variety of fish	Pescado variado	x		4	8	A	Imported	
Hake	Merluza	x	x	2	6	A	Imported	
Croaker	Corvina		x	3	4	A	Loc/Imp	*Pseudotolithus sp.*
Red snapper	Colorado	x		1	3	A	Loc/Imp	*Lutjanus sp*
Sea barbel	Barbo de mar / Disco		x	----	2	A	Imported	
Biglip grunt	Pescado negro		x	----	1	A	Local	*Plectorhinchus macrolepies*

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED BB	BF	Other villages (n=8)	Num. households (n=105)	Procu-rement	ORIGIN	SCIENTIFIC NAME (only local products)
Tilapia	Tilapia / Tarapia		x	----	1	A	Imported	
Tuna	Atún		x	----	1	A	Imported	
Cod	Bacalao		x	----	1	A	Imported	
Bonito	Bonito	----	----	1	1	A	Imported	
Sea bream	Besugo	----	----	1	1	A	Imported	
FRESH								
Sardine	Sardina	x	x	4	20	A/P	Local	*Sardinella maderensis*
Crab	Cangrejo	x		3	20	P	Local	*Ocypode cursor/O. africana*
Needlefishes	Aguja / Culó	----	----	1	6	P	Local	*Tylosurus spp.*
Variety of fish	Pescado variado	----	----	4	5	A/P		
?	Lomod	----	----	3	4	A/P	Local	?
c.f. Biglip grunt	Pescado negro / Biasa	----	----	2	4	A	Local	*c.f. Plectorhinchus macrolepies*
Moray eel	Anguila	----	----	1	1	A/P	Local	*Gymnothorax afer; Muraena robusta*
White grouper	Bacalao / Isupela	----	----	1	2	A/P	Local	*Epinephelus aeneus*
Periwinkle	Caracoles / Futi	----	----	1	1	P	Local	Littronidae
CANNED								
Sardine	**Sardina**	**x**	**x**	**8**	**53**	A	**Imported**	
Tuna	Atún	----	----	4	5	A	Imported	
SMOKED								
Barracuda	Picuda	x			1	A	Local	*Sphyraena spp*
Unidentifiable	No identificables	x		3	4	A	Local	
SALTED								
White grouper	Bacalao	----	----	1	1	A/P	Local	*c.f. Epinephelus aeneus*
Croaker	Corvina	----	----	2	2	A	Local	*Pseudotolithus spp.*
Unidentifiable	No identificables	----	----	2	2	A/P		
GRAIN LEGUMES AND LEGUME PRODUCTS (GL&LP)								
Lentils	Lentejas	x		2	4	A	Imported	
Beans	Judias / aricó		x	1	3	A	Imported	

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED BB	BF	Other villages (n=8)	Num. households (n=105)	Procu-rement	ORIGIN	SCIENTIFIC NAME (only local products)
Chickpeas	Garbanzos	----	----	1	1	A	Imported	
Peas	Guisantes	----	----	1	1	A	Imported	
MEAT, POULTRY AND EGGS (M,P&E)								
DOMESTIC FROZEN								
Chicken	**Pollo**	**x**	**x**	**8**	**71**	A	**Imported**	
Pork	Cerdo	x	x	7	28	A	Imported	
Turey	Pavo	x	x	7	22	A	Imported	
Beef	Carne	x	x	4	12	A	Loc/Imp	*Bos indicus*
DOMESTIC FRESH								
Egg	**Huevo**	**x**	**x**	**8**	**35**	A	**Imported**	
Beff (Zebu meat)	Carne (Carne de cebú)		x	3	5	A	Local	*Bos indicus*
Chicken	Pollo	----	----	1	1	P	Local	*Gallus gallus domesticus*
DOMESTIC CANNED								
Mortadella[b]	**Mortadela[b]**	**x**	**x**	**7**	**37**	A	**Imported**	
Chorizo/Salami	Chorizo/Salchichón		x	2	6	A	Imported	
DOMESTIC SMOKED								
Chiken	Pollo	x		1	3	A	Local	*Gallus gallus domesticus*
WILD HUNTED								
Pouched rat	**Rata**	**x**	**x**	**8**	**35**	**P**	**Local**	*Cricetomys emini*
Blue duiker	Antílope	x	x	7	21	P	Local	*Philantomba monticola*
Porcupine	Puercoespín	x	x	2	5	P	Local	*Atherurus africanus*
Squirrel	Ardilla	x		3	4	P	Local	*Protoxerus stangeri;Anomalurus spp.*
Snake	Vívora		x	----	1	P	Local	*Bitis spp.; Naja spp.*
Pangolin	Pangolín	----	----	1	1	P	Local	*Dendrohyrax dorsalis*
WILD HARVESTED								
Snail	**Caracol**	**x**	**x**	**8**	**47**	**P/A**	Local	*Archachatina marginata; Achatina iosotoma; Achatina spp.*
MISCELANEOUS (M)								
Candies	Caramelos		x	2	2	A	Imported	

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED BB	BF	Other villages (n=8)	Num. households (n=105)	Procu-rement	ORIGIN	SCIENTIFIC NAME (only local products)
MILK AND MILK PRODUCTS (M&MP)								
Milk powered	**Leche en polvo**	**x**	**x**	**8**	**45**	A	**Imported**	
Condensed milk	Leche condensada	x	x	3	15	A	Imported	
Cheese	Queso		x	2	3	A	Imported	
Yogurt	Yogures		x	----	1	A	Imported	
NUTS AND SEEDS (N&S)								
Bush mango	Modica / Chololate	x	x	6	20	A	Local	*Irvingia gabonensis*
Groundnut	Cacahuetes		x	3	12	A	Local	*Arachis hypogaea*
Pumpkin seeds	Calabaza	----	----	1	1	A	?	*Cucurbita sp.*
OILS AND FATS (O&F)								
Imported oils[c]	**Aceites importados[c]**	**x**	**x**	**8**	**99**	**A**	**Imported**	
Palm oil	**Aceite de palma**	**x**	**x**	**6**	**58**	**P/A**	**Local**	***Elaeis guineensis***
Margarine	Mantequilla	x	x	6	36	A	Imported	
Mayonnaise	Mayonesa		x	3	11	A	Imported	
PRESERVES (P)								
Chocolate	Chocolate		x	3	7	A	Imported	
STARCHY ROOTS, TUBERS AND FRUITS (SR,T&F)								
Plantain	**Plátano**	**x**	**x**	**8**	**87**	**P/A**	**Local**	***Musa sapientum (*Sin. *Musa balbisiana)***
Taro	**Malanga**	**x**	**x**	**8**	**80**	**P/A**	**Local**	***Xanthosoma violaceum; Colocasia esculentum***
Cassava	Yuca	x	x	4	15	A	Local	*Manihot esculenta*
Potato	Patata		x	5	11	A	Imported	
Yam	Ñame	x		4	7	P/A	Local	*Dioscorea dumentorum*
Sweet potato	Batata		x	0	1	A	Local	*Ipomea batatas*

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED					ORIGIN	SCIENTIFIC NAME (only local products)
		BB	BF	Other villages (n=8)	Num. households (n=105)	Procu-rement		
SUGAR AND SYRUP (S&S)								
Sugar	**Azúcar**	**x**	**x**	**6**	**37**		**Imported**	
Sugar cane	Caña	x	x	4	15	P	Local	*Saccharum officinarum; S. spp.*
VEGETABLES AND VEGETABLE PRODUCTS (V&VP)								
AGRICULTURAL FRESH PRODUCE								
Onion	**Cebolla**	**x**	**x**	**8**	**87**	A	**Imported**	
Garlic	**Ajo**	**x**	**x**	**8**	**49**	A	**Imported**	
Chilli	**Picante**	**x**	**x**	**8**	**36**	**P/A**	**Local**	***Capsicum frutescens***
Eggplant	Berengena	x	x	6	30	P/A	Local	*Solanum incanum*
Parsley	Perejil	x	x	4	15	P/A	Local	*Petroselinum crispum*
Palm dates	Dátiles (palma)		x	3	4	P	Local	*Elaeis guineensis*
Carrot	Zanahoria		x	3	5	A	Imported	
Tomato	Tomate	x	x	2	19	A/P	Local	*Lycopersicum sculentum*
Atanga	Atanga		x	1	2	P/A	Local	*Dacryodes edulis*
Lettuce	Lechuga		x	1	2	A	Local	*Lactuca sativa*
Red pepper	Pimiento		x	1	5	P/A	Local	*Caspicum sp.*
Leek	Puerro		x	1	4	A	Imported	
Cabagge	Repollo	----	----	2	2	P	Local	*Brassica oleracea var. capitata*
Celery	Apio		x	----	2	A	Imported	
Lemon	Limón		x	----	1	A	Local	*Citrus limonum*
AGRICULTURAL CANNED PRODUCE								
Tomato	**Tomate**	**x**	**x**	**8**	**74**	**A**	**Imported**	
Vegetable salad	Macedonia (de verduras)			3	3		Imported	
FRESH LEAVES FROM AGRICULTURAL PLANTS[d]								
Taro leaves	**Hojas de malanga**	**x**	**x**	**3**	**26**	**P**	**Local**	***Colocasia esculentum***
Eggplant leaves	Cheá (hojas de berengena)	x	x	5	11	P	Local	*Solanum incanum*
Sweet potato	Batatalif (hojas de batata)	----	----	2	3	P	Local	*Ipomea batatas*

FOOD CATEGORY AND SUBCATEGORY Food item	Local name	VILLAGES WHERE IT IS CONSUMED BB	 BF	 Other villages (n=8)	 Num. households (n=105)	 Procu-rement	ORIGIN	SCIENTIFIC NAME (only local products)
leaves								
Cassava leaves	Bambucha (hojas de yuca)	x		1	2	P	Local	*Manihot esculenta*
WILD EDIBLE PLANTS[d]								
	Topepán	x		6	26	P	Local	*Chenopodium album*
	Bitalif	x		6	23	P	Local	*Vernonia cf. calvoana*
	Green	x	x	5	26	P/A	Local	*Amaranthus hybridus*
	Coja	x		3	16	P	Local	*Amaranthus spinosus*
	Ocro	x		5	8	P	Local	*Abelmoschus esculentus* (sin. *Hibiscus sculentus*)
	Nahú/Sisa	x	x	1	6	P	Local	*Solanum nigrum*
	Topechipechi	x		3	5	P	Local	*Vernonia hymenolepis*
	Berilahualé	x		1	4	P	Local	*Vernonia cf. conferta*
	Crencren	x		2	3	P	Local	*Corchorus olitorius*
	Tolepá	x		2	3	P	Local	*Emilia cf. sonchifolia*
	Watalif		x	2	3	P	Local	*Hydrophyllum spp.*
	Meñiñang		x	----	1	P	Local	*Basella alba*
	Ndeng	----	----	4	5	P/A	Local	?
	Tononorí	----	----	1	4	P	Local	?
	Ucombong	----	----	2	2	P	Local	*Telfairia occidentalis*
	Bentó	----	----	2	2	P	Local	?
	Tomall	----	----	1	2	P	Local	?
	Bijem	----	----	1	1	P	Local	?
	Crocolif	----	----	1	1	P	Local	?
	Thotó	----	----	1	1	P	Local	?
	Cabech	----	----	1	1	P	Local	?
	Bologuí	----	----	1	1	P	Local	?
	Mabembe	----	----	1	1	P	Local	?

[a]Trade marks; [b]Canned meat, which could be pork or beef; [c]Mainly soyabean and sunflower oils; [d]Fresh leaves from agricultural plants and wild edible plants were commonly referred to as ‘verduras’.

4.1.5.2 Protein intake

Quantitative analysis of protein intake from meat and fish was carried out in all sample villages (Section 4.1.6). In contrast, analysis of total food protein intake was done only in BB and BF. It can be argued that, regarding ethnicity, livelihood activities, and other demographic factors, the two villages exhibit several attributes like those of the overall sample (see Section 3.2.1 and Table 4.1-1). Additionally, the average [median (IQR)] daily consumption of meat and fish per reference adult (RA) in these two villages [264.79 (155.9 – 419.6) g corresponding to 48.27 (32.48 – 76.83) g of protein in BB, and 307.82 (255.7 – 367.7) g corresponding to 50.69 (45.2 – 71.9) g of protein in BF] is comparable to the median for the entire sample [253.41 (144.40 – 339.04) g]. Furthermore, the products consumed in Basilé Bubi and Basilé Fang encompassed most of those consumed in the other villages (Table 4.1-3). It is, therefore, most reasonable to assume that the vegetable and total protein intakes in these villages are also within the average values for the entire rural sample.

The total protein intake in both villages was 94.32 $g \cdot RA^{-1} \cdot day^{-1}$, with meat and fish contributing 60.4%. Together with dairy products (1.5%), they made up the total protein of animal origin. Plant-based food accounted for 38.1%; home-produced products contributed 16.8% (14.6% agricultural and 2.1% wild/semi-domesticated) and purchased or acquired products contributed 21.9% (3.9% local and 16.9% imported).

Hunted wild meat contributed 14.05% to the total meat/fish protein consumed (close to 16.42% for the total village sample in Section 4.1.6.2.2), 13.58% to total animal protein (including dairy), and 8.34% to total protein from all sources. This contribution was lower than that of domestic meat (24%) and fish (23%) but comparable to that of the highest contributing plant groups, C&CP (13%) and SRT&F (13%), which have much lower protein content but higher daily consumption per RA (Table 4.1-4). Within these plant groups, staple foods like taro, bread, plantain, and rice stand out for their protein contribution.

Food was also categorized by origin (local or imported) and state (fresh or processed, e.g., canned, packed, frozen). As shown in Table 4.1-1, plant-based local products were mainly F (except for apples, which were imported from South Africa or Europe), SR, T&F (except for potatoes, imported from Cameroon), and V&VP (except for garlic, onion, leek, carrot, and celery, which were mainly imported from Cameroon). Palm oil (O&F) and sugar cane (S&S) were also produced on the island and by the rural families in our sample. Groundnuts and modica (N&S), although local products, were not produced by the rural families in our sample but were purchased in Malabo. Local animal products included wild meat, fresh fish, and seafood (with a small proportion of frozen, salted, or smoked fish), as well as zebu meat to a lesser extent. Thus, local food was mostly fresh, while imported food was mostly packaged or frozen. In this context, wild meat contributed 23% to both daily fresh protein intake [34.8 ± 4.0 $g \cdot RA^{-1} \cdot day^{-1}$] and daily local protein intake [34.33 ± 4.7 $g \cdot RA^{-1} \cdot day^{-1}$].

All products and their origin are shown in Table 4.1-3. Figure 4.1-4 illustrates the contribution of different protein sources to the total intake, while Table 4.1-4 provides information on the contribution and the protein content of various food types.

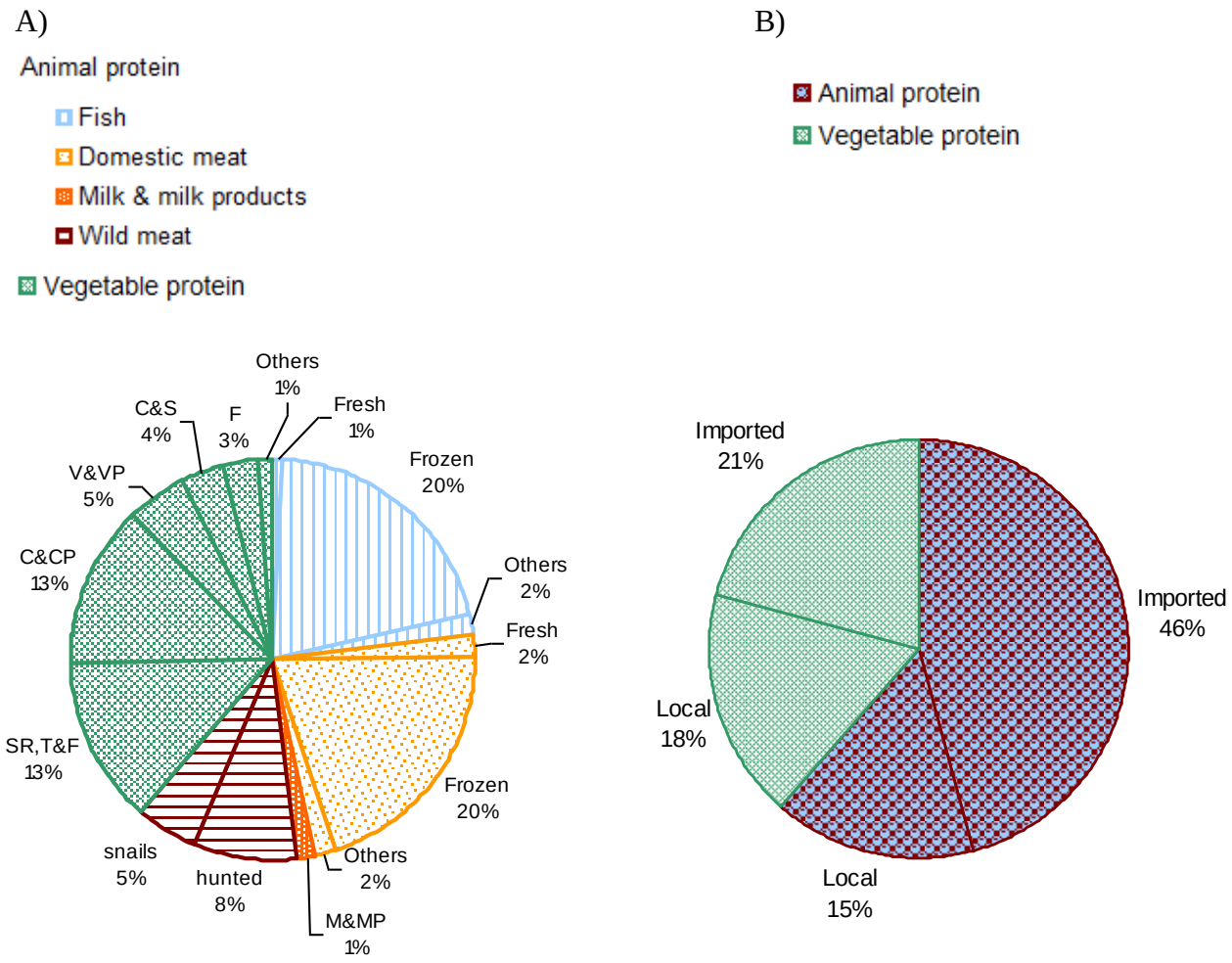


Figure 4.1-4 Contribution of the various sources of protein to total protein intake (per day and RA): (A) Categorized by food group and state and (B) by their origin. Acronyms of plant groups and origin of food items are shown in Table 4.1-3. The term "others" refers to canned, salted or smoked. Total protein intake was on average 94±8.5 g·RA^{-1}·day^{-1} (median = 81g; n= 27 households in 2 villages, BB and BF). Food items within each category, their contribution and protein content are shown in Table 4.1-4.

Table 4.1-4 Contribution of the various types of meat, fish and vegetables to average daily protein intake per Reference Adult and their protein content. Acronyms of plant groups are shown in Table 4.1-3. Data is based on 27 households in 2 representative villages, Basilé Bubi and Basilé Fang.

Category	Species/product	Protein intake ($g \cdot RA^{-1} \cdot day^{-1}$)		Protein/100g edible portion[a]
Domestic meat[b]				
	Chicken	**12.9**	**(14%)**	20.5
	Turkey	**4.8**	**(5%)**	22.4
	Pork	**2.7**	**(3%)**	12.4
	Beef (Zebu)	1.0	(1%)	18.2
	Eggs	2.3	(1%)	12.5
	Mortadella	12.9	(1%)	12.3 - 14.2
	Subtotal	*22.5*	*(24%)*	
Fish				
Frozen	**Mackerel**	**13.2**	**(14%)**	15.7
	8 sp.	5.8	(6%)	12.5 - 27.1
Fresh	Sardine and crabs	0.9	(1%)	12.5 - 23.0
Other[c]	5 sp.	1.5	(2%)	17.7 - 23.0
	Subtotal	*21.3*	*(23%)*	
Wild meat				
Harvested	**Snails**	**4.8**	**(5%)**	18.2
Hunted	**Blue duiker**	**2.7**	**(4%)**	20.8
	Pouched rat	**3.4**	**(3%)**	20.1
	3 other sp[d]	1.9	(2%)	20.5 - 26.4
	Subtotal (hunted)	8.0	(8%)	
	Subtotal (hunted+snails)	*12.8*	*(13%)*	
Milk & MP				
	Milk (powdered)	0.44	(0.5%)	23.6
	Others	1.99	(1%)	4 - 12.6
	Subtotal	*1.43*	*(2%)*	
C&CP				
	Bread	**6.08**	**(6%)**	7.8
	Rice	**4.08**	**(4%)**	2.4
	others	2.23	(2%)	4.2 - 11.3
	Subtotal	12.39	(13%)	
SR,T&F				
	Taro	**8.1**	**(9%)**	2.6
	Plantain	**3.6**	**(4%)**	1.3
	others (5)	0.4	(0.5%)	1 - 3.7
	Subtotal	12.1	(13%)	
V&VP				
	"Verduras"	2.61	(3%)	2.7 – 22.9
	Fresh agricultural	1.32	(1%)	0.5 - 12
	Canned	0.33	(0.01%)	1.4 - 3.2
	Subtotal	*4.26*	*(5%)*	
Remaining plant groups				
	Subtotal	*0.98*	*(1%)*	*0 – 25.2*
Total		**94.32**	**(100%)**	

[a]Protein contents references are given in Section 3.2.2.4

[b]Domestic meat was mostly frozen and imported except for zebu, about half of which was fresh (this being probably local). Mortadella was canned meat, which could be pork or beef.

[c]Refers to canned, smoked or salted

[d]Include the porcupine (1.02 $g \cdot RA^{-1} \cdot day^{-1}$), the squirrel (0.46 $g \cdot RA^{-1} \cdot day^{-1}$) and the viper (0.38 $g \cdot RA^{-1} \cdot day^{-1}$).

4.1.6 Consumption of animal protein and related factors

The results in this section highlight the contribution of wild meat to daily animal protein intake[9] in the 10 villages. They also address whether the distance to Malabo (the primary supplier of domestic meat and frozen fish) or the sea (the primary source of fresh fish) affects the consumption of various animal protein sources. The analysis incorporates village characteristics (as gathered in the livelihood activities survey, see Section 4.1.3), and data on meat and fish procurement and prices, which are discussed first in this section.

Additionally, for a subset of households with socioeconomic and food consumption information (22 households in three villages: Basilé Bubi, Basilé Fang and Basacato), I analysed the influence of income, expenditure, and wealth (assets) on the consumption of wild meat and other animal protein sources, which is covered in the final point of this section.

4.1.6.1 Meat and fish procurement and prices

4.1.6.1.1 Frozen products

All frozen domestic meat and fish consumed in the rural villages were sourced from Malabo. These products were transported by either enterprising village shop/bar owners (who had a refrigerator and an electric generator), household members who occasionally travelled to Malabo, or relatives living in the city who occasionally visited the village. Shop/bar owners bought wholesale at lower prices (e.g. 1300 XAF/kg for chicken) and sold retail at prices like the Malabo market (e.g. 1500 XAF/kg for chicken). Families who purchased products in Malabo sometimes bought at retail and wholesale prices.

On average, the price per kg of frozen products purchased in Malabo (specifically chicken and mackerel, due to their high consumption and similar prices per kg) was 10% cheaper than those bought in village shops (1,383±155 XAF vs. 1,528±100 XAF, $p<0.0001$, n= 141 purchases with weight recorded).

Most villages had several shops/bars where frozen products could be purchased, except for the remote villages with only one (Bantabaré and Inasa Maule) or none (Copé and Bomá). Households in Inasa Maule, Copé and Bomá (hunting and/or farming villages) primarily purchased frozen products in Malabo and, to a lesser extent, in neighbouring villages. Conversely, households in Bantabaré (a village of wage labourers) bought most of their frozen products in the village shop (see Figure 4.1-5).

Villages situated near Malabo, except for Rebola, and those located at the greatest distance from the capital, except for Bantabaré, purchased most of their frozen products in Malabo (Figure 4.1-5). The former did so due to proximity, while the latter did so due to the unavailability of local suppliers. The exception of Rebola is likely attributable to

[9] Animal protein refers to all meats and fish (including seafood), excluding milk and milk products. The previous section details the contribution of wild meat to the total daily protein intake, including milk and milk products and vegetable protein.

its status as a municipality, its considerable population (see Table 3.2-1), and its elevated employment rate (see Table 4.1-1). These attributes likely underpin its substantial number of services and autonomy relative to other villages (pers. observ.). As for Bantabaré, it exhibits the highest employment rates (see Section 4.1.3.7**)**, This undoubtedly contributes to a higher purchasing power compared to the other villages distant from Malabo, enabling its residents to buy products from the village's only registered store, despite the high prices. For a sample of 107 items purchased in the villages of Rebola, Basacato, Bososo, Bakake Grande, and Bantabaré (the other five villages had insufficient sample size as explained in Figure 4.1-5), prices of frozen products in Bantabaré were. 14% higher than in other villages [1,697±13) XAF (median 1800) compared to 1,493±6.1) XAF (median 1,500); X^2=30.922, df=4, p<0.0001]. There were no significant differences when Bantabaré was excluded from the analysis (X^2=9.605, df=3, p=0.021). It seems reasonable to posit that the price increase is attributable to higher transport costs associated with the greater distance.

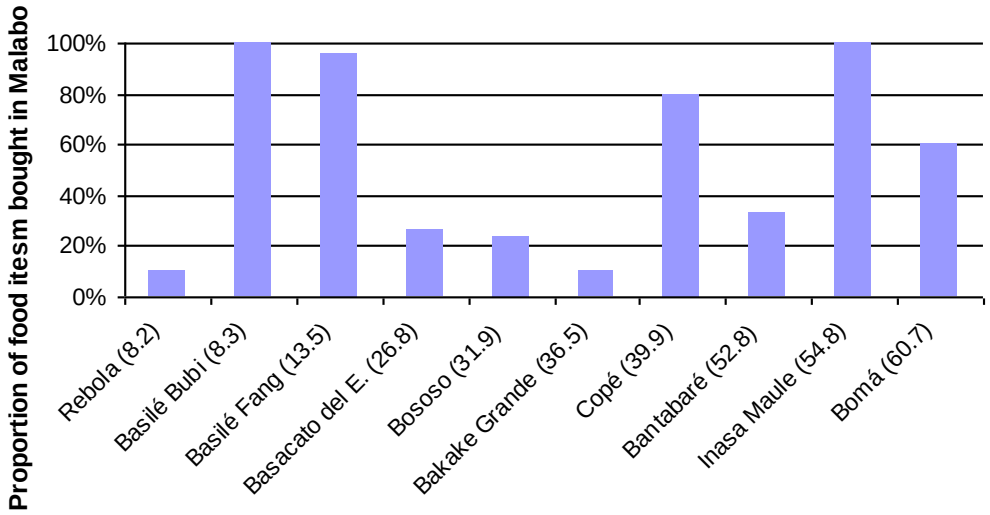


Figure 4.1-5 Proportion of main frozen products (chicken and mackerel) consumed in households purchased in Malabo (and not in shops in the village or in neighbouring villages). N= 442 food items with origin recorded in the 155 consumption diaries across the 10 sample villages. The X-axis shows each village and its distance to Malabo (in km). Both the closest and the most distant villages (except Rebola and Bantabaré, discussed in the text) purchased most of their food items in Malabo. The former was due to their proximity, and the latter was because of the unavailability of nearby distribution points: Bantabaré and Inasa Maule had only one local supplier, while Bomá and Copé had none. Thus, in these two villages, the proportion of frozen products not purchased in Malabo was purchased in neighbouring villages; in the other villages, it was mostly purchased in the same village.

4.1.6.1.2 Fresh fish

In those households where fresh fish (and seafood) were consumed, 94.91 kg was recorded. Over half (54%) of the fish and seafood were caught by the households, and 41% were purchased (41%). The origin of the remaining 5% was not recorded. Specifically, 33% of the purchases occurred in villages where fishing was practised

(Bakake Grande, Bososo and Basacato) by families who did not fish themselves, 2% in villages without fishing (Rebola and Bomá) and the remaining 6% in Malabo (by residents of Basilé Fang, Basilé Bubi, Bososo and Bantabaré). Household members collected all seafood (crabs) on the beach; only fish was purchased.

The sample size of fresh fish prices was small and highly variable due to the difficulty of weighing many quantities and the price differences between species. For 29 purchases where price and weight were possible to record, I obtained a mean of 1,734±130 XAF/kg [median 1,818 (range 500 – 4,000)). No significant differences were found between the mean prices in villages where fishing was practised [1,643±207 XAF/Kg (median 2,000), n=18] and those where it was not [1,884±62) XAF/kg (median 1,818), n= 11; Z = - 0.555, p = 0.592].

The mean price per kilogram of fresh fish was significantly higher than that of frozen products (see above). Specifically, the price difference was 17.0% (Z = -5.082, p < 0.0001, n = 103). Even in villages where fishing was practiced, fresh fish remained 10% more expensive than frozen meat/fish (which had a mean of 1,501±3.9 XAF/kg (median = 1,500), n= 54; Z=-2.237, p=0.031)

An analysis was conducted to compare the average prices of domestic meat and fresh fish to gain insight into the rural consumption patterns discussed in Section 4.1.6.2.2 (see the summary at the end of the section), an analysis was conducted to compare the average prices of domestic meat and fresh fish. As expected, the differences were statistically significant, with fresh fish being 16.5% more expensive than domestic meat (1,488 ±13 XAF, n= 103; Z= -5.082, p<0.0001).

4.1.6.1.3 Wild meat

The rural households in the sampled villages consumed a limited variety of wild animals (vertebrates), with the following totals recorded:

- 68 rats (across all 10 villages)
- 25 blue duikers (in 9 villages)
- 8 porcupines (in 3 villages)
- 7 squirrels (in 4 villages)
- 1 pangolin (in 1 village)
- 1 viper (in 1 village)

Most of these animals (77%) were hunted by the households, while 19% were purchased. The remaining 2% were received as gifts, and 4% had unspecified origins.

Among the purchased animals, the breakdown is as follows:

- 13 rats (in 6 villages)
- 6 blue duikers (in 5 villages)
- 2 porcupines (in 1 village)

The price of rats was consistent across the six villages where they were bought, ranging from 2,500 to 3,000 XAF. However, the price of blue duikers varied: it was 6,000-7,000

XAF in Basilé Bubi, Inasa Maule, and Bomá (n=4), and 10,000 XAF in Basacato and Basilé Fang (n=2). This price difference is likely due to the source of the purchase (as explained in more detail below); in the former case, the animals were bought directly from hunters, while in the latter, they were bought from traders.

The low proportion of purchased wild animals across all villages suggests that price has little influence on their consumption. It also implies that all villages have easy access to harvestable faunal populations, at least for the most consumed small and medium-sized species. This is consistent with that all the villages in northern Bioko (including those in my sample) are distributed along the road around PBNP, at low altitudes, immersed in secondary lowland rainforest where these species are abundant. Only Basilé Fang has greater access to harvestable faunal populations, as it is located at the base of the only road into the PBNP, which allows access to the montane and mossy forests, hosting larger populations and species (e.g., primates and red duikers). However, as demonstrated in Section 4.1.6, this has not led to an increase in wild meat consumption in Basilé Fang, as most of the wild meat hunted (especially the most valuable species) was intended for sale rather than for consumption.

In Basilé Fang, an offtake study recorded the prices of 3,426 animals sold in village and city markets between August 2010 and November 2011. This study revealed three types of wild meat prices: the price offered by the hunter to his trading partner (Price 1), the price offered by the hunter or trading partner to the final consumer in the village (Price 2), and the price offered by the trader to the final consumer in the city market (Price 3) (Table 4.1-5)

The wild meat purchased by rural households in my sample could have been bought directly from a hunter or from a trader in the village (Price 2). The prices recorded in Basilé Fang indicated that, in all cases, the price per kilogram of wild meat was higher than that of frozen domestic meat and fish (1,486 ± 10 XAF) and fresh fish (1,734 ± 130 XAF). These differences were statistically significant, with the mean price per kilogram of the most consumed wild meats (rat, antelope, porcupine, and squirrel) being significantly higher (3,575 ± 32 XAF) than that of frozen domestic meat ($Z=-19.841$, $p < 0.0001$) and fresh fish ($Z=-5.413$, $p < 0.0001$).

Additionally, the price of harvested wild meat (snails) was the highest of all (5,047 XAF/kg (median 2,644 XAF/kg, n=12 recorded purchases), but like hunted wild meat, it was collected mainly by households (90% of the 61.42 kg consumed in the 10 villages with declared origin) rather than purchased.

These results suggest that small—and medium-sized wild meat was accessible to the population through hunting but was less accessible through purchase compared to its alternatives. The same was true for snails. Larger wild meat was generally not accessible to the rural population in either way.

Table 4.1-5 Average wild meat price per kg (in XAF) for the various species and the three types of transactions carried out by BF villagers. Prices in each group are ordered from most expensive to least expensive for Price 2.

	Price 1 hunter -> trader[a]		Price 2 hunter or trader -> village consumer[b]		Price 3 trader -> Malabo consumer[c]	
Group (species)	Mean (SE)	n	Mean (SE)	n	Mean (SE)	n
Mammals						
Pangolin (*Phataginus tricuspis*)	---	---	13,056 (834)	2	---	---
Brush-tail porcupine (*Atherurus africanus*)	5,156 (186)	33	7,623 (151)	41	8,167 (159)	33
Giant pouched rat (*Cricetomys emini*)	2,259 (64)	100	4,194 (131)	66	4,799 (74)	104
Blue duiker (*Philantomba monticola*)	2,006 (6)	1218	3,342 (10)	792	3,452 (5)	2085
Squirrel (*Protoxerus stangeri; Anomalurus spp*.)	2,021 (148)	23	3,329 (84)	90	3,751 (126)	33
Cercopithecines (*C.erythrotis; Allochrocebus preussi*)	1,385 (94)	17	3,178 (374)	3	2,862 (87)	39
Tree hyrax (*Dendrohyrax dorsalis*)	2,299 (118)	7	3,065	2	3,558 (200)	7
Ogilby's duiker (*Cephalophus ogilbyi*)	1,432 (35)	48	2,166 (96)	1	2,262 (59)	58
Black colobus (*Colobus satanas*)	1,467	1	2,709 (96)	10	2,184 (261)	3
Birds and reptiles						
Snakes (*Bitis spp.; Naja spp*.)	---	---	5,000 (931)	6	---	---
Blue plantain eater (*Corythaeola cristata*)	---	---	4,297 (393)	14	4,696 (378)	14
Python (*Python sebae*)	784 (61)	4	2,892	1	2,169	1

[a] Price offered by the hunter to his trading partner,
[b] Price offered by the hunter or trading partner to the final consumer in the village
[c] Price offered by the trader to the final consumer in the city market.

4.1.6.2 Distance to supply points and correlation between the various types of meat/fish

4.1.6.2.1 Consumption as a percentage of households

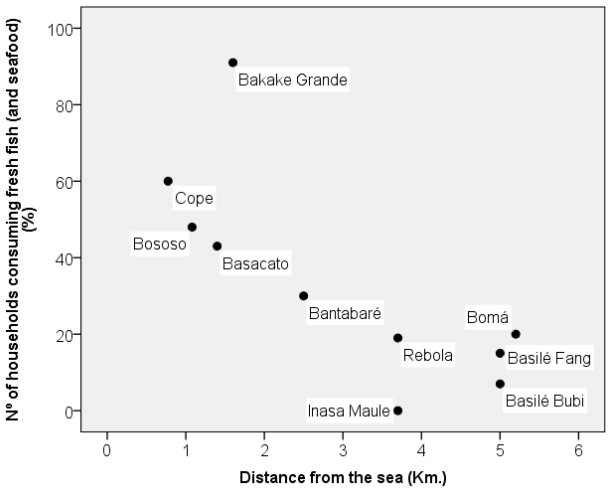
Of the 105 households in the 10 villages that completed the one-week consumption diary, only one consumed some animal product. Domestic meat (chicken, poultry, pork and beef) and fish (including seafood; hereafter fish only) were the most widely consumed, reported in 86% and 95% of the sampled households, respectively. In contrast, only 48% of households reported eating hunted wild meat (vertebrates), and 45% harvested wild meat (snails). All these food types were consumed in all villages

(see full list of products and number of villages and households in which they are consumed in Table 4.1-3).

The proportion of households reported eating domestic meat or fish was high in all villages (from 86 to 100% and 60 to 100%, respectively). A greater contrast was observed when hunting wild meat and snails. The village with the lowest percentage of households consuming hunted wild meat was Basilé Bubi (29%), the closest to the capital, while the highest was Bomá (100%), the furthest away. However, no significant correlation was found between these proportions and distance to Malabo. This is due to the peculiarities of Bantabaré, since a significant and positive correlation was observed when it was excluded from the analysis (r= 0.770, p= 0.015, n=9; Figure 4.1-6-A). Bantabaré exhibited characteristics that differed from what might be expected given its geographical location due to its high employment rates (see Table 4.1-1). This undoubtedly provided households with greater purchasing power and access to domestic meat, like villages closer to Malabo (see Section 4.1.5.1.1). The proportion of households consuming snails ranged from 0.2% to 58%. In this case, there was a significant and positive correlation with distance to Malabo (r= 0.665, n= 10, p=0.018; see Figure 4.1-6-B). In other words, the further away a village is from Malabo, the higher the proportion of households consuming wild meat (unless the village has high purchasing power).

While domestic meat was in almost all cases imported frozen meat (only four families in four villages reported having consumed fresh zebu meat, and one family ate a chicken raised by them), among the families that consumed fish, 36% ate fresh fish (sea fish in all cases and some seafood, see Table 4.1-3). In this case, there was a significant negative correlation (two-tailed Pearson's correlation) between the percent of households consuming fresh fish and the distance from the village to the sea (r= -0.772, p=0.004, n=10) (see Figure 4.1-6-C). In other words, villages situated closer to the coast have a higher percentage of households consuming fresh fish.

A



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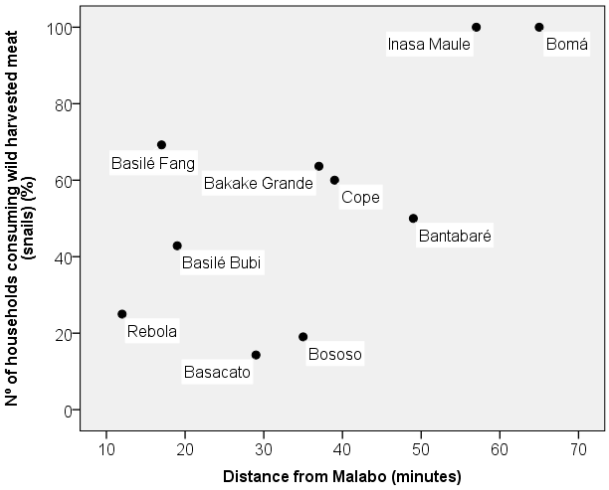


C

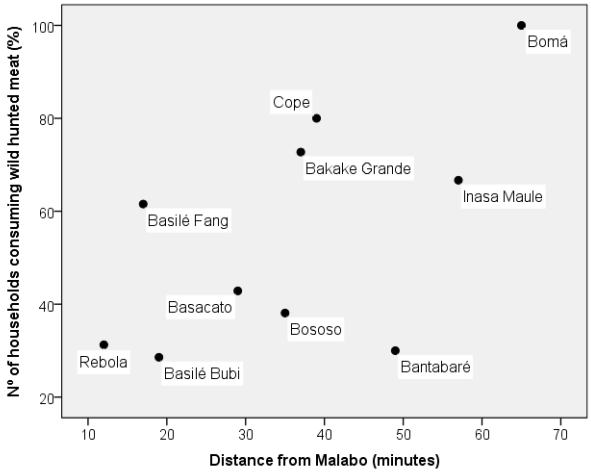


Figure 4.1-6 Types of meat and fish whose consumption (as a percentage of households) is significantly influenced by the distance to Malabo (the main supply point for domestic meat and frozen fish in the villages) or the sea (the main supply point for fresh fish). In Figure A (wild hunted meat), significance is obtained by excluding Bantabaré from the analysis. Bantabaré exhibited different characteristics than expected given its geographic location due to high employment rates that surely endowed households with greater purchasing power resulting in greater access to frozen meat and fish as reflected in consumption surveys. No other significant correlations were observed (including or not Bantabaré).

4.1.6.2.2 Consumption as quantity and protein intake

The average daily consumption of meat and fish (including wild sources) among the inhabitants of all studied villages was 277.95±17.22 g·RA^{-1}·day $^{-1}$ [median 253.41 (144.40–339.04)]. This translates to an average protein intake of 49.82±3.17 g·RA^{-1} ·day^{-1}, [median 45.16 (26.59 – 61.81)].

Domestic meat and fish were the most significant contributors to this protein intake, accounting for 37% and 36%, respectively. Most of the protein from these sources came from frozen products, with 85% for domestic meat and 63% for fish. Wild hunted meat contributed 16%, and when combined with snails, the total contribution from wild terrestrial sources was 27% (see Figure 4.1-7).

At the species level, chicken was the most widely consumed domestic meat, contributing 21% to total animal protein intake (19% excluding eggs). Other significant contributors among domestic meats were turkey, pork, and zebu. All except Zebu were imported and frozen, with imported eggs being fresh. Mackerel (frozen and imported) was the most consumed for fish, contributing almost as much to animal protein intake as the combined total of other frozen and fresh fish species (18%). Among wild meats, land snails, specifically the giant West African snail or banana rasp snail (*Archachatina marginata*) and the lilac-mouth Achatina (*Achatina iosotoma*), were the most widely consumed and contributed the most to protein intake, followed by rat and blue duiker (see Table 4.1-6).

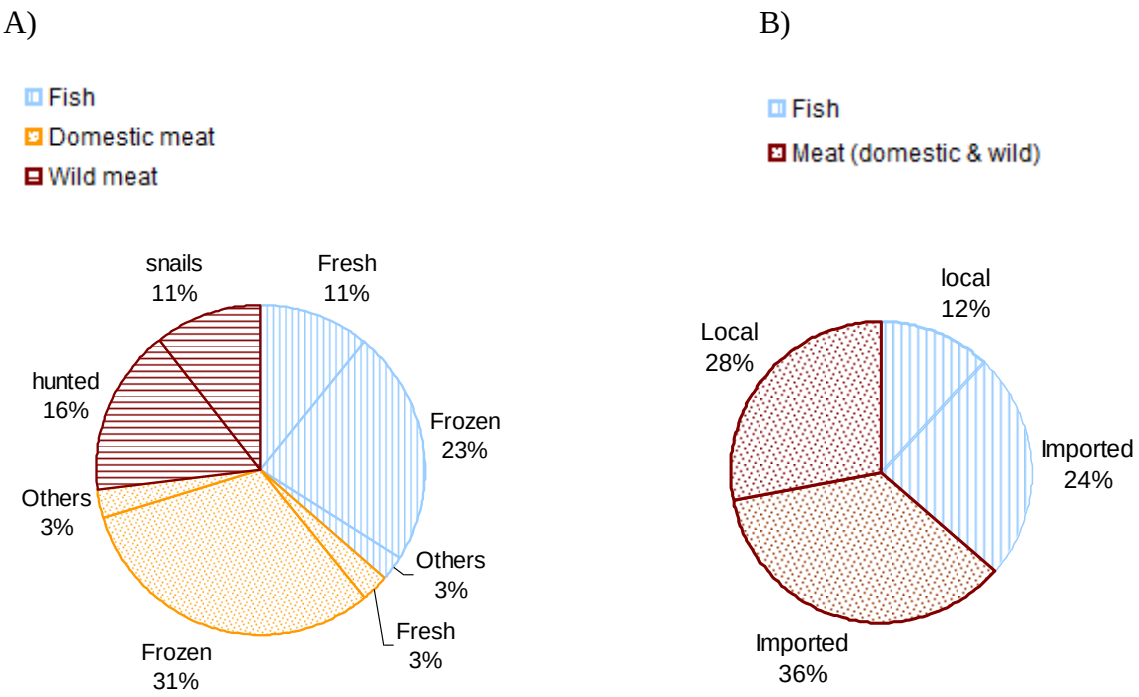


Figure 4.1-7 Contribution of the different sources of animal protein (except milk and milk products) to total meat/fish protein consumed: (A) categorized by state and (B) by their origin: local or imported. The term "others" refers to canned, salted or smoked. Total animal protein intake was on average 49.8±3 g·RA^{-1}·day $^{-1}$ (median = 45 g; n= 105 households in 10 villages). Food items within each category, and their contribution, are shown in Table 4.1-6. Local animal products included all wild meat and all fresh fish, and a small proportion of frozen, salted or smoked fish and fresh domestic meat (See Table 4.1-3); thus, the local animal food consumed was primarily fresh, and the imported one was mostly frozen.

Table 4.1-6 Contribution of various types of meat and fish to the average daily animal protein intake per RA. Those most widely consumed (number of villages and households) and contributing most are shown in bold.

Category	Species	Animal protein intake ($g \cdot RA^{-1} \cdot day^{-1}$)		Number of households (n=105)	Number of villages (n=10)
Domestic meat[a]					
	Chicken	**10.4**	**(21%)**	**83**	**10**
	Turkey	3.0	(6%)	23	9
	Pork	2.8	(6%)	49	7
	Beef (Zebu)	1.2	(2%)	14	7
	Mortadella	1.0	(2%)	37	9
	Subtotal	*18.3*	*(37%)*	*90*	*10*
Fish					
Frozen	**Mackerel**	**8.9**	**(18%)**	**77**	**10**
	10 spp.	2.5	(5%)	25	10
Fresh	12 sp. (3 invertebrates)	5.4	(11%)	47	9
Other[b]	5 spp.	1.3	(3%)	61	10
	Subtotal	*18.1*	*(36%)*	*100*	*10*
Wild meat					
Harvested	**Snails**	**5.3**	**(11%)**	**47**	**10**
Hunted	**Pouched rat**	**4.2**	**(8%)**	**35**	**10**
	Blue duiker	**2.4**	**(5%)**	**21**	**9**
	4 other spp.[c]	1.6	(3%)	11	7
	Subtotal (hunted)	8.2	(16%)		
	Subtotal (hunted+snails)	*13.4*	*(27%)*	*68*	*10*
Total meat/fish		**49.8**	**(100%)**	**104**	**10**

[a]Domestic meat was mostly frozen and imported except for zebu beef, about half of which was fresh (this being probably local). Mortadella was canned meat, which could be pork or beef.
[b]Refers to canned, smoked or salted.
[c]Includes the squirrel (0.73 $g \cdot RA^{-1} \cdot day^{-1}$), the porcupine (0.70 $g \cdot RA^{-1} \cdot day^{-1}$), the viper (0.10 $g \cdot RA^{-1} \cdot day^{-1}$). and the pangolin (0.05 $g \cdot RA^{-1} \cdot day^{-1}$).

➢ *Distance to supply points*

The average amount of total meat and fish protein consumed, as well as some specific types and their proportions, varied between villages (Table 4.1-7). As in the previous section, I examined these differences and their possible relationship with distance from Malabo or the sea. These results are summarised in Table 4.1-7 and illustrated in Figure 4.1-8.

- **Wild meat consumption**: Differences in the average amount of hunted wild meat consumed at the village level were significant (X^2=26.77, *df*=9, *p*=0.002), primarily due to the higher values in Bomá and Copé (40.02±11.0 and 25.45 ±11.04 $g \cdot RA^{-1} \cdot day^{-1}$, respectively; values in the rest of the villages ranged from 2.4±0.84 to 10.4±3.41 $g \cdot RA^{-1} \cdot day^{-1}$). On omitting these two villages, there was no significant difference (X^2=10.02, *df*=7, *p*=0.187). Bomá and Copé, along with Basilé Fang, are the villages with the highest proportion of commercial hunters (see Table 4.1-1). However, Bomá and Copé are located farther from Malabo (see Figure 1.3-1), have lower population densities (Table 3.2-1), and their households have a distinctly different family structure, primarily consisting of men or recently established Fang couples who, in addition to hunting, focus

exclusively on cultivating their fields. In contrast, Basilé Fang is a somewhat larger, more established village with entire families engaged in a broader range of livelihood activities, including commercial hunting (see Table 4.1-1). Despite this, the contribution of wild hunted meat to the total meat and fish protein consumed was similar across all villages (X^2=15.27, *df*=9, *p*=0.084), since total consumption of meat and fish protein in Bomá and Copé (see Table 4.1-8) was also significantly higher (X^2=41.13, *df*=9, *p*<0.0001).

The average amount of protein consumed from harvested wild meat (snails) was positively correlated with distance from Malabo (*r*=0.724, n=10, *p*=0.018). Consequently, total wild meat consumption also showed a positive correlation, though to a lesser extent (*r*=0.668, n=10, *p*=0.035), as hunted wild meat was not correlated, as mentioned above. The contribution of snails to the total protein intake was positively correlated with the distance from Malabo, approaching statistical significance (*r*=0.612, n=10, *p*=0.06). The contribution of all wild meat (both hunted and harvested), however, showed a significant positive correlation with distance (*r*=0.663, n=10, *p*=0.037).

Based on these analyses and considering the socio-economic characteristics of the villages, I can conclude that wild meat protein intake and its contribution to total animal protein intake increased significantly in the villages farthest from Malabo, with no employment or fishing opportunities (Copé) and poor road access (Inasa Maule and Bomá). If the village was mainly engaged in commercial hunting (Copé and Bomá), consumption of both snails and hunted vertebrates, as well as animal protein in general, increased; if the village was mainly engaged in agriculture and had low economic resources (Inasa Maule), only snail protein consumption increased.

- **Other meat and fish types:** The average fish protein consumption did not vary between villages, but consumption of fresh and frozen types differed. While the amount of fresh fish protein consumed was negatively correlated to distance to the sea (*r*= -0.746, n=10, *p*=0.013), that of frozen fish was positively correlated (*r*=0.732, n=10, *p*=0.016). No other significant correlation was observed between the amount of protein consumed from the other types of meat or fish and the distance to Malabo or the sea. The contribution (%) of fresh fish was significantly and negatively correlated with distance to the sea (*r*=-0.729, n=10, *p*= 0.017), while the contribution of frozen fish was with the distance to Malabo (*r*=-0.796, n=10, *p*=0.009). These proportions are also shown in Figure 4.1-8.

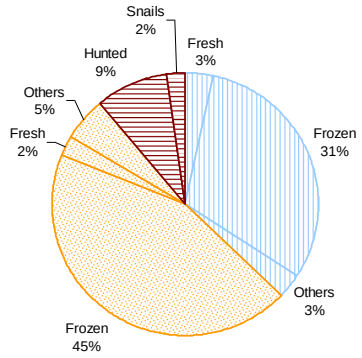
  Based on these analyses and considering the socio-economic characteristics of the villages, the consumption of fresh fish protein and its contribution to total animal protein intake were higher in the coastal Bubi villages where fishing practices are well established (i.e. Basakato, Bososo, and Bakake Grande; although Copé is also near the sea, it was inhabited by Fang groups who focused on commercial hunting rather than fishing). In contrast, frozen fish consumption increased with distance from the coast but decreased further from Malabo, reflecting the challenges faced by Equatorial Guinea's fishing sector, particularly in terms of infrastructure for resource preservation and transport.

Table 4.1-7 Kruskal-Wallis test results on village differences in protein intake (g·Reference Adult^{-1}·day^{-1}) from various meat and fish types and their contribution (%) to total meat/fish protein consumed, and Pearson's correlation with distance to Malabo and distance to the sea. Data from 105 one-week food diaries in 10 villages.

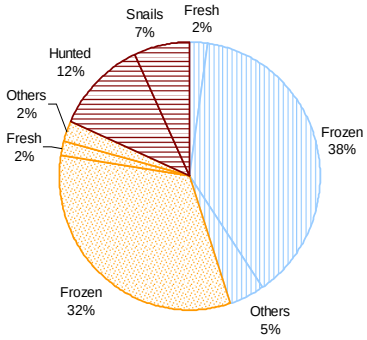
		Protein intake (g·RA^{-1}·day^{-1})			**Protein intake (% to total)**		
		Differences between villages (K-W test)	**Distance to Malabo (Pearson's correlation)**	**Distance to the sea (Pearson's correlation)**	**Differences between villages (K-W test)**	**Distance to Malabo (Pearson's correlation)**	**Distance to the sea (Pearson's correlation)**
Fish	**Fresh**	***		-	***		-
	Frozen	*		+	*	--	
	Other						
	Total				***		
Domestic Meat	**Fresh**				**		
	Frozen	***					
	Other						
	Total	***			***		
Wild Meat	**Hunted**	**					
	Snails	***	+		***		
	Total	***	+		***	+	
Total (meat/fish)		***					

Note: Significance levels and correlation directions are indicated by symbols: 1 symbol = $p<0.05$; 2 symbols = $p<0.001$; 3 symbols = $p<0.0001$. A blank cell indicates no significant relationship. See detailed results in the text.

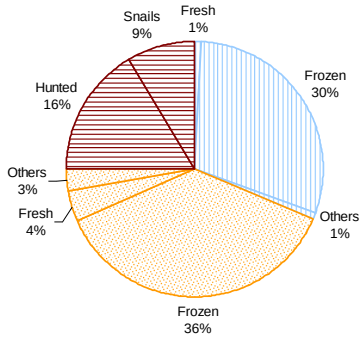
Rebola (N=16)

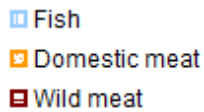


Basilé Bubi (N=14)

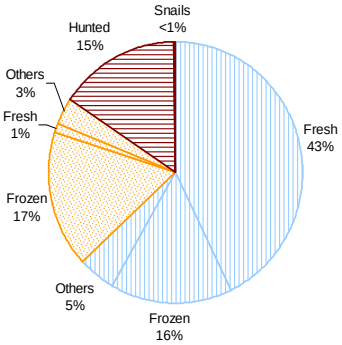


Basilé Fang (N=13)

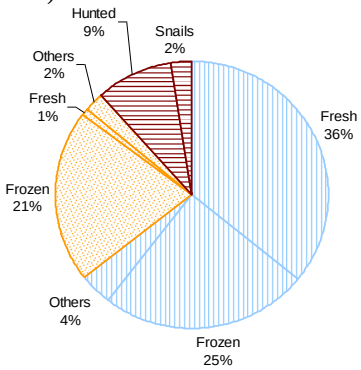




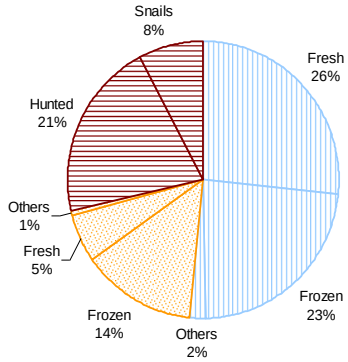
Basacato (N=7)



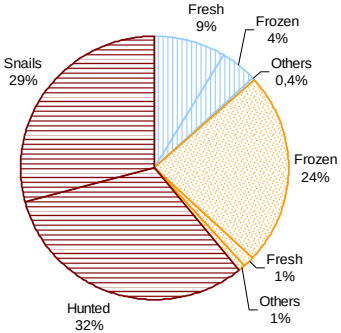
Bososo (N=21)



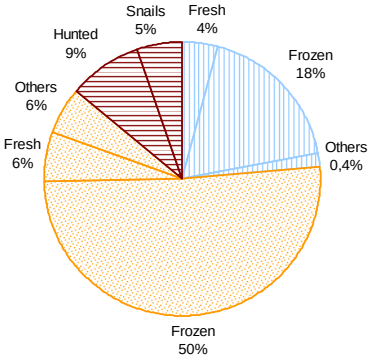
Bakake Grande (N=11)



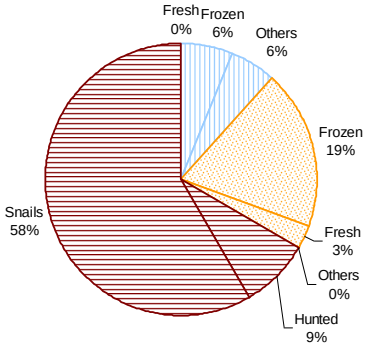
Cope (N=5)



Bantabaré (N=10)



Inasa Maule (N=3)



Bomá (N=5)

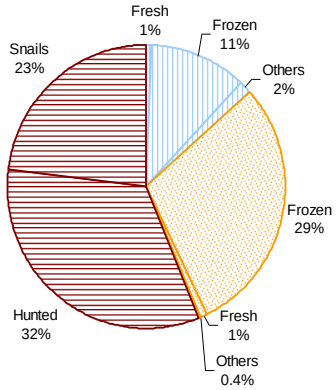


Figure 4.1-8 Contribution of the various animal protein sources (except milk and dairy products) to total meat/fish protein consumed in the ten sample villages (see Table 4.1-8), ordered by proximity to Malabo (see Figure 1.3-1 and Table 3.2-1). Characteristics of the villages in the first row: close distance to the capital (8-14 km.), good road access, far distance to the sea (3.7 – 5 km); second row: medium distance to Malabo (27-40 km,), good road access, close distance to the sea (0.8-1,6 km); third row (Bantabaré): far distance to Malabo (53 km,), good road access, medium distance to the sea (2.5 km,) and special characteristics commented in the text; third row (Inasa Maule, Bomá): far distance to Malabo (54-66 km,), poor road access, far distance to the sea (3.7 - 5.2 km,); Inasa Maule could be classified as the poorest settlement of all, due to its poor living conditions (pers. observation), with families with very few resources living in an old abandoned cocoa shack and far from the road.

Table 4.1-8 Average values (mean±standard error) of total meat/fish protein intake across the sampled villages. The median is shown in parenthesis for non-normal distributed data.

Villages	Protein intake ($g \cdot RA^{-1} \cdot day^{-1}$)	Number of households (n=105)
Rebola	37.02 ± 4.28	16
Basilé Bubi	49.41 ± 7.10	14
Basilé Fang	64.31 ± 11.64 (50.69)	13
Basacato	46.84 ±11.72	7
Bososo	26.20 ± 3.66 (22.82)	21
Bakake Grande	43.76 ± 4.06	11
Copé	80.17 ± 9.90	5
Bantabaré	60.81 ± 8.85	10
Inasa Maule	45.02 ± 9.60	3
Bomá	121.50 ± 12.74	5
All	49.82 ± 3.17 (45.17)	105

- *Correlation between the various types of meat/fish*

To complement the above analyses, I examined the influence of consuming some types of meat and fish over others.

While disparities in wild meat and fish (fresh and frozen) consumption between villages were influenced by distance to Malabo and the sea, as previously demonstrated, discrepancies in domestic meat consumption were not. Figure 4.1-8 suggests that these differences may be related to fish consumption, at least for the subset of villages where both were more available (excluding Copé, Inasa Maule, and Bomá). To test this hypothesis and to explore any other correlations between different types of meat and fish protein consumption, I analysed the correlations between the amounts (and proportions) of protein from various food types for both the full sample and a subset of villages. The significant correlations found were as follows:

- **For the subset of villages,** I found four strong negative correlations: 1) between the proportion of domestic meat protein and fish protein (r= -0.911, p=0.004, n=7), 2) between the proportion of domestic meat protein and fresh fish protein (r= -0.812, p=0.03, n=7), 3) between the proportion of frozen domestic meat protein and fresh protein (r= -0.829, p=0.02, n=7), and 4) between the proportion frozen domestic meat protein and fish protein (r= -0.886, p=0.008, n=7).

  In other words, in villages where both domestic meat and fish are readily available, an increase in fish protein consumption (both total and fresh) is associated with a decrease in domestic meat protein consumption (both total and frozen). This suggests a preference for fish, especially fresh fish, over domestic meat (mostly frozen). Additionally, fresh fish, primarily purchased (41%; see Section 4.1.6.1.2), is 16.5% more expensive than domestic meat, further supporting this preference.

- **For the full sample of villages**, a strong negative correlation was observed between the proportion of fish and wild meat protein (r= -0.764, p= 0.01, n= 10). This suggests that fish is also a substitute for wild meat, where the former is accessible.

Based on the analyses presented, including those in Section 4.1.6.2.1, it can be inferred that when rural households in Bioko have the option, they prioritize the consumption of fresh fish, followed by frozen products (fish and domestic meat), and lastly, wild meat.

4.1.6.3 Income and wealth

In the subset of households with quantitative socioeconomic and consumption data (n = 22 households in BB, BF, and BC), the intake of wild meat protein (hunted, harvested, or total) and other alternative protein sources [domestic meat (frozen, fresh others and total) and fish (frozen, fresh others and total)], and their contribution to total animal protein intake, was not influenced by any socioeconomic variables (income, expenditure, and assets), p>0.1 in all cases. However, there was a weak trend towards higher consumption of domestic meat (r=0.398, p=0.091) and total animal protein (r=0.393, p=0.096) in higher-income households.

4.1.7 Contrasts in livelihoods and protein intake between commercial and subsistence hunters

The following results show the nutritional and economic importance of wild meat in two comparable villages (thus controlling for possible confounding factors). Still, the one engaged in commercial hunting and with more access to wildlife (Basilé Fang), and the other practising subsistence hunting only (Basilé Bubi) (see more details in Section 3.2.1 and 3.2.2.2). Thus, they answer whether commercial hunting households were nutritionally favoured over subsistence hunting households because of their higher income from the wild meat trade and greater access to wild animal protein.

These results were published in Grande-Vega *et al.* (2013) with some differences. In this thesis, I refine the edible portion and protein content of foods, using a larger bibliographic database and my own data, calculated in the villages, on the edible portion of certain foods (as explained in Section 3.2.3.4). Additionally, I excluded the income, wealth, and expenditure data of a Basilé Fang hunter, as I found them to be unreliable after triangulating the socioeconomic interviews with the offtake survey. I have also refined the average hunting income estimated from the offtake survey by differentiating between regular and non-regular hunters and excluded income data from seven individuals who were not actually hunters but had sporadically killed a few animals during the study period. Furthermore, I have included the income that the experienced shotgun hunters would have obtained from primate hunting, by extrapolating the information from the monitoring and interviews, as detailed in Section 3.2.3.6. These changes do not affect the final conclusions of the results published in Grande-Vega *et al.* (2013), although they improve the data and its statistical significance. I therefore recommend referring to the data in the thesis.

4.1.7.1 Household income and wealth

4.1.7.1.1 Household income and expenditure

The average annual income per household in Basilé Fang (BF) was more than double that of Basilé Bubi (BB) ($p= 0.42$) and the average annual household expenditure (as an alternative measure of income) was four times higher in BF than in BB ($p= 0.016$) (Table 4.1-9). The income-generating activities recorded for both villages (described in detail in Section 4.1.3) were:

- Sale of home-grown agricultural produce
- Cocoa
- Sale of wild meat
- Shop/bar trade
- Paid work
- Casual work
- Timber extraction
- House renting
- Help received (from family or friends)

In BF, the income-generating activity in which most families were involved (based on livelihoods interviews; based on income interviews)[10] was the sale of wild meat (90%; 82%), followed by shop/bar trade (29%; 45%), sale of home-grown agricultural products (26%; 36%), paid work (26%; 27%), house renting (NA; 18%) and timber extraction (7%; 9%). It should be noted that occasional work, cocoa, and help received were not registered in BF. In BB, the sale of home-grown agricultural produce was the income-generating activity in which most households were involved (57%; 100%), followed by paid work (35%; 50%), shop/bar trade (14%; 25%), the occasional sale of wild meat (11%; 25%), cocoa (7%; 13%), occasional work (NA; 13%), house renting (NA; 13%) and help received (NA; 13%). Timber extraction was not registered in BB.

At the village level, the livelihood activities that contributed most to total annual income in BF (42,283,791 XAF, n=11 households) were also the sale of wild meat (33%) and the shop/bar trade (29.2%), followed by the sale of home-grown agricultural produce (12.6%). In BB, with a total income of 14,006,534 XAF, paid work (40.6%) and sale of agricultural products (32.4%) were the main contributors, followed by shop/bar trade (17.7%); by contrast, hunting and sale of wild meat only contributed 1.2% since it was conducted solely using traps placed around crops and intended mainly for consumption.

At the household level, in BB, paid work was also the activity that, on average, provided the most income per year to the families that practised it (1,422,800 XAF or $2,796), followed by the shop/bar trade (1,242,500 XAF or $2,442) and the sale of agricultural products (567,260 XAF or $1,115). In BF, however, it was not the sale of wild meat that provided the highest income to a household (1,745,913 XAF or $3,431), but the shop/bar trade (2,466,980 XAF or $4,848), timber extraction (2,100,000 XAF or $4,127) and household renting (2,100,000 XAF or 4,127 $) ranked above. Paid work and the sale of agricultural products, however, ranked below (1,373,376 XAF or $2,699 and 1,330,366 XAF or $2,614, respectively) (Figure 4.1-9). The same activities performed by a family in BF and BB provided more annual income on average to the former, except if it was paid work, which provided similar income (Figure 4.1-10).

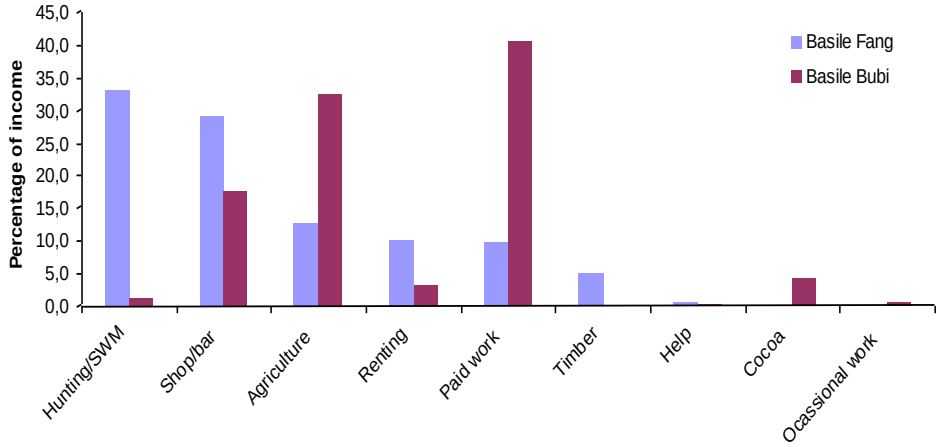


Figure 4.1-9 Contribution of the various income-generating activities to the total annual income in BF (42,283,791 XAF; n=11 households) and in BB (14,006,534 XAF; n=8 households) (US$1= 508.82 XAF).

[10] The livelihood interviews (Section 3.2.2.3) were conducted in 27 out of 32 households in BB and in 31 out of 31 households in BF. In contrast, the income interviews (Section 3.2.2.5) were only conducted in 8 households in BB and 11 in BF (Table 3.2-1). However, in light of the results, the smaller sample can be deemed representative of the larger one.

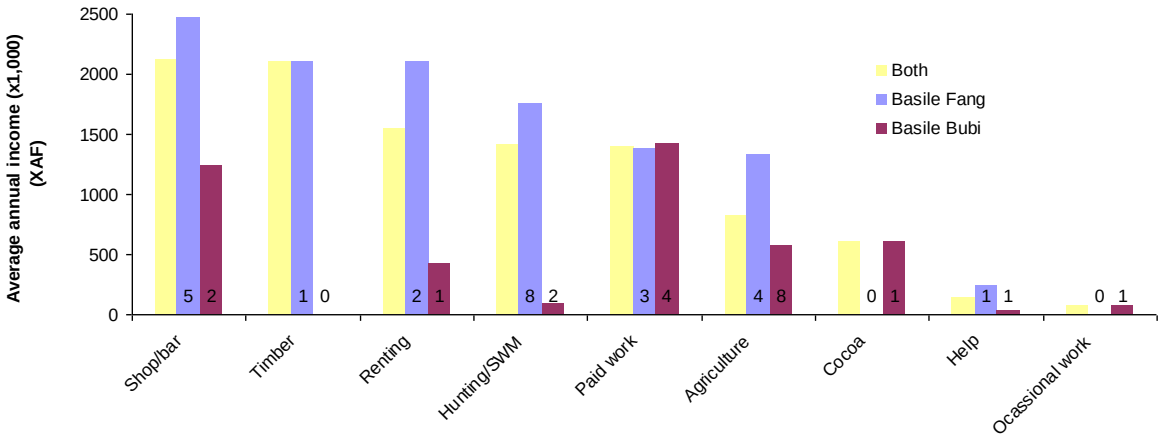


Figure 4.1-10 Average annual household income from the various livelihoods in BF, BB and both villages combined (US$1 = 508.82 XAF). The number of households engaged in each activity (from a total sample of 11 households in BF and 8 in BB) is indicated at the base of the bars.

4.1.7.1.2 Household wealth

Results from the assets-based calculations to assess household wealth indicated significant disparities between the two villages. The average value of all items and properties per household was 3.5 times higher in BF than in BB (p=0.049) (Table 4.1-9).

Although the quality and value of the primary dwelling were similar in both villages (self-built houses with wooden planks, tin roofs, with or without a cement layer on the floor, and without any other internal or external covering material, valued at around 350,000 XAF or $689), households in BF possessed more and higher-value items. Specifically, the average value of items in BF was $697.7 (212.5 – 2,078.3) compared to $34.39 (15.7 – 406.5) in BB (U=14.5, p=0.013).

Additionally, 5 of the 12 households interviewed in BF owned at least one second concrete house in the city, each valued at approximately 1,700,000 XAF ($3,341). In contrast, only one of the 8 households interviewed in BB had a second property, which was made of wood.

Table 4.1-9 Univariate test results and average values of household income, expenses, wealth and protein consumption in BB and BF. Average values are expressed as Mean (SE) for normally distributed data or Median (IQR) for non-normal data.

Variables	Basilé Bubi	Basilé Fang	Test (p)
Economic variables ($)			
Income	3,440 (1,043)	7,555 (1,546)	$t_{16.3}$= -2.206 (0.042)
Expenditure	226 (87 - 2,012)	2,666 (1,417 - 4,625)	*Z*= -2.643 (0.007)
Wealth (assets)	757 (704 - 1,748)	2,683 (900 - 7,400)	*Z*= -1.983 (0.049)
Protein consumption ($g.RA^{-1}.day^{-1}$)			
Total	79,6 (63,1 - 114,6)	80,9 (71,6 - 113,1)	*Z* = -0.776 (0.458)
Vegetable	36.6 (2.7)	35.2 (4.1)	t_{25}= 0.302 (0.765)
Animal	48.2 (32.5 – 76.8)	57.8 (48.6 - 76.3)	*Z*= -1.165 (0.259)
Total wild meat	1.4 (0.0 - 12.3)	14.5 (6.6 - 15.9)	*Z*= -1.868 (0.063)
Wild hunted meat	0.0 (0.0 - 3.4)	9.2 (0.0 - 14.3)	*Z*= -1.546 (0.130)
Wild harvested meat	0.0 (0.0 - 1.9)	4.8 (0.0 - 6.6)	*Z*= -1.981 (0.048)
Total wild meat (%)	2.1 (0.0 - 19.3)	16.0 (9.0 - 21.4)	*Z* =-1.426 (0.160)
Wild hunted meat (%)	0.0 (0.0 - 7.5)	11.5 (0.0 - 14.5)	*Z*= -1.279 (0.214)
Wild harvested meat (%)	0.0 (0.0 - 2.91)	6.4 (0.0 - 9.6)	*Z*= -1.879 (0.062)

4.1.7.2 Hunting income and contribution by gender

Income from hunting and wild meat trade in BB and BF could also be estimated from another data source other than the household socioeconomic interviews, that was the wild meat offtake survey (as explained in Section 3.2.2.6).

4.1.7.2.1 Hunter income

A total of 34 hunters were recorded in BF during the first six months of the wild meat offtake Survey. Nineteen of them were regular hunters, i.e., they were exclusively engaged in hunting throughout the study period. Six were relatives of regular hunters from outside the village who spent a few months in the village hunting with the regular hunter in his same or adjacent hunting area. Nine were opportunistic or sporadic hunters, i.e. those who had recently moved into the village to try their luck, generally for a short period of time because they usually changed their activity or residence afterwards. Three regular hunters (one shotgun hunter and two trappers) were not very cooperative in reporting or showing their catches. After triangulating their data with the information from the interviews and the hunter-follows, I confirmed that their data were underreported, and they were subsequently discarded.

Income derived from the wild meat offtake survey for the final sample of 31 BF hunters revealed that hunters earned on average 1,306,991±301,544 XAF (i.e. $2,569) per year, or median (IQR) = 571,603 XAF (255,672 – 1,686,569) (i.e. $1,123), since. As shown in Figure 4.1-11, income distribution from hunting per hunter was right sewed. At one extreme, 8 more successful hunters than the rest earned above 1,686,569 XAF or $3,315 ($75^{th}$ percentile), and of these, 2 above 3,376,735 XAF or $6,636 ($90^{th}$ percentile). These eight hunters were regular hunters, and except for one, all had been living in the village and hunting in the area for more than four years, with three of them for more than 12 years. The group earning below 1,686,569 XAF (75^{th} percentile), was more varied,

consisting of 8 regular hunters, all the visiting relatives and sporadic hunters (6 and 9, respectively).

As explained in Section 3.2.3.6 this estimate did not include the proportion of concealed primates. To incorporate this proportion, I used data from hunter follows and hunter interviews, which indicate that an experienced shotgun hunter can hunt an average of 3.5 cercopithecines per hunting trip in the montane forest and 1.5 cercopithecines and 0.2 black colobus in the mossy forest. With personal knowledge of each hunter and his hunting area, as well as the number of hunting trips per year for each one, I verified the proportion of primates that had not been reported in the offtake survey. I added this to the reported captures, as shown in Table 4.1-10.

Including the estimate of unreported primates, the average annual income per hunter in BF would amount to 1,620,366±45,419 XAF (i.e., $3,184), although the median (IQR) remains unchanged at 571,604 (237,882 – 2,024,865) XAF (i.e., $1,123). This is because the distribution remains skewed to the right with the same top 11 hunters, and only 7 of them saw their income increase by an average of 25% (range 12-45%) due to the estimation of unreported primates (see Figure 4.1-12).

Regular hunters had significantly higher average annual incomes than visiting relatives and sporadic hunters, who did not differ from each other (ANOVA on the Log10 annual income: $F_{(2,\ 30)}$=26.719, p<0.0001; post hoc Tukey HSD test: p<0.0001 for the two significant groups and p=0.729 for the non-significant one). These differences were expected because regular hunters spend more time hunting per year. However, when income per hunting trip was tested, regular hunters and visiting relatives had similar and higher incomes than sporadic hunters (ANOVA on the Log_{10} income per hunting trip: $F_{(2,\ 30)}$=3.364, p=0.049; post hoc MDS test: p=0.040 for regular vs. sporadic, p=0.027 for relatives vs. sporadic and p=0.494 for regular vs. relatives) (see average incomes in Table 4.1-11).

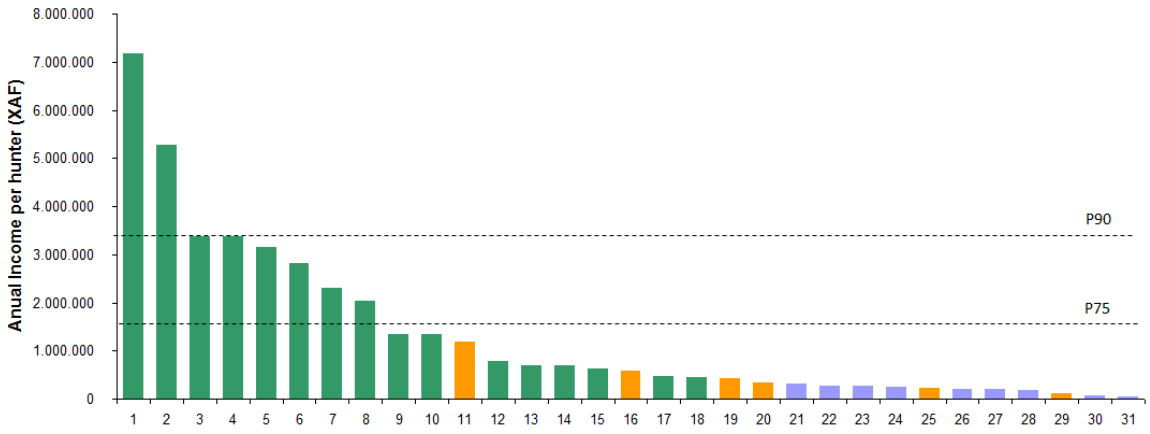


Figure 4.1-11 Average annual income of BF hunters estimated from offtake survey data. The bars on the x-axis represent each of the 31 hunters in the sample. Green bars correspond to regular hunters, yellow bars to visiting relatives and purple bars to sporadic hunters. The dotted lines mark the 75th and 90th percentiles, indicating the income levels surpassed by the top 25% and 10% of hunters, respectively.

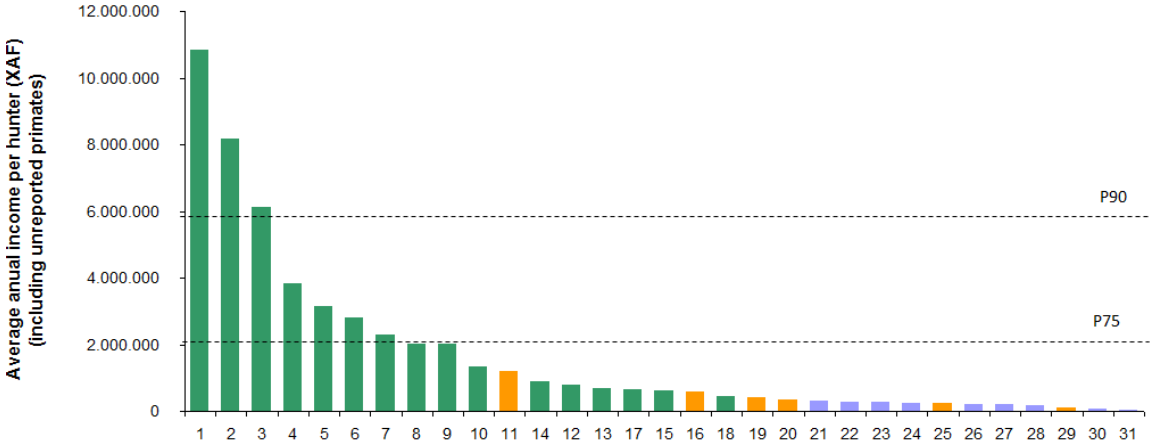


Figure 4.1-12 Average annual income of BF hunters estimated from the offtake survey data, the hunter-follows and the interviews. The latter two methodologies allowed me to estimate the volume of primates not reported in the offtake survey and include it. The numbers on the x-axis refer to specific hunters and correspond to those in the previous graph. Green bars correspond to regular hunters, yellow bars to visiting relatives and purple bars to sporadic hunters. The dotted lines mark the 75th and 90th percentiles, indicating the income levels surpassed by the top 25% and 10% of hunters, respectively.

In Basilé Bubi where hunting was conducted solely using traps placed around crops, most of the catch was consumed, and only 1.2% of the 4,666 animals captured during the study period were sold. The average number of animals sold per hunter per year was 5 (range: 1-15), resulting in an average annual income of 19,840 XAF (range: 1,380 - 56,324) (n=7 hunters). Therefore, it cannot be considered an income-generating activity in Basilé Bubi.

Tabla 4.1-10 Average annual income of BF hunters on data collected from the offtake survey (Aug. 2010-Nov. 2011) and the hunter follows and interviews (Mar.-Oct. 2011).

Hunter	Reported primates[a]	Estimated primates[b]	Primates (final estimate)[c]	Animals (other than primates)[a]	Hunting trips[a]	Animals/ hunting trip[d]	Proportion of sampled hunting trips[e]	Hunting trips/year[f]	Animals/ year	Prey price per hunter[a]	Annual Income (XAF)[g]
Regular 1	12	210	198	507	60	11.76	0.19	68.87	809.73	13,383	10,836,923
Regular 2	23	175	152	380	50	10.65	0.16	57.39	611.07	13,365	8,167,222
Regular 3	3	151	148	413	43	13.04	0.14	49.36	643.72	9,497	6,113,691
Regular 4	13	39	26	220	22	11.18	0.07	25.25	282.27	13,565	3,828,989
Regular 5				235	35	6.71	0.11	40.17	269.73	11,679	3,150,134
Regular 6				260	39	6.67	0.12	44.76	298.43	9,406	2,806,988
Regular 7				176	24	7.33	0.08	27.55	202.01	11,386	2,300,058
Regular 8				244	28	8.71	0.09	32.14	280.06	7,237	2,026,771
Regular 9	-	74	74	162	21	11.22	0.07	24.10	270.49	7,479	2,022,959
Regular 10				164	16	10.25	0.05	18.36	188.24	7,123	1,340,747
Visiting relative 11				86	8	10.75	0.03	9.18	98.71	12,029	1,187,398
Regular 14	5	23	18	69	13	6.69	0.04	14.92	99.86	8,747	873,475
Regular 12				58	10	5.80	0.03	11.48	66.57	11,629	774,190
Regular 13				65	14	4.64	0.04	16.07	74.61	9,356	698,017
Regular 17	-	9	9	33	5	8.37	0.02	5.74	48.03	13,313	639,433
Regular 15				64	13	4.92	0.04	14.92	73.46	8,609	632,437
Visiting relative 16				40	4	10.00	0.01	4.59	45.91	12,450	571,604
Regular 18				55	12	4.58	0.04	13.77	63.13	6,973	440,181
Visiting relative 19				29	3	9.67	0.01	3.44	33.29	12,672	421,816
Visiting relative 20				29	5	5.80	0.02	5.74	33.29	10,375	345,344
Occasional 21				28	3	9.33	0.01	3.44	32.14	9,607	308,758
Occasional 22				17	3	5.67	0.01	3.44	19.51	14,188	276,835
Occasional 23				66	4	16.50	0.01	4.59	75.75	3,439	260,550
Occasional 24				25	6	4.17	0.02	6.89	28.69	8,740	250,794
Visiting relative 25				16	2	8.00	0.01	2.30	18.36	12,250	224,969
Occasional 26				20	3	6.67	0.01	3.44	22.96	8,895	204,187
Occasional 27				19	8	2.38	0.03	9.18	21.81	9,200	200,635
Occasional 28				11	3	3.67	0.01	3.44	12.63	14,591	184,222
Visitng relative 29				11	2	5.50	0.01	2.30	12.63	8,409	106,171
Occasional 30				9	1	9.00	0.00	1.15	10.33	6,667	68,868
Occasional 31				20	1	20.00	0.00	1.15	22.96	2,100	48,208

[a] Data reported in the offtake survey.
[b] Estimated number of primates hunted per hunter during the offtake survey period based on information of hunter follows and interviews.
[c] Obtained from the subtraction of the two preceding columns.
[d] Obtained from the sum of "Primates (final estimate)" plus "Animals (other than primates)" divided by the number of hunting trips.
[e] Proportion of days of hunting trips out of the 318 days sampled during the survey.
[f] Estimated number of hunting trips per year (above ratio multiplied by 365).
[g]Average prey price from the sale of all carcasses, including the estimated number of cercopithecines and colobus not reported.

Table 4.1-11 Average income per hunter in BF (annual and per hunting trip) for the total sample and by hunter type. Average values are expressed as Mean (SE) for normally distributed data or Median (IQR) for non-normal data.

Hunter type	Income/year (XAF)	Income/hunting trip (XAF)	n
Regular	2,024,865 (736,104 - 3,489,562)	85,936 (9,935)	16
Visiting relative	296,012 (75,573)	96,790 (14,586)	6
Occasional	200,340 (29,926)	55,542 (6,978)	9
All	571,604 (255,672 – 1,686,569)	63,064 (49,875-93,834)	31

4.1.7.2.2 Contribution of women traders

Among the 19 regular hunters in Basilé Fang, seven had wives who were wild meat traders. These women were responsible for selling all or most of their husbands' catch and, in some cases, sold game hunted by visiting relatives. Additionally, they purchased carcasses from other hunters, with whom they had prior agreements, selling this wild meat independently of their husbands' or relatives' activities. Notably, there was also a woman in the village whose husband was not a hunter, yet she operated as a trader, buying wild meat from other hunters.

Based on the data from the offtake survey and information gathered through hunter tracking and interviews, as detailed above, I estimated the annual income of the women traders from the sale of carcasses that did not belong to their husbands or relatives. This income reflects earnings from hunting activities that contributed to the household exclusively through the women, independent of the men's involvement. Table 4.1-12 presents these calculations. On average, women traders earned 1,876,686 ± 327,623 XAF, or $3,688 per year, representing approximately 43.6 ± 11.98% of their household's annual income from hunting.

Table 4.1-12 Average annual income of BF woman traders from the sale of wild meat from hunters other than their husbands or family members. The estimation is based on data collected in the offtake survey (Aug. 2010-Nov. 2011), and the hunter-follows and interviews (Mar.-Oct. 2011).

Trader	Animals traded[a]	Unreported primates[b]	Purchase days[a]	Animals / purchase day[c]	Proportion of sampled purchase days[d]	Purchase days/ year[e]	Animals/ year	Prey profit per trader[a,f]	Annual income (XAF)[g]
1	282	90	33	11.27	0.10	37.88	426.95	7,976	3,405,270
2	399	14	40	10.32	0.12	45.91	473.79	5,266	2,495,094
3	213	58	33	8.21	0.09	37.88	310.97	7,091	2,205,110
4	245	38	30	9.42	0.05	34.43	324.37	6,488	2,104,606
5	318	2	37	8.64	0.09	42.47	367.03	5,025	1,844,185
6	221	21	28	8.65	0.13	32.14	277.86	5,830	1,619,901
7	107	18	15	8.31	0.10	17.22	143.12	6,600	944,651
8	55	0	7	7.86	0.02	8.03	63.13	6,252	394,668

[a]Data reported in the offtake survey (Aug. 2010-Nov. 2011).
[b]Estimated number of primates concealed in the offtake survey based on the information of hunter follows and interviews (see Sections 3.2.2.6 and 4.1.6.2.1).
[c]Sum of animals traded plus unreported primates, divided by the number of purchase days.
[d]Proportion of purchase days out of the 318 days sampled during the offtake survey
[e]Estimated number of purchase days per year (previous proportion * 365).
[f]Average profit (selling price minus purchase price) from selling all carcasses, including the estimated number of cercopithecines and colobus concealed.
[g]Number of animals per year multiplied by the prey profit per trader.

4.1.7.3 Protein intake

A total of 126 foods were collected in the two villages of BB and BF. Of these, 27 were unique to BB and 48 to BF (see Table 4.1-3). The seven most consumed foods (>700 $g \cdot RA^{-1} \cdot day^{-1}$ in BF and >570 $g \cdot RA^{-1} \cdot day^{-1}$ in BB) were identical in both villages and corresponded to the staple foods in all villages: taro, plantain, rice, banana, bread, chicken, and greens (see Section 4.1.5.1).

The foodstuff from which the greatest amount of protein was obtained per RA per day was also the same in both villages: mackerel (frozen fish). This was followed by taro and chicken in BB, and turkey and bread in BF. Consequently, in both villages, the primary sources of protein intake were fish (25.7% in BB and 19.8% in BF), predominantly frozen and imported, and domestic meat (20.8% in BB and 27.4% in BF), primarily frozen and imported.

Hunted wild meat was not a significant protein component consumed in either village. It contributed 6.6±3.5% and 9.2±2.5% of all protein consumed in BB and BF, respectively, and 12.2±6.2% and 16.3±3.8% of all animal protein consumed (see Figure 4.1-8.). The two species that contributed the most were the same in both villages: the rat and the blue duiker. However, their contribution to the total protein intake varied. In BB, the rat contributed more (3.1%) than the blue duiker (1.7%), whereas in BF, the blue duiker contributed more (5.4%) than the rat (2.3%). In both villages, the contribution of snails surpassed that of the most consumed wild meat species (3.9% in BB and 6.2% in BF)

The following plant groups also contributed more significantly to daily protein intake compared to wild meat: C&CP (mostly imported) at 10% in BB and 16.5% in BF, and in BB, SR, T&F (mostly local) at 17.9%. In BB, 53.6% of the vegetable protein consumed per RA per day originated from products grown by the families themselves, while in BF, this figure was 33.3%.

No significant differences were observed in the total protein intake between the two populations or in the intake of each type —vegetable or animal (Table 4.1-8). Similarly, there were no differences in the total amount or proportion of animal protein consumed, whether from wild meat, hunted or harvested (Table 4.1-8).

4.2 Reproductive parameters and body condition of the blue duiker: implications for sustainability assessments

4.2.1 Sample characteristics

A total of 535 blue duiker carcasses (259 females, 276 males) were examined in this study. Of these, 331 (62%) were hunted in Pico Basilé, 152 (28%) in Riaba and 52 (10%) were of unknown origin. In the Pico, 61 (18%) were taken in lowland forest, 184 (56%) in montane forest and 86 (25%) in mossy forest. Most animals were trapped 371, (69%), 134 (25%) were shot, and 30 (6%) had no capture method recorded.

Overall sex ratio (51.6% males, 48.4% females) did not differ from 1:1, neither by locality. The same was true for adults and juveniles separately. The age ratio for the entire sample (15.5% juveniles, 84.5% adults) differed significantly from 1:1 (χ^2=254.507, p<0.001).

The proportion of animals captured with guns and traps did not differ between sexes and age classes. Among juveniles, 43.8% of females and 42.2% of males were captured with guns, with the remainder captured using traps (χ^2=0.018, df=1, p=1.0). Among adults, 22.0% of females and 25.1% of males were captured with guns, with the remainder captured using traps (χ^2=0.572, df=1, p=0.495).

4.2.2 Body measurements

Body mass and body measurements for adult males and females are shown in Table 4.2-1 Females were slightly larger than males (significant values for W, HB, HS, HL, T, p<0.05), though males had larger horns with more grooves (HL, G, p<0.001).

Body mass varied according to the reproductive status of females, with pregnant females being the heaviest (3.99±0.59 kg, n=47), followed by lactating females (3.69±0.45. n=24) and non-pregnant females (3.28±0.51, n= 137). Analysis of variance (ANOVA) showed significant differences ($F_{2,207}$=33.615, p < 0.0001) and subsequent Tukey HSD post-hoc test revealed that significant differences occurred only between non-pregnant females and the other two groups (p<0.0001 compared to pregnant females and p=0.002 compared lactating females), which did not differ between them (p=0.061). When pregnant and lactating females were excluded, the body mass of audlt males and females showed no significant differences (Table4-2—1).

Table 4.2-1 Comparison of body mass and measurements[a] between adult male and female blue duikers in the entire Bioko sample. Mean ± *SD* (min-max).

	n	Female	n	Male	Test[b]
W- Body mass[c] (kg)	213	3.49 ± 0.60 (1.96 - 4.54)	218	3.28 ± 0.46 (1.93 - 4.75)	$p<0.0001$
W-Body mass[c] (kg) (excluding pregnant and lactating females)	137	3.28 ± 0.51 (1.96 - 4.54)	218	3.28 ± 0.46 (1.93 - 4.75)	$p=0.995$
HB- Head and body[d] (cm)	214	54.61 ± 3.04 (45.0 - 64.0)	225	53.50 ± 3.27 (47.0 - 60.0)	$p<0.0001$
HS-Height at shoulder (cm)	212	32.21 ± 2.07 (26.3 - 37.5)	223	31.62 ± 2.22 (23.0 - 38.5)	$p<0.01$
H- Head (cm)	213	12.99 ± 0.66 (11.1 - 15.0)	220	12.94 ± 0.54 (11.2 - 14.3)	$p=0.43$
E- Ear (cm)	208	4.65 ± 0.32 (3.7 – 5.5)	224	4.63 ± 0.35 (3.5 - 5.9)	$p=0.51$
HL- Horn length (cm)	214	3.09 ± 0.52 (1.5 - 4.4)	219	4.09 ± 0.57 (2.7 - 5.7)	$p<0.0001$
G- Number of horn grooves	159	4.70 ± 1.75 (0 - 10)	157	5.79 ± 1.52 (2 - 10)	$p<0.0001$
TL-Total length[d] (cm)	209	62.69 ± 3.26 (51.5 – 75.0)	218	61.33 ± 2.92 (53.0 - 70.8)	$p<0.0001$
Ho-Hoof length (cm)	213	2.36 ± 0.21 (1.9 - 2.9)	223	2.39 ± 0.24 (2.0 - 3.3)	$p=0.57$
Hf- Hind foot length (cm)	212	15.38 ± 0.74 (12.5 - 17.0)	225	15.25 ± 0.70 (13.5 - 17.4)	$p=0.059$
T-Tail length (cm)	211	8.01 ± 1.11 (3.6 - 11.0)	225	7.56 ± 0.99 (5.8 - 10.0)	$p<0.0001$

[a] Taken following Wilson (2001) (p.14-18)
[b] Student T test
[c] Undressed weight.
[d] HB does not include the tail, TL does

4.2.3 Reproductive stage

Macroscopic examination of 216 adult females revealed that 54 (25%) were pregnant. Subsequent histological analyses of 102 adult females (47%), confirmed that 11 of the 87 initially classified as not pregnant were pregnant. If the proportion of non-detected pregnancies (13%) is assumed to be comparable for the remaining 74 non-pregnant females for which I did not have histological samples, there would be another 9 pregnant females in the overall sample. Thus, the corrected pregnancy rate would be 74 (34%). This calculation was also performed by locality in Section 4.2.5. Lactating (and not pregnant) females were 13 (6%) and 11(5%) both pregnant and lactating females.

Sperm sample was collected for a total of 226 (82%) male blue duikers. All males with a left testis mass and length greater than 1.6 g and 2 cm exhibited mature sperm cells.

Testes weight (*tw*) and testis length (*tl*) were strongly correlated with each other (r=0.879, p<0.0001) as well as with body mass (r=0.650 vs *tw*, r=0.625 vs *tl*, p<0.0001) and with body measurements (r>0.117, p<0.004). Among these, those with the highest correlation were G (r=0.737 vs *tl*, r=0.616 vs *tw*, p<0.0001), H (r=0.695 vs *tl*, r=0.656 vs *tw*, p<0.0001) and HL (r=0.647 vs *tl*, r=0.504 vs *tw*, p<0.0001).

4.2.4 Body condition

4.2.4.1 Validity of the KFI as a measurement of body condition in hunted blue duikers

Kidney mass did not vary significantly between the dry and wet seasons within any of the age-sex-reproductive status groups analyzed (Table 4.2-2), which supports the validity of its inclusion in the KFI for measuring body condition in blue duiker (Section 3.3.4.2.1).

However, animals hunted with traps exhibited lower KFI values compared to those shot. These differences were observed across all age-sex-reproductive status groups analyzed except non-pregnant females and lactanting females, althoguht the former showed a marginal tendency (p<0.1) (Table 4.2-3). These results support the hypothesis that the capture method influences the KFI value, likely due to the physiological stres and lack of food experienced by animals caught in traps (see Section 3.3.4.2.2).

Considering these results, I used the KFI, but included only shot animals, to measure the body condition of blue duikers and examine differences across sex, age, reproductive status, seasons, and localities.

Table 4.2-2 Seasonal variation in kidney mass across age-sex-reproductive status groups.

	Dry		Wet		
	n	**Mean ± SD**	**n**	**Mean ± SD**	***p*-value[a]**
Females					
Young	16	7.01 ± 2.52	14	6.09 ± 1.69	0.252
Adult					
Non-pregnant[b]	58	9.48 ± 2.45	78	9.12 ± 2.01	0.351
Pregnant	32	11.09 ± 2.37	15	10.07 ± 2.11	0.163
embryonic stage	14	11.11 ± 2.36	7	10.56 ± 1.59	0.582
foetal stage	18	11.07 ±2.44	8	9.65 ± 2.50	0.186
Lactating[c]	11	11.62 ± 1.89	13	10.33 ± 1.95	0.117
Males					
Young	14	6.81 ± 1.97	24	6.76 ± 1.97	0.940
Adult	87	9.63 ± 1.99	110	9.74 ± 2.2	0.706

[a] Student's t-test
[b] And non-lactating
[c] All of them were non-pregnant or pregnant at embryonic stage

Table 4.2-3 Differences in KFI between trapped and shot animals, by sex, age and reproductive stage.

	Trap		Gun		
	n	**Median (IQR)**	**n**	**Median (IQR)**	***p*-value[a]**
Females					
Young	17	0 (0-6)	11	12.3 (7.1-20.8)	0.002
Adult					
Non-pregnant[b]	94	8.6 (0-22.4)	29	12.5 (0-37.6)	0.078
Pregnant[b]	35	10.4 (0-29.2)	7	32.4 (28.4-37.7)	0.036
embryonic stage	17	0 (0-10.9)	3	29.7 (29.1-31.1)	0.020
foetal stage	18	18.4 (6.8-43.3)	4	37.7 (20.9-50.2)	0.375
Lactating[c]	14	6.5 (0-13.2)	5	0 (0-1.9)	0.272
Males					
Young	21	0 (0-13.8)	17	16.7 (11.7-21.9)	0.019
Adult	140	10.7 (0-21.6)	48	13.7 (6.7-25.2)	0.027

[a] Mann-Withney U test
[b] And non-lactating
[c] All of them were non-pregnant or pregnant at embryonic stage

4.2.4.2 Variations across age, sex and reproductive status

Highest KFI values were found in pregnant (and non-lactating) females and lowest in lactating females (all of them non-pregnant or pregnant at embryonic stage). KFI values were middle of the range for young females, adult non-pregnant (and non-lactating) females and young males and adult males (Table 4.2-3 and Figure 4.2-1). Kruskal-Wallis test with all groups showed significant differences (χ^2=12.91, *df*=5, *p*=0.024). Subsequent post-hoc analysis showed that the differences were only between pregnant (non-lactating) and lactating (non-pregnant or pregnant at embryonic stage) females (Z= 3.54, *p*=0.006).

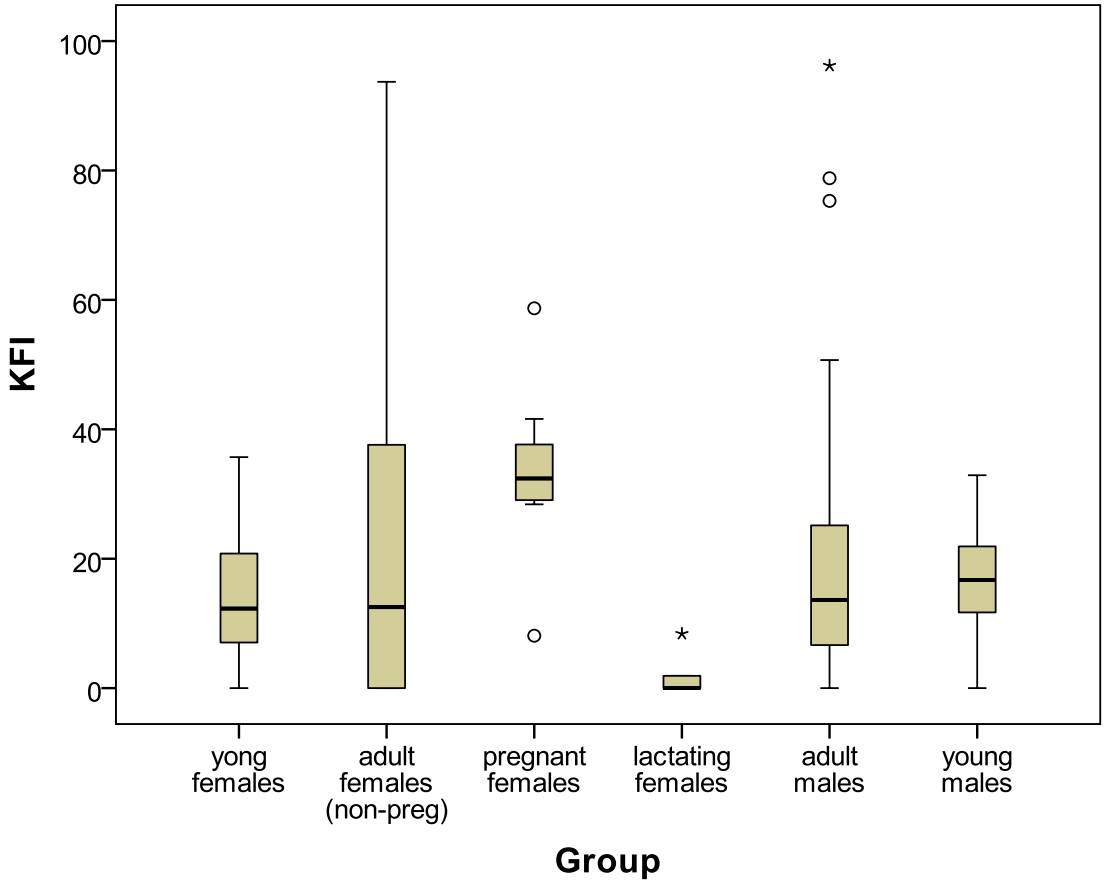


Figure 4.2-1 Body condition (expressed as the Kidney Fat Index, KFI) across different age, sex, and reproductive status groups.

4.2.4.3 Seasonal and local variations

Seasonal variation in KFI is shown in Figure 4.2-2. Young and adult individuals (in the case of females, excluding pregnant and lactating ones) were grouped, as they exhibit no significant local and seasonal variation in KFI (p>0.1 in all cases). While males showed significantly higher values of KFI during the wet season for the entire Bioko sample (which seemed to occur in each locality) (Figure 4.2-2A), females from Pico present an opposite pattern, with higher values during the dry season although these differences were not significant (Figure 4.2-2B). Annual KFI values did not differ between hunting sites (Pico and Riaba) neither in males (U=291.5, p=0.24) or females (U=176.0, p=0.90). Comparison between the three Pico habitats was not possible due to insufficient sample of animals caught by gun.

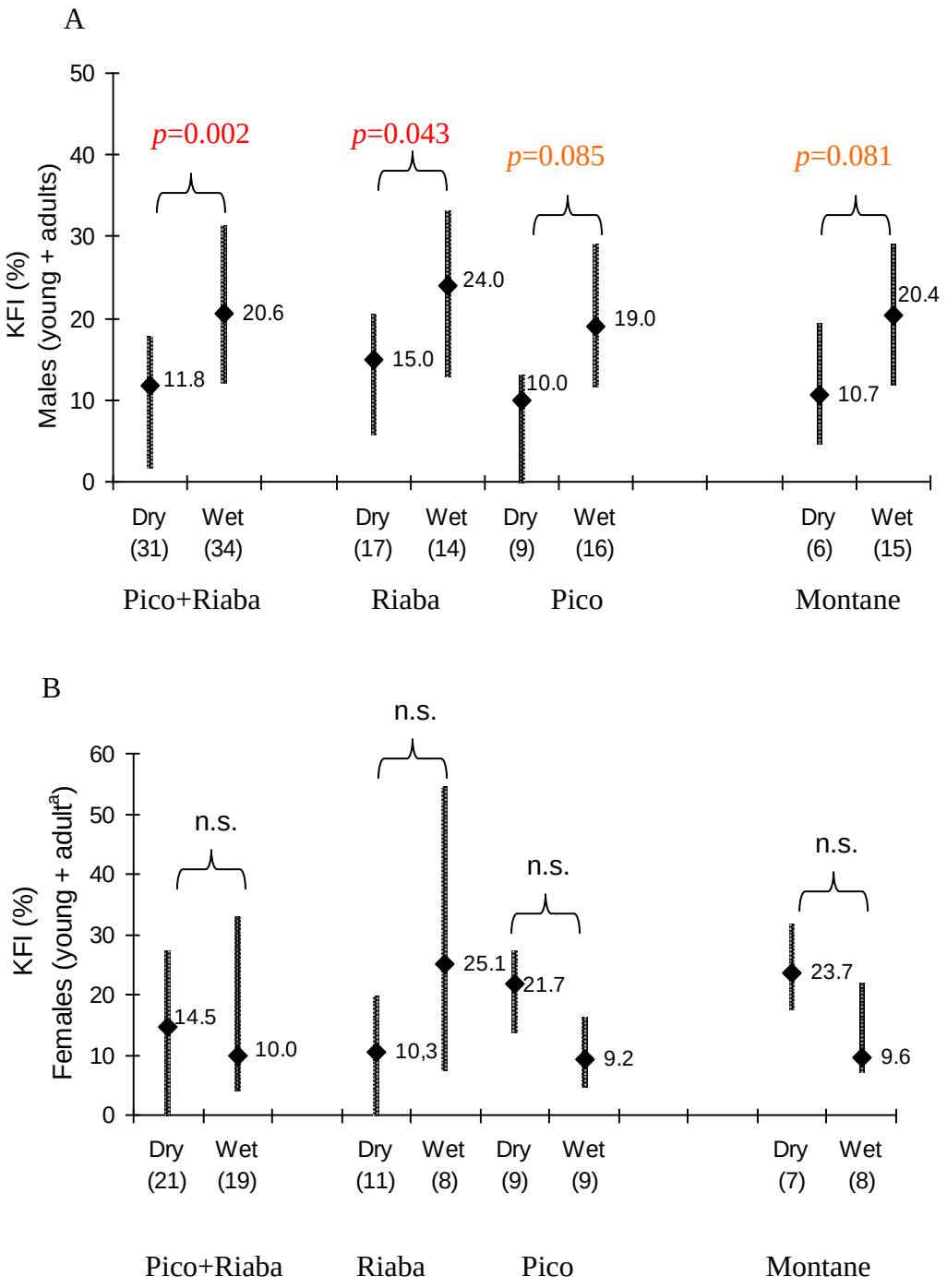


Figure 4.2-2. Seasonal variation in body condition (expressed as the Kidney Fat Index, KFI) for males and females hunted with shotguns for the entire Bioko sample (Pico + Riaba) and by locality. [a]Excluding pregnant and lactating females (as they have significantly higher and lower KFI respectively). Localities include the two hunting sites (Pico and Riaba), and, within Pico, three distinct habitats (lowland, montane and mossy forest); however, only the montane habitat provided a sufficiently large sample size. Both significant *P*-values (p <0.05) and those approaching significance (p <0.10) which may suggest a trend, are indicated; p >0.10 are marked as n.s. Symbols and bars represent the median and Interquartile range (IQR) respectively.

4.2.5 Reproductive performance and maximum intrínsic rate of natural increase

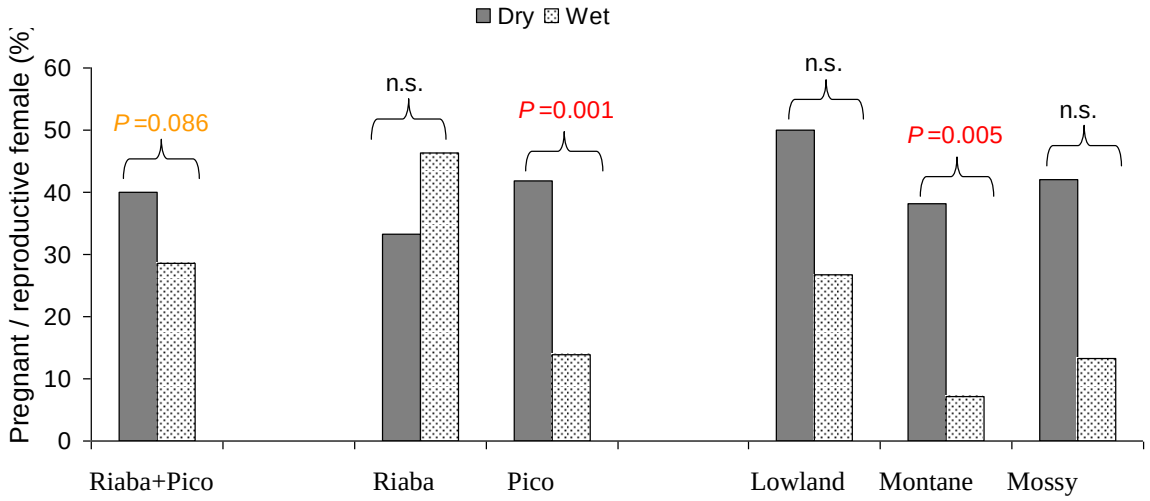
The overall estimated percentage of pregnant females in my sample was 34% (n=216 adult females). All reproductive tracts examined had only one embryo or foetus. Using Wilson (2001) gestation period of 205 days, I calculated 0.6 young per female per year and a theoretical mean interbirth interval of 598 days. As the data on the sex of the embryos or foetus were not taken adequately in some cases, and in others it was not possible (due to the early state of pregnancy), I assumed a ratio of female conceptuses of 0.5 (Dubost, 1980) to calculate female birth rate (0.3). All parameters were calculated for each locality (Table 4.2-4).

There were no significant differences in annual pregnancy rate (thus neither in gross productivity) between hunting sites ($\chi 2$=2.76, p=0.068) or habitats ($\chi 2$=1.74, df=2, p=0.434). However, I observed a tendency ($\chi^2 = 3.15$, $p = 0.086$) for a higher proportion of pregnant females during the dry season across the entire Bioko sample (Figure 4.2-3A). When analyzed by locality, this difference was significant in Pico, where 28% more pregnant females were recorded during the dry season ($\chi 2$=12.49, p=0.001), but not in Riaba ($\chi 2$=0.97, p=0.418). The same pattern was found for each Pico habitat, although significant differences were only found in mountain forest ($\chi 2$=8.43, p=0.005), probably due to low sample size in the other two habitats.

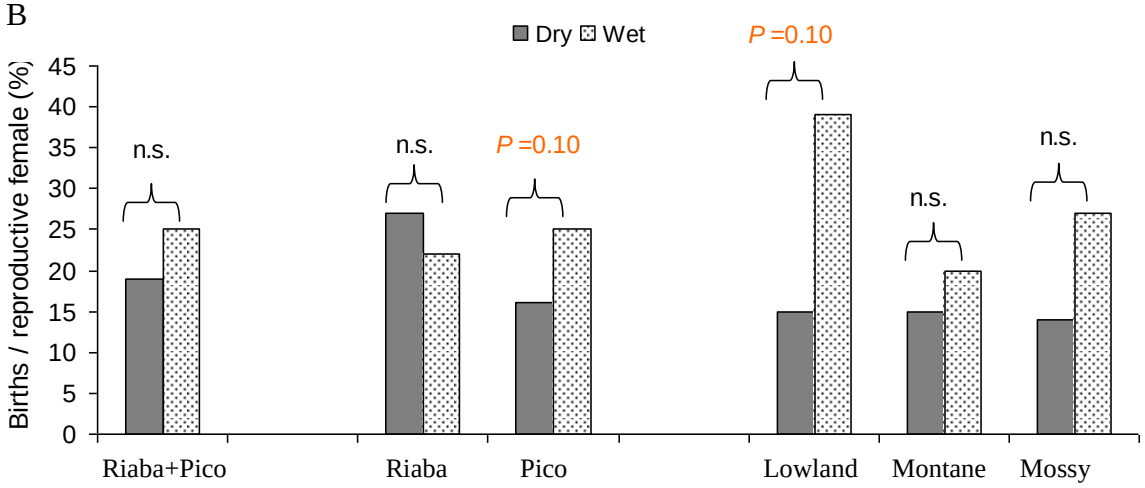
No significant seasonality was detected in conceptions or births, but a tendency of more births ($\chi 2$=3.06, p=0.10) during the wet season in Pico (Figure 4.2-3B) and of more conceptions ($\chi 2$=3.24, p=0.086) during the wet season for the entire Bioko sample (Figure 4.2-3B). Conceptions and births occurred every month of the year and I did not find significant monthly differences either. Testis weight (which was not affected by capture method) showed no monthly or seasonal significant differences, in any locality or in the entire sample; no relation with conception peaks was found.

Overall value for r_{max} calculated from Cole's (1954) equation (0.22) was around 4 times lower than from Caughley and Krebs' (1983) formula (0.96). Performing this calculation for each locality separately I also obtained values between 3 and 6 times lower with Cole's equation (Table 4.2-4).

A


Dry Wet
Pregnant / reproductive female (%)
60
50
40
30
20
10
0
P =0.086
n.s.
P =0.001
n.s.
P =0.005
n.s.
Riaba+Pico
Riaba
Pico
Lowland
Montane
Mossy

B


Dry Wet
Births / reproductive female (%)
45
40
35
30
25
20
15
10
5
0
n.s.
n.s.
P =0.10
P =0.10
n.s.
n.s.
Riaba+Pico
Riaba
Pico
Lowland
Montane
Mossy

C

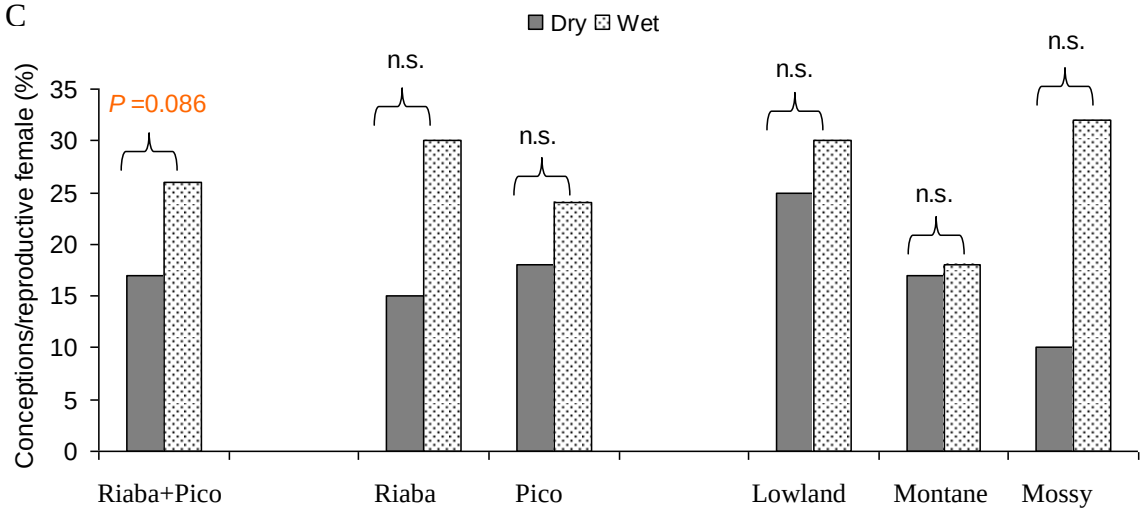

Dry Wet
Conceptions/reproductive female (%)
35
30
25
20
15
10
5
0
P =0.086
n.s.
n.s.
n.s.
n.s.
n.s.
Riaba+Pico
Riaba
Pico
Lowland
Montane
Mossy

Fig 4.2-3. Reproductive parameters: (A) pregnancy rate, (B) birth rate and (C) conception rate, for the entire Bioko sample (Pico+Riaba) and by locality. Localities include the two hunting sites separately (Pico and Riaba), and then inside Pico the three different habitats (lowland forest, montane forest and mossy forest). We indicate both significant *p* values ($p < 0.05$) and those close to significance ($p < 0.10$) which indicate a trend. $p > 0.10$ are indicated as n.s.

Table 4.2-4 Reproductive performance and maximum intrinsic rate of natural increase (r_{max}) for the entire Bioko sample and by locality.

	Bioko sites			Pico habitats			Total
Reproductive parameters	Pico	Riaba	Un-known	Lowland	Montane	Mossy	
Pregnant females	42	26	6	12	18	11	74
Adult females	136	62	18	31	70	34	216
Pregnancy rate	0.31	0.42	0.33	0.39	0.26	0.32	0.34
Gross productivity (young/female)	0.5	0.7	0.6	0.7	0.5	0.6	0.6
Interbirth interval	664	489	615	530	797	634	598
Parturition-conception	459	284	410	325	592	429	598
Gross fecundity (female offspring)	0.3	0.4	0.3	0.3	0.2	0.3	0.3
Maximum intrinsic rate of natural increase							
r_{max} (Cole's)	0.19	0.30	0.23	0.26	0.14	0.21	0.22
Mean weight	3.396	3.491	3.720	3.673	3.325	3.285	3.446
r_{max} (Caughley & Krebs)	0.966	0.956	0.935	0.939	0.973	0.978	0.961

Chapter 5: DISCUSSION

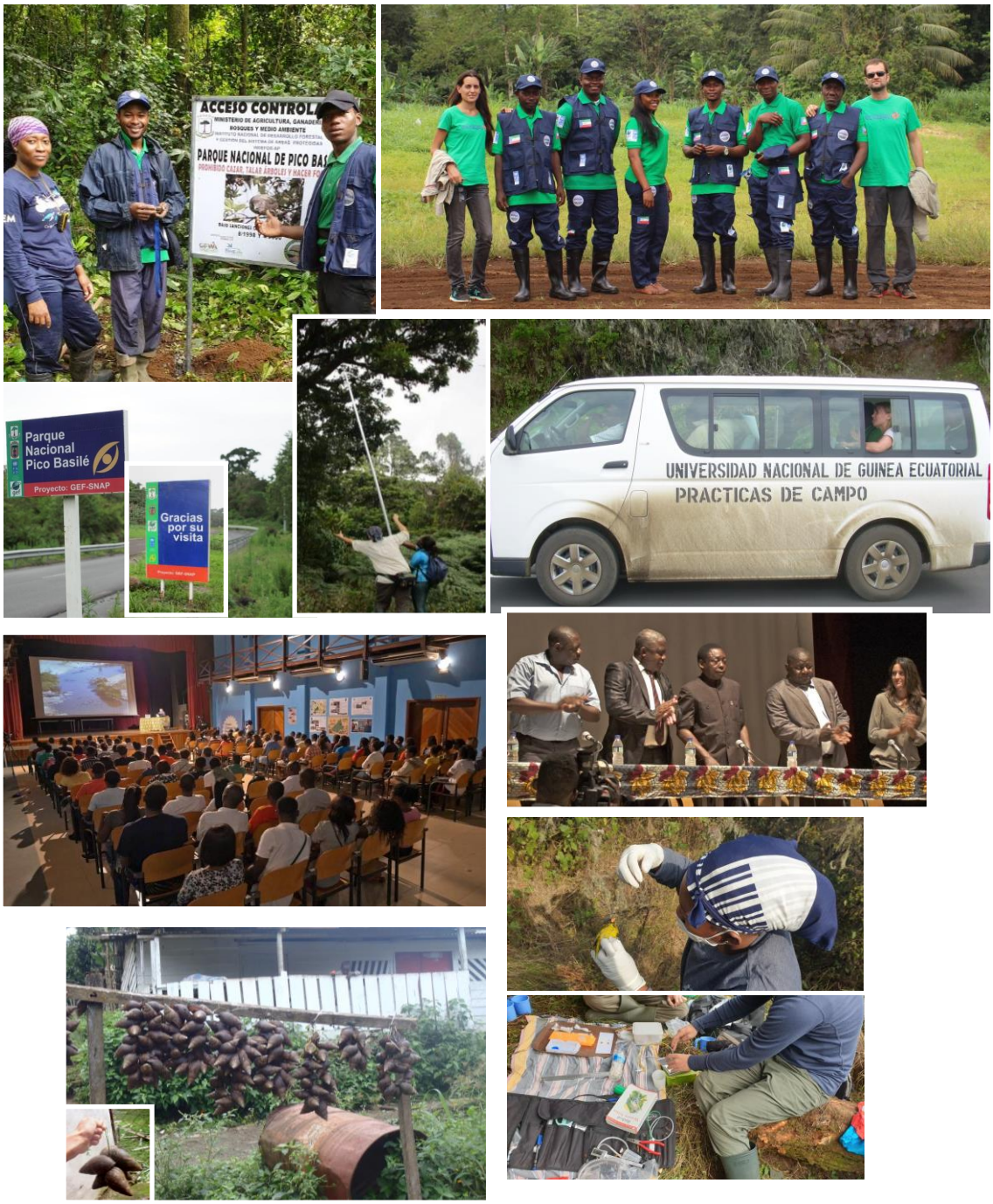


Photo captions can be found in Appendix P

5.1 The contribution of wild meat to rural livelihoods and diet: implications for food security and management.

In this section, I first present an overview of the main findings related to the contribution of wild meat to rural livelihoods and diet, answering the questions posed in Section 3.2.3. I then discuss them in more detail and consider their implications for the practical management of hunting and the wild meat trade in Bioko (sections 5.1.2 to 5.1.5). Finally, based on these implications, I discuss the most appropriate alternatives for the use of wild meat (Section 5.1.6).

5.1.1 Overview

Overall, hunted wild meat was not a major source of protein in the diets of people living around the PBNP. Generally, these had access to domestic meat and fish, frozen and imported, and their daily protein intake exceeded the recommended minimum daily amounts. The fact that households engaged in commercial hunting, and therefore with more access to this resource, did not result in more wild meat protein consumed. Limited access to alternative protein sources was also necessary.

Commercial hunting did, however, provide an important source of income (and wealth) for rural households, and resulted in one of the most profitable livelihoods along with wage employment and shop/bar trading. Although the average annual household income from commercial hunting was similar to that from wage employment, the negative and significant association between these two activities and the answers of hunters and traders indicated that wage employment was preferred over hunting.

These results have important implications for management, as they indicate both the necessity and the likely feasibility of developing income-generating alternatives if hunting is to be reduced. They also suggest that developing local sources of alternative protein to wild meat is less urgent if the levels of meat and fish imports are maintained. Nevertheless, the development of alternative sources of fresh products, particularly fish, could also contribute to reducing wild meat consumption.

5.1.2 Rural livelihoods and the contribution of wild meat

Agriculture emerged as the most prevalent livelihood activity, with 84% of households producing food primarily for their own consumption. Additionally, 41% of these households also sold a portion of their produce to generate income. Despite its importance, agricultural product sales were among the least profitable activities. The average annual income from produce sales (mean: $1,459; median: $1,180) was significantly lower—by approximately 2.5 times—than the income generated from the other three most common livelihood activities: paid work, wild meat trade, and shop/bar trade, with no significant difference in income levels among them. Nevertheless, household agricultural production was crucial in supporting household nutrition, with 44% of the vegetable protein consumed being supplied from home. Beyond this subsistence agricultural production, only remnants of cocoa cultivation remain (in line

with its decline described in Section 2.1.4); only 4% of households engaged in this activity. Other initiatives, such as agricultural cooperatives supported by external cooperation agencies, have also been unsuccessful due to poor management and the abrupt cessation of subsidies once transferred to the Equatoguinean administration (as discussed in more detail in Appendix 2.1-2).

In the continental region, Kümpel's (2006) study in Sendje revealed a similar pattern to my findings in Bioko, with the three most profitable activities, both at the household and individual levels, being shop/bar trade, paid work, and hunting, while agriculture lagged significantly behind. However, Allebone-Webb (2009) observed variations, indicating that in some northeastern Rio Muni villages, agriculture was more commercialised and played a more significant role in livelihoods. Nevertheless, the findings from these studies, along with my research, suggest that agricultural trade in Equatorial Guinea remains largely domestic. This contrasts with other countries in the region, such as Cameroon, Nigeria, and Ghana, where agriculture is a major export earner (Kümpel, 2006).

In this respect, Equatorial Guinea's country profile and economy are like Gabon — comparable geography, climate, and culture, which also has experienced an oil boom, but in the 1970s. In both countries, oil wealth has favoured urban development at the expense of the rural economy. On the one hand, national agricultural production costs have increased relative to the cost of imported goods due to the overvaluation of the local currency, and on the other hand, there has been a rural exodus to the cities in search of higher incomes from oil-dependent urban employment (Starkey, 2004; Wunder and Sunderlin, 2004; Kümpel *et al.*, 2010b).

This urban development and economic growth, coupled with the scarcity of fresh meat alternatives (Section 2.1.4.2), have fuelled the trade in wild meat from rural areas to the city (Section 2.1.6.1 and Cronin *et al.* 2015a). Consistent with this, my findings show that hunting was the second most common livelihood, with 52% of households in my sample (n=155) engaged in hunting, and 30% doing so for income. As previously highlighted, hunting ranked among the most profitable livelihood activities, generating average annual household incomes comparable to shop/bar trade and wage employment. This finding contrasts with Kümpel (2006), where hunting, although profitable, was less lucrative than wage employment, which generated an average of 1.7 times more income per household per year, and even less than shop/bar trade, which generated an average of 4.4 times more income per household per year. Similarly, in Allebone-Webb's (2009) study of the agricultural villages of Beayop and Teguete in the interior of Rio Muni, the average daily household income from wage employment was nearly double (1.9 and 1.6 times, respectively) that from the sale of animal forest products.

Kümpel (2006) also conducted an offtake survey and analysed the monthly income of hunters, distinguishing between those exclusively engaged in hunting and those combining hunting with other livelihood activities. Even when focusing solely on hunters who specialised in hunting, their income was significantly lower than that from wage employment, which generated 1.6 times more income per person per month. In contrast, my analysis of hunters exclusively involved in commercial hunting reveals an annual income of $5,730 (median $3,980), surpassing the annual household income from wage employment by 1.1 times and 1.5 times, respectively, when comparing the median and mean. Additionally, comparing my findings with Kümpel's (2006) data

from mainland Equatorial Guinea in 2003, adjusted for inflation, indicates that hunting in Bioko is more profitable by a factor of two or more. This observation is further supported by interviews with hunters in BF, who reported migrating to Bioko due to the higher profitability of hunting and the reduced risks associated with the absence of large mammals.

Regarding bar-shop trade, although it proved as profitable as commercial hunting and paid work, it was pursued by a smaller proportion of households—18% compared to 30% engaged in commercial hunting and 43% in wage labour. Kümpel (2006) attributes this disparity, also observed in Rio Muni, to the higher initial investment required for bar-shop trade, which acts as a barrier for many households, unlike paid work and hunting. Consistent with this, my findings from the three villages where I collected quantitative socioeconomic data (Basilé Bubi, Basilé Fang and Basacato) reveal that households with higher average annual incomes also tended to have a higher percentage of bar-shops.

Beyond these liveihoods, logging was the only other potentially more profitable endeavour. However, it was carried out on a relatively small scale by a limited number of individuals due to its large-scale prohibition in the island region (Section 2.1.4.3.1). It is noteworthy that during the second phase of the offtake survey conducted in Basilé Fang (2017-2020), an increase in logging activity was observed compared to the first phase (2010-2011). While this issue falls outside the scope of this study, it underscores the need to monitor logging activities and assess their potential impacts on the PBNP and local wildlife populations.

Regarding fishing, which was a subsistence activity in all cases, I was unable to collect economic data, so I do not know its contribution to the income of fishing households. To my knowledge there are no other studies that collect this information for any part of the country (but see Allebone-Webb, 2009 for the contribution of inland fishing in two Rio Muni villages). In any case, it was a much less practiced activity and a much less developed trade than wild meat or the sale of agricultural products. Only 8% of the households in my sample (n=160) were engaged in fishing, and only in three of the ten villages. Although these villages were the closest to the sea, none of them was on the coast itself or well connected to it, except by a path through the forest. There is a historical explanation for this. According to Aymemi (1942), after living close to the sea (as evidenced by the archaeological discoveries at Carboneras), the inhabitants of Bioko chose to stay away from the slave traders who could reach their shores and moved towards the mountain. Thus, even though Bioko is an island, fishing is a very rare activity. Furthermore, the conditions are not optimal for the maintenance and transportation of the product, which impedes the development of commercial activity.

In addition to the livelihoods discussed above, only two other income-generating activities were recorded: renting houses and piecework. No other income-generating activities were identified. In contrast, some artisanal work was documented in the mainland region (Allebone –Webb, 2009).

In summary, the results of this study show the importance of wild meat as a source of income for rural households living around PBNP, and indicate that if hunting is to be reduced, income-generating activities for the rural population must be developed.

5.1.3 Factors influencing hunting activity

When income generation is the primary reason for hunting the development of equally or more profitable alternatives may lead to a reduction in hunting. However, it is important to understand the capabilities, motivations, and willingness of households or individuals to engage in both hunting and alternative livelihoods if effective and feasible interventions are to be developed (SCDB, 2011).

In the mainland region, in the village of Sendje, where hunting was an important source of income, Kümpel (2006) found that 66% of hunters reported hunting due to the lack of alternative income sources but indicated a preference for a regular salary. The veracity of these statements was confirmed seven years later, when increased employment opportunities in Sendje led to a shift in livelihood activities away from hunting, resulting in a significant reduction in hunting pressure (Gill *et al.*, 2012). A similar shift in livelihood activities away from hunting in favour of employment and educational opportunities was documented by Coad *et al.* (2013) in Central Gabon, and in Zimbabwe, Lindsey *et al.* (2011) found that wild meat hunting was predominantly carried out by unemployed young men.

Consistent with these studies, the responses gathered in my survey on past activities and motivations for change in Basilé Fang, a hunting village with characteristics similar to those of Sendje, indicated that only 17% of respondents had come to Bioko specifically to hunt, while the remaining 83% had migrated to the island in search of employment or to pursue academic studies. Upon failing to secure employment, losing their jobs, or exhausting funds for their education, they turned to commercial hunting.

Additionally, in my cross-sectional study in 155 households in 10 Bioko villages, univariate analyses at both the village and household levels revealed a strong and statistically significant negative correlation between employment and hunting. Villages with a higher prevalence of salaried employment had a lower incidence of households involved in hunting activities, and households with members in salaried positions were less likely to engage in hunting. A multinomial logistic regression analysis that included ethnicity (Bubi and Fang), hunting type (subsistence and commercial) indicated that among the Fang, unemployment was a stronger predictor of commercial hunting practices, while among the Bubi, unemployment was moderately associated with subsistence hunting. These findings align with the Fang's historical involvement in commercial hunting, contrasted with the Bubi's predominantly agricultural lifestyle and their more limited access to firearms, due in part to the Fang's political dominance (see Section 2.1.2 for details).

This information is particularly relevant considering the ongoing economic crisis in Equatorial Guinea since 2014, further exacerbated by the COVID-19 pandemic, from which the country has yet to recover (see Section 2.1.4.3). The rise in unemployment suggests that the already alarming overexploitation of wildlife on Bioko Island—discussed in detail in Section 2.1.6.3—may be worsening, as more individuals likely turn to hunting as a means of survival amidst economic hardship.

5.1.3.1 Feasibility of alternatives to hunting

Considering the above, there is an urgent need to find alternatives to hunting on Bioko Island. However, these alternatives need to be attractive to the key individuals whose behaviour must change to make hunting more sustainable, i.e. commercial hunters and those who have the greatest impact on wildlife; otherwise, the substitution effect of the activity will not achieve the desired results (Coad *et al.*, 2013; Wicander *et al.*, 2014).

In the Pico Basilé, Basilé Fang stands out as a central key village for commercial hunting, with unique access to the PBNP and larger species, facilitated by the Pico Road (see Figure 2.2-1 and Section 3.3.1). My findings reveal a high concentration of specialised hunters (56%), defined as individuals who have exclusively engaged in hunting for several years and earned significantly higher incomes than other, less dedicated commercial hunters. Moreover, 37% of these specialised hunters had wives who were specialised traders, contributing nearly half (44%) of the household's annual income from hunting. Currently, Pico Basilé remains a hunting hotspot. According to the 2023 PBNP annual report, based on patrol data, "*despite efforts to reduce poaching and wildlife trafficking within the PBNP, and despite having a barrier to prevent unauthorized personnel from entering, Basilé Fang remains one of the most critical areas for illegal hunting, accounting for over 35% of the recorded extractions during the operations. Although Basilé Fang is one of the key hunting sites, hunters are increasingly targeting other areas of interest, such as Bombe and Moeri*" (INDEFOR-AP, 2024).

Basilé Fang is therefore a key area for management consideration, where transforming hunting practices is essential. The seminar-workshop held in Basilé Fang, which assessed hunters' and traders' willingness and capacity to engage in alternative livelihoods (Section 3.2.3.7), provided valuable insights. While some participants expressed willingness to engage in alternative activities – provided they offered higher profit margins - a distinct group of more experienced hunters, who earn the most from hunting, were resistant to change unless the new activities aligned with their interests and skills. These experienced hunters emphasised their desire to maintain a connection to the forest and would only consider roles such as Eco-guards or park guides. This feedback, along with their income data (see Section 4.1.7.2), is crucial for designing attractive, viable alternatives for this higher-impact group.

5.1.4 Rural diet and the contribution of wild meat

Household diets in the various villages sampled (and on Bioko in general) showed remarkable consistency. Local products, described in Section 4.1.5.1, along with wild meat, formed the basis of the traditional Bioko diet, as outlined in Gil-Esparza (2004) and Carrasco (1966). Over time, imported and frozen products became increasingly prevalent. In the Carrasco (1966) study, 80-90% of animal protein intake was derived from hunting and fishing and imported dried fish. In contrast, this study reveals a significant shift, with 60% of animal protein now coming from imported domestic meat and fish.

Wild meat (comprising both harvested invertebrates and hunted vertebrates), although consumed in all villages, was an infrequent food and a minor contributor (27%) to the

average daily intake of animal protein. Specifically, the protein contribution of hunted wild meat was 8.2 g·RA^{-1}·day^{-1} (16%), corresponding to 39.3 g·RA^{-1}·day^{-1} (median = 29 g) of meat. This amount is within the lower range of reported consumption of wild meat from hunting in other rural areas of West and Central Africa. Despite the inherent limitations of cross-site comparisons, Wilkie and Carpenter (1999) and Nasi *et al.* (2011) have suggested that a value of 130 and 140 g·person-^{1}·day^{-1}, respectively, may be indicative of typical consumption patterns in rural communities in the Congo Basin [corresponding to *c.* 170 g·AME^{-1}·day^{-1} and *c.* 185 g·AME^{-1}·day^{-1}- *c.* 1/3 more than per capita calculations (Wilkie *et al.*, 2005)]. Fa *et al.* (2022) also collated data from sixteen previous studies and converted grams of meat into grams of protein, and only two studies showed values below 10 g·person^{-1}·day^{-1}, while the rest ranged from 15.5 to 56.3 g·person^{-1}·day^{-1}.

The low levels of wild meat consumption in Bioko compared to those described in these studies are easy to understand. Wild meat becomes more important as a protein provider in places and at times when alternatives are scarce and expensive (Williamson, 2002; Swamy and Pinedo-Vasquez, 2014; Fa *et al.*, 2015). This is often the case in many rural areas of East and Central Africa (Cawthorn and Hoffman, 2015), in contrast to urban areas with greater access to affordable alternatives. However, this is not the case in the rural area of Bioko. During this consumption study, Equatorial Guinea was in a favourable economic situation (see Section 2.1.4.3). Domestic meat and fish, both frozen and imported, were available and affordable, not only in the city but also in most villages (with some differences that I discuss in next section), given the small size of Bioko Island and the good state of the roads. This availability was particularly evident in the villages in the north of Bioko (my sample), which were closer and better connected to the capital. Thus, while elsewhere there is a clear increase in wild meat consumption in rural areas compared to urban areas, my results for the rural area of Bioko did not show a higher consumption than that recorded by Albrechtsen *et al.* (2006) for the city of Malabo or that recorded by Fa *et al.* (2009) for the city of Bata in the continental region.

With alternative protein sources in both urban and rural areas consisting mainly of imported and frozen meat and fish, wild meat has become an important contributor to fresh and local meat. As in most Congo Basin countries (Nasi *et al.*, 2011), the livestock sector in Equatorial Guinea was very limited and the few animals raised in households were mainly reserved for celebrations and rituals (Section 4.1.2.3 and Kümpel, 2006). My results show that hunted wild meat contributes 40.4% to the total fresh animal protein consumed [20 g RA day-1 (median 12.5 g.)]. The remaining fresh animal protein came mainly from local fishing (27%), snails collected in the forest (26%), and a small proportion from fresh domestic meat (7%). These data are significant as they highlight a strong preference in Equatorial Guinea for fresh food over processed alternatives, with fresh food perceived as healthier and more nutritious (East *et al.*, 2005, Kümpel, 2006). This suggests that increasing the availability of fresh domestic meat and fish could potentially reduce the current demand for hunted wild meat, offering a viable alternative to support both food security and wildlife conservation.

The contribution of vegetable protein was also significant, representing 40% of the total protein intake, which amounts to 94.31 g·RA^{-1} ·day^{-1}. Concerning this figure, the contribution of wild meat was even less significant, representing only 8% of the total protein intake. This figure is considerably below that of domestic meat (24%) and fish

(23%), as well as that of the main vegetable groups, namely C&CP (13%) and SRT&F (13%), which had a much lower protein content but a much higher consumption per RA per day (Table 4.1-4). The wild meat species that contributed most were the resilient and fast-reproducing blue duiker (5%) and giant rat (4%), followed by the porcupine (1%) and squirrels (0,5%). In contrast, endangered species such as Ogilby's duiker and primates were not consumed. This higher proportion of resilient species, as opposed to the more occasional consumption of vulnerable and endangered species, is a general pattern observed in Central African communities (Bessone *et al.*, 2024).

Furthermore, the estimated total value of protein consumed is well above the recommended amount of 33-66 g per day to meet dietary needs, according to the FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (FAO/WHO/UNU, 2007) for sedentary adults of both sexes weighing between 40 and 80 kg. It is important to note that the lifestyles of the men and women in the villages were not precisely sedentary. Nevertheless, the total protein consumption of my sample is well above this figure. Given the low contribution of wild meat discussed above, it can be concluded that even without the consumption of hunted wild meat, the population around PBNP could meet their dietary needs for protein. This is provided that the documented levels of imports of both animal and plant foods, which contribute 67% (46% animal-based and 21% vegetable-based) of the total protein consumed, are maintained. Consequently, as proposed by Albrechtsen *et al.* (2006), maintaining import levels of meat and fish is also a viable conservation strategy that may be less costly than domestic production, which is still constrained by numerous unresolved issues**.**

5.1.5 Factors influencing consumption of wild meat and other sources of animal protein

Although wild meat contributed only a small proportion to the protein intake in the sample of villages, there were significant differences between villages. It was important to understand this variability and determine why some villages depended more on wild meat consumption than others. This understanding is necessary to design effective management interventions that meet the population's needs.

I hypothesised that differences in access (including availability and affordability) to alternative protein sources would cause these differences. Accordingly, I examined the influence of distance to alternative sources on animal protein intake and the interaction between different types of animal protein while considering the different socio-economic characteristics and food prices in the various villages (n=10).

In addition, for the subsample of villages where I had collected quantitative socioeconomic data (Basacato, Basilé Bubi, and Basilé Fang), I also analysed the influence of income on the consumption of wild meat and other protein sources. The characteristics of two of these three villages, which were comparable (thus controlling for possible confounding factors), but with one dedicated to commercial hunting with greater access to wildlife (Basilé Fang) and the other to subsistence hunting (Basilé Bubi), allowed me to further investigate the influence of income, wealth, and greater access to wildlife on protein intake. I hypothesised that commercial hunter households

were nutritionally favored over subsistence hunters due to their higher income from the wild meat trade and greater access to wild-animal protein. Accordingly, I investigated differences in income and wealth, and in protein intake, between the two villages.

5.1.5.1 Access to alternative protein sources

The results of Pearson's correlations and the geographic and socioeconomic characteristics of the various villages, summarised in Section 4.1.5.2.2, indicate that the consumption of protein from all wild meat (both hunted vertebrates and harvested snails) and its contribution to the total animal protein consumed increased significantly in the villages farthest from Malabo, with less availability of domestic meat and fish, and without employment opportunities. In the case of villages where commercial hunting was the primary economic activity (Copé and Bomá), there was an increase in the consumption of protein from both snails and hunted vertebrates, as well as in animal protein in general. In the case of villages mainly engaged in agriculture and with few economic resources (Inasa Maule), only the consumption of snail protein increased.

These results show the importance of wild meat consumption, both of hunted vertebrates and of harvested snails (the latter at least during the rainy season, the period from which the consumption data of this thesis come), in areas where access (which includes both availability and affordability) to alternative protein sources is more limited. They also show the different utilization of the type of wild meat, hunted or harvested, according to economic level: in Inasa Maule, by far the poorest village, households probably did not have sufficient resources to benefit from hunting, and therefore the consumption of wild meat protein came mainly from snails, while in Copé and Bomá, where they could afford the necessary hunting equipment, it came from both snails and hunted vertebrates (Figure 4.1-8). This is consistent with the explanation provided by De Merode *et al.* 2004 in their study of a community of poor households in the DRC, which also did not find high levels of consumption of hunted wild meat compared to the Wilkie and Carpenter's (1999) estimates. De Merode *et al.* (2004) conclude that household use of wild foods is determined more by social and economic constraints than by the abundance of the resource in the community and observes that poorer households (within an already impoverished community) are constrained from capitalising on the most valuable wild foods (i.e., wild meat and fish) as a source of food or cash income.

Other studies, such as that of Fa *et al.* (2009) in mainland Equatorial Guinea, or that of Starkey (2004) and Wilkie *et al.* (2005) in Gabon, also demonstrate a similar pattern to that of Bioko in terms of higher consumption of hunted wild meat in more isolated forest villages, as opposed to more coastal or urban villages with more domestic meat and fish alternatives. In these studies, fish consumption was highest in rural coastal areas. In contrast, for my sample of villages, the average fish protein consumption did not vary between villages, but the types of fish protein, fresh and frozen, did. While the amount of fresh fish protein consumed was negatively correlated with distance to the sea, that of frozen fish was positively correlated. The ratio of fresh fish protein to that of all other meat and fish also decreased significantly with distance to the sea, while that of frozen fish decreased with distance to Malabo. These results are to be expected given the situation of the fishing sector in Equatorial Guinea, which lacks the necessary conditions for the preservation and transportation of the resource. These findings also reflect the Bioko population's preference for fish, with a particular inclination towards

fresh fish. Furthermore, for the subset of villages with greater access to domestic meat or fish (i.e., all except Copé, Bomá, and Inasa Maule), a negative correlation was observed between the consumption of domestic meat protein and fresh fish protein. This can be interpreted as a preference for fresh fish over frozen meat when both are available, despite the fact that the average price per kilogram of fresh fish was 16.5% significantly higher than that of domestic meat (Section 4.1.5.1). These results are consistent with the studies of East *et al.* (2005) and Kümpel (2006) for the continental urban and rural regions, respectively, which found that there was a preference for fresh meat and fish, with fish being the most highly valued.

The study by Brashares *et al.* (2004) in Ghana on a large geographic scale also supports the importance of fish in the diet of rural communities and shows how it tends to replace wild meat in coastal and riverine areas. Consistent with this, my village-level results also show a significant and negative correlation between fish and wild meat consumption. This suggests that fishing villages situated at a considerable distance from the city of Malabo would likely consume a greater quantity of wild meat in the absence of fish. Conversely, non-fishing villages situated at a greater distance from Malabo, would likely consume a lesser quantity of wild meat if fish were available. These findings indicate the potential for local fisheries development, not only for enhancing food security in rural Bioko, but also for reducing the demand for wild meat in Bioko.

5.1.5.2 Income and wealth and access to wildlife

In the subset of households with quantitative socioeconomic and consumption data (n=22 in Basilé Bubi, Basilé Fang y Basacato), the intake of wild meat protein and other alternative protein sources and their contribution to total animal protein intake was not influenced by any socioeconomic variables (income, expenditure, and assets). However, there was a weak trend towards higher consumption of domestic meat and total animal protein in higher-income households.

Although the influence of economic factors (price of wild meat, price of alternatives and level of household income) on wild meat consumption is well established (as I discuss in Section 1.2.2.1 and as I have just demonstrated in the previous section), this influence is not observed in the households of these three villages. It should be noted that this is a small sample of households, which also have similar access to alternative protein sources (Section 4.1.6.1). On the other hand, although there are economic differences between households across the three villages, these differences are not as pronounced as when compared to more distant villages from Malabo, with no fishing options as discussed above.

In line with these results, the comparative study between Basilé Fang and Basilé Bubi also shows no differences in the consumption of hunted wild meat between the two villages. The households of commercial hunters in Basilé Fang were wealthier and generated more income from the wild meat trade compared to the households in Basilé Bubi, which were engaged in subsistence hunting. Furthermore, Basilé Fang households had greater access to a wider variety of wild meat, including larger species. However, protein intake from hunted wild meat was similar in both villages. No significant differences were found in the total animal protein consumption or in the consumption of plant protein either. The latter did differ in terms of origin, with Basilé Bubi (a village more focused on agriculture) mainly consuming plant protein grown by the households

themselves, while in Basilé Fang, a higher proportion of plant protein was purchased. The consumption of gathered wild meat (snails) did differ, being higher in Basilé Fang, but this is likely explained by the fact that two households in the sample were involved in their trade.

Thus, the results of this study reveal that although households engaged in commercial hunting possess greater wealth and better access to wild meat compared to those focused on subsistence hunting, this does not lead to higher wild meat consumption if both villages have similar access to alternative protein sources. Instead, the surplus of animals and the more valuable species obtained by BF households are primarily intended for sale rather than local consumption. This highlights the commercial nature of hunting in Basilé Fang and highlights the role of alternative protein availability in shaping consumption patterns.

5.1.6 Concluding remarks and alternatives to the use of wild meat

5.1.6.1 Promoting ecotourism as a source of income at national and local levels

Overall, hunted wild meat was not a major source of protein in the diets of people living around Pico Basilé National Park, who generally had access to domestic meat and fish, frozen and imported, and exceeded the recommended minimum daily protein intakes. However, it did provide an important source of income (and wealth) for rural households and resulted in one of the most profitable livelihoods along with wage employment and shop/bar trading.

Therefore, if hunting is to be reduced, alternative income-generating activities for the rural population must be developed. These initiatives must be designed with consideration for the preferences and capabilities of the population, particularly those who have the greatest impact on wildlife. Most of the commercial hunters in Basilé Fang who had the greatest impact on wildlife stated that they would accept an equally or more profitable alternative activity to hunting only if it allowed them to remain in contact with the forest. Among all the activities discussed in a seminar-workshop attended by numerous environmental institutions in Equatorial Guinea, the ones they accepted were eco-guard or park guide.

This, combined with the need to maintain imports to meet the recommended daily protein intake without increasing pressure on local resources, suggest that managing protected areas to promote ecotourism is an ideal strategy. On the one hand, it would help create employment opportunities for the rural population, especially for those who have a greater impact on wildlife (such as more experienced hunters who could become part of the Eco-guard staff). On the other hand, it would strengthen the country's economic level after the recession caused by the fall in oil prices that began in 2014 (aggravated with COVID-19 pandemic), which in turn would help maintain the level of food imports needed to meet protein intake requirements.[11]

[11] Details on the potential contribution of eco-tourism were discussed during the Biodiversity Week held in Malabo in 2015 (see page 214 in Appendix 2.1-2).

Equatorial Guinea possesses many of the necessary characteristics to effectively manage its protected areas and promote ecotourism, particularly in Bioko. Firstly, because of its particular and interesting geographical history that has given rise to the beauty and diversity of its landscapes and its enormous biodiversity in such a small space, of interest to tourists and researchers and of recognised value for conservation worldwide. Second, because of the development of its infrastructures, such as roads, hotels, an airport, telephone coverage and Internet access. In the case of the PBNP, also its accessibility, with the road that reaches the top, which allows potential visitors to stay in Malabo, the country's capital, and access the heart of the park in less than two hours. And finally, for the development of legislation and institutions in charge of the conservation and management of protected areas that already exists in Equatorial Guinea and Bioko (as I detail in Section 2.1.7), and the support they receive from NGOs and research groups that have been working in the field for a long time. In addition, management plans have already been drawn up, which, although with limitations and without having been politically recognized, have been implemented thanks to the efforts of INDEFOR-AP, the UNGE and their collaborating partners.

From my experience in Equatorial Guinea, I believe that INDFOR-AP would be able to carry out greater management of protected areas in collaboration with its partners if it had the necessary resources. They still need the support of researchers, conservators and managers to develop this management and continue to acquire greater training, but they are open to it, and have a great vocation for the conservation of the environment. Since the creation of the Faculty of Environment in 2005, which has developed numerous collaborations with foreign universities and NGOs both for research and conservation, many of its students (and from the University School of Agricultural, Fisheries and Forestry Studies) have become part of INDEFOR-AP. INDEFOR-AP for its part has also already developed numerous projects with NGOs and research groups, they have received training and have launched awareness programs and development of alternatives to hunting, but the main problem has been the lack of financial and long-term resources of both INDFOR-AP and its partners. In the case of INDEFOR-AP, this is mainly due to the absence of a firm political commitment to ensure a steady flow of funds, enabling INDEFOR-AP to effectively carry out the essential functions mandated by the government itself. For its partners, this challenge may stem from a lack of recognition for the work carried out by small NGOs and research groups, which often struggle not only to secure funding but also to sustain it over time. An example of this is the situation observed during the development of this thesis. In Equatorial Guinea, the government received substantial funding from international entities such as GEF and UNDP, among others, to implement projects aimed at conservation goals. However, these funds were poorly managed, and few of the established objectives were achieved. Notably, the few tangible outcomes that were attained resulted from the involvement of NGOs actively working in the field alongside INDEFOR-AP. It is precisely in this area where efforts must focus, building stronger support for the institutions that can truly drive meaningful change.

5.1.6.2 Enhancing local production of animal protein

While wild meat contributed only a small portion of the overall protein intake in most villages sampled, some villages with limited access to alternative protein sources showed a higher dependence on wild meat. This underscores the critical role that wild meat (both vertebrates and snails) and locally caught fresh fish play in ensuring food

security. These resources could become even more vital if the availability or affordability of imported frozen meat and fish diminishes, especially for poorer or more isolated families—a situation that may already be unfolding due to the country's ongoing financial crisis.

The development of alternative animal protein products, such as large and small livestock, has had its ups and downs (as detailed in Appendix 2.1-2). Large livestock development was only successful in the colonial period, specifically in the mossy forest clearings transformed into grasslands of the southern region. These areas have suitable climatic conditions, but the ecological impact of large-scale development would need to be assessed. After independence, government initiatives were developed but were frustrated by mismanagement.

The same has occurred with small-scale livestock farming. The Basilé Farm, established by German Cooperation in the 1980s in the village of Basilé Bubi, is a clear example of the potential effectiveness of such initiatives and the subsequent failure they can face due to poor management when transferred, in this case hastily, to the Equatoguinean side. This suggests that these types of projects should be sustained or co-managed for an extended period. Nevertheless, they always leave a legacy. The 'Basilé Farm' was a rural agricultural and livestock development project. It included a facility in the village of Basilé Bubi for training the rural population, which comprised a building for practical training and courses, as well as a laboratory. A cooperative garden was initiated, featuring a variety of products that are not typically grown in local agriculture but are instead imported. The farm also had pens for raising chickens, rabbits, geese, goats, and pigs. Local grinding machines and dryers were available for producing local feed from the crops grown in the garden. All individuals interviewed in Basilé Bubi who had contact with the farm spoke highly of its successful operations. A small community garden was left as a legacy in this village (the only garden recorded among the 10 sample villages), which has since been maintained by four individuals from two families. This garden allowed them to sell products that are typically not cultivated by the local population, providing both income and food.

On its part, the AAD also carried out a successful goat breeding project, and explored the breeding of wild species, particularly African poched rats. However, this initiative did not yield positive outcomes (Castelo, pers. comm.). According to Castelo, the rat breeding project aimed to replicate experiments conducted in other regions, published in scientific articles, by introducing male and female pairs into cement pits. These studies were based on the West African giant rat (*Cricetomys gambianus*), which is more docile than Bioko's species (*Cricetomys emini*). Additionally, Castelo mentioned that insufficient time was devoted to the project, as it lasted only one year, leaving no opportunity to implement new ideas, such as capturing already-pregnant females or testing alternative approaches.

Drawing on the insights gathered in this thesis, my work experience in Equatorial Guinea, and my involvement in developing small-scale livestock and family farming projects in Guanajuato, Mexico, I believe that promoting small-scale livestock farming in Bioko households could yield significant benefits. Utilizing the same species currently raised, a comprehensive training, guidance, and monitoring program would be essential—not only for the successful implementation of this initiative but also to

transform the perception of these animals from being reserved for special occasions to playing a consistent role in enhancing household nutrition and income generation.

This initiative could be particularly beneficial in more isolated villages, where access to imported products from the city and fresh fish is limited, resulting in a greater reliance on wild meat (both hunted and gathered). In these areas, small-scale livestock farming could bolster household nutrition and stimulate local sales. Similarly, villages closer to Malabo could also benefit and, in addition, could supply fresh domestic meat to city markets, contributing to a greater availability of locally sourced fresh meat for urban consumers. This, in turn, could potentially reduce urban demand for hunted wild meat.

On the other hand, the breeding of snails is another area that could yield very positive results. As various studies show, it presents numerous advantages and conveniences compared to breeding other types of wild meat or livestock (Adeyeye *et al.*, 2020), and it is an excellent source of animal protein, iron, and calcium (Kouassi *et al.*, 2007; Ngbolua *et al.*, 2022). In many West African countries, snail farming is experiencing rapid growth, especially on a small scale, and its contribution as a food resource and source of employment and income in both rural and urban households has been demonstrated (Adeyeye *et al.*, 2020; Adewale and Belewu, 2022). In Equatorial Guinea, it is not a widespread activity, although there are some very small-scale initiatives, such as the personal experience shared by the Dean of the Faculty of Environmental Sciences during the Seminar-Workshop. The AAD also conducted breeding projects, but the snails did not grow large enough to be attractive for sale in the market (Castelo, pers. comm.).

However, significant progress has been made since the AAD projects in 1995. Currently, snail farming is being promoted throughout Africa as both a backyard activity and a large-scale commercial enterprise, in both rural and urban areas (Adeyeye *et al.*, 2020; Meyo *et al.*, 2021). Its greatest development has occurred on a small scale. Therefore, there is a substantial amount of literature on the breeding of these species, particularly the species present in Bioko. It would be very interesting for the government and NGOs to promote their development.

The Faculty of Environmental Sciences and the University School of Agricultural, Fisheries and Forestry Studies of UNGE should also play an important role in research related to these initiatives.

As the results of my thesis show, the development of local fishing would strengthen food security and could also reduce the consumption of wild meat. However, this task is more complicated without significant government support and would undoubtedly take longer than the small-scale initiatives I have just mentioned.

5.2 Reproductive parameters and body condition of the Bioko blue duiker: implications for its sustainable management

In this section, I focus on the most hunted and consumed species, and thus the most economically important in the wild meat trade on Bioko: the Bioko blue duiker (*Philantomba monticola melanorheus*). The blue duiker (*Philantomba monticola*) is a highly abundant species, widely distributed across Central, Eastern, and Southern Africa, and is also among the most heavily hunted throughout its range (IUCN SSC Antelope Specialist Group, 2016). The lack of knowledge about its reproductive performance in the wild limits the accurate assessment of hunting sustainability (see Section 1.3.3.2).

In the following sections, I discuss the findings related to the reproductive performance and body condition of the Bioko blue duiker, as well as their implications for adaptive and sustainable management of the species, addressing the five research questions outlined in Section 3.3.4.

5.2.1 Overview

This study is among the few that estimate pregnancy rates—a fundamental component of most sustainability models—and is the first to provide data on body condition, reflecting energy reserves in wild blue duikers. Body condition, which is influenced by environmental factors, plays a critical role in reproductive performance. My research builds on previous studies by incorporating histological analyses of the reproductive tracts of hunted animals (but see Dubost and Feer, 1992) and by evaluating the impact of capture methods on body condition assessments.

The sample includes individuals captured across the altitudinal range of Bioko Island and from two distinct areas (north and south), enhancing its representativeness and enabling comparisons of biological parameters across three distinct habitats: lowland forest, montane forest, and mossy forest. Furthermore, a participatory methodology was employed, with data collection conducted in collaboration with hunters, traders, and students from the National University, laying the groundwork for participatory research initiatives for future wildlife monitoring on Bioko Island.

5.2.2 Validity of the KFI as a measurement of body condition in hunted blue duikers

Assuming that the KFI is a reliable indicator of total fat reserves in wild blue duikers, as demonstrated for other ungulate species (Smith, 1970; Monro and Skinner, 1979; Rioux and Diouf, 2006), my results further indicate that kidney weight does not exhibit seasonal variations across any age group, sex, or reproductive status. This satisfies the assumption that kidney weight remains a constant function of animal size and can therefore be included in an index for comparisons between animals of different sizes.

Although the potential distortion of KFI values due to seasonal variations in kidney weight has been investigated in other species (Batcheler and Clarke, 1970; Dauphine, 1975; Van Vuren and Coblentz, 1985), it had not been studied in the blue duiker.

The potential impact of hunting methods on KFI values warrants particular attention. As detailed in Section 3.3.4.2.1, energy loss and, consequently, a decline in body condition may occur during the period between when the animal is caught in the snare and when it either dies in it (47% of cases in my study) or is retrieved alive (53%). My findings, which show significantly lower KFI values in trapped animals compared to those shot, support this hypothesis. Animal welfare concerns associated with snares, including slow deaths and high rates of non-fatal wounding, have been documented (Noss, 1998). However, no studies have examined the effect of snares on KFI values. Most studies that have used the KFI to assess body condition have done so in animals hunted with shotguns. Yet, in many parts of Africa, including my study area, snares are a commonly used hunting method, highlighting the need to better understand how this method may impact KFI measurements.

My results, therefore, validate the use of the KFI for the Bioko blue duiker, and probably for the other subspecies, but warn that the KFI may be distorted for samples taken from trapped animals.

5.2.3 Pregnancy rates, body condition and body size: implications for sustainability assessments

The overall estimated percentage of pregnant females in my sample was 34%. Only three other studies have gathered data on pregnancy rates of wild blue duiker: (1) Noss (1995), who obtained a value of 27% by palpating foetus in the uterus, probably underestimating pregnancy rates (since in our study 52% of pregnant females were pregnant at embryonic stage and of these, 15% were only detected by histological analysis of reproductive tracts); (2) Hart (2000) (pregnancy rates quoted in Kingdon *et al.*, 2013), who inspected animals killed by local hunters and obtained a value of 79%, a figure that could have been even higher and (3) Dubost (1980) and Dubost and Feer (1992), whose studies incorporated very large sample sizes, and included histological analyses of reproductive tracts of hunted animals as well as direct observation of interbirth intervals in captive wild animals; their pregnancy rate was 53% and their interbirth interval of 399 days (corresponding with a pregnancy rate of 51%), respectively. The considerable differences between the latter two studies could be attributed to density-dependent response of reproduction (Gaidet and Gaillard, 2008) due to hunting pressure since in Hart's study hunting pressure was very high and density low (6.9-17.8 /km^2), while in Dubost's hunting pressure was very low and density substantially higher (70/km^2). In Pico Basilé, however, despite being an area subjected to high hunting pressure (Grande - Vega *et al.*, 2016), there were 45% less pregnant females recorded than in Hart (2000) and 20% less than in Dubost (1980). A possible explanation could be that higher population densities are likely on the island compared to the mainland because of a higher primary productivity and food availability due to the absence of predators, megaherbivores and competitors (Butynski *et al.*, 2001); and despite high extraction rates, populations are not diminished below a threshold beyond which pregnancy rates would rise. This explanation can only be

corroborated with appropriate data on duiker population structure and densities, and more extensive knowledge of the food supply and feeding ecology of the species throughout the island and in the different habitats. Body condition, which is an indicator of nutritional status and a proxy for habitat quality (Morellet *et al.*, 2007; Stephenson *et al.*, 2020), and exhibits the same density-dependent response as recruitment (increasing from high to low population densities) (Choquenot, 1991; Stewart et al., 2005; Gaidet and Gaillard, 2008), can aid in better understanding population dynamics. In this regard, a long-term study of reproductive rates and body condition, together with offtake surveys, would help to better understand these relationships.

My findings indicate that each pregnancy results in a single foetus, and births occur throughout the year, consistent with previous studies on this species both in captivity and in the wild (Wilson 2001; Kingdon *et al*. 2013). However, there is some evidence of seasonal patterns in parturition and conception in other regions. For instance, Dubost and Feer (1992) found that, in a study of seven ruminant species in northeastern Gabon, although all species produced young year-round, birth peaks occurred during the dry season among the four studied frugivores (three duikers, including the blue duiker, and the water chevrotain), whereas peaks were observed during the rainy season among the three folivore-herbivores (goats, sheep, and Bates' dwarf antelope). These authors suggested that the most important ecological factor explaining these birth peaks was food quality—such as the increased availability of edible fruits on the forest floor during peak birth periods. They also argued that food supply during fertilization and gestation stages could influence seasonality.

By using fat reserves (Kidney Fat Index, KFI), an indicator of short-term environmental favorability (Caughley, 1970), I observed better body condition (higher KFI) in males during the wet season, as well as better body condition (higher KFI) in females during the dry season. However, the differences in females did not meet the threshold for statistical significance ($p > 0.1$) and were only evident in the Pico sample. In turn, the highest conception rates were observed during the wet season, while the highest pregnancy rates and a higher trend in birth rates were observed in the Pico sample during the dry season. These results might align with Sinclair and Duncan (1972) and Clutton-Brock *et al.* (1982), who observed fat deposition peaks before the rut in tropical and temperate male ungulates, respectively, and with Stewart *et al.* (2005), who showed that body condition influences whether female elk become pregnant. These studies underscore the different ways in which males and females interact with their environment— females prioritise investment in offspring, while males focus on copulation. My KFI results for females, showing the highest values during pregnancy and the lowest during lactation, also support this pattern, reflecting an accumulation of fat reserves before birth and lactation, which are the most energetically demanding periods for females (Oftedal, 1985; Clutton-Brock *et al.*, 1989).

Unlike most Bovids, duiker females are slightly larger than males (Castelló, 2016). My data on body weight and measurements suggest a slight difference between sexes and show that the Bioko subspecies is the smallest for the species. Adult females weigh 1.6-1.8 kg less, and adult males 0.9-1.4 kg less than reported by Dubost (1980) for Gabon, Payne (1992) in Cameroon and Wilson (2001) in eight localities of Sub-Saharan Africa (including Zanzibar Island). Mean height at shoulder is 1.8-4.0 cm less in females and 1.4-4.4 cm less in males, whereas total body length is 3.5-11.0 cm less and 6.0-10.5 cm less for Bioko females and males respectively compared with other subspecies. These

differences are sufficient to suggest that the lower body mass of the Bioko subspecies should be used when estimating biomass extraction or when using Caughley & Krebs' (1983) equation to calculate its r_{max}. However, overall value for r_{max} calculated from Cole's (1954) equation (0.22) was around four times lower than when using Caughley and Krebs' (1983) formula (0.96). These findings are consistent with those reported by Van Vliet and Nasi (2008), which noted similar discrepancies for the blue duiker, but not for others duikers. These discrepancies suggest that the method chosen to estimate r_{max} for the blue duiker can significantly influence sustainability assessments. While Caughley and Krebs' formula provides a practical alternative when detailed reproductive data are unavailable, its reliance on weight alone may overestimate population growth potential, potentially leading to overly optimistic sustainability thresholds. Therefore, incorporating more precise reproductive parameters, as in Cole's equation, should be prioritized whenever possible to ensure accurate evaluations of wildlife exploitation levels.

Previous sustainability assessments for the blue duiker (including those conducted for Bioko) have used Cole's equation but have not estimated local pregnancy rates to calculate r_{max}. Instead, they have used productivity values obtained from captive species, from estimates from localities other than the study population or simply divided by the gestation period (as summarised in Table 5.2-1). Several authors (Milner-Gulland and Akçakaya, 2001; Negrín, 2011) suggest that r_{max} is best computed from information directly obtained from the local populations for which sustainability calculations are to be conducted. In this study, I estimated productivity from local pregnancy rates to calculate r_{max} although ages at first and last reproduction (a and w, respectively) were taken from captive data. These pregnancy rates differed significantly from previous studies of the same species, both for animals in captivity and in the wild and, my r_{max} was considerably lower than if I had used non-local data (even from populations subject to high hunting pressure, like my study area) or data from captive populations. This comparison is presented in Table 5.2-1, where I also review the sources and calculations of the reproductive parameters used in previous blue duiker studies to estimate r_{max} (see footnotes). Using the same values of w and a as each author, but employing my own productivity values to calculate b (based on gestation duration, pregnancy rates, and litter size, as detailed in Section 3.3.3.5), I obtained an r_{max} approximately two times lower than that from Fitzgibbon *et al.* (1995), almost 3 times lower than that from Payne (1992) and around six times lower than that from Noss (1995). These differences highlight the importance of incorporating local reproductive data, in agreement with these authors, as non-local or captive data may (in this case) overestimate productivity and, consequently, impact sustainability assessments. This may also have occurred in the previous assessments shown in Table 5.2-1.

Table 5.2-1 Comparison of annual gross productivity (young/female), female birthrate (*b*) and intrinsic rate of natural increase (r_{max}), between previous studies and this one.

	Noss (1995)	This study[a]	Payne (1992); Fa *et al.* (1995)	This study[a]	Fitzgibbon *et al.* (1995)	This study[a]
Gross productivity	0.9[b] – 1.7[c]	0.56	1.7[d]	0.56	1[e]	0.56
b (per female)[f]			0.689	0.28	0.5	0.28
b (per individual)[g]	0.23 – 0.43	0.14				
a	1.5 - 2.5	1.5 - 2.5	1.09	1.09	1	1
w	10	10	7	7	10	10
r_{max}	0.11 – 0.29	0.02 – 0.05	0.49	0.17	0.39	0.22

[a] Using the same values of *w* (age at last reproduction) and *a* (age at first reproduction) as each author in the previous column, but applying my own gross productivity data (number of offspring per female per year) and gross fecundity (*b*, annual birth rate of female offspring), we recalculated r_{max} using Cole's (1954) equation: $1=e^{-rmax}+be^{-rmax(a)}- be^{rmax\,(w+1)}$ (see Sections 1.2.1.1 and 3.3.3.5).

[b] Noss (1995) used Dubost's (1980) interbirth interval (from wild animals) of 399 days to calculate gross productivity (parturitions per year*litter size): 365/399*1=0.9 young per female per year (see Section 3.3.3.5).

[c] Noss (1995) provided a second calculation of gross productivity assuming no interval between parturition and conception, thus using only the gestation length given by Wilson (2001) of 205 days: 365/205 *1 = 1.7 young per female per year.

[d] Payne (1992) used Von Ketelhodt (1977) interbirth interval (from captive animals) of 265 days to calculate productivity: 365/265 * 1= 1.7 young per female per year.

[e] Fitzgibbon *et al.* (1995) gave no explanation on how the figure was calculated for Duikers spp.

[f] The gross fecundity or birthrate of female offspring (*b*) is typically calculated as a proportion of total adult female population. Thus, assuming a 1:1 foetal birth ratio, *b* is obtained by dividing gross productivity by 2

[g] Noss (1995), however, calculated the annual birthrate of female offspring as a proportion of total population. Thus, assuming a 1:1 foetal birth ratio and a 1:1 population sex ratio, *b* is obtained by dividing gross productivity between 4.

5.2.4 Concluding remarks and future directions: participatory and long-term research for sustainable and adaptive management

Similar to Negrín (2011), and for the first time in an African context, this study demonstrate how by collaborating with traders and hunters it is possible to gather large amounts of reproductive and body condition data of a tropical forest ungulate. This information, when accompanied by histological analyses of ovaries and uteri, can provide a more accurate estimate of pregnancy rates and, consequently, of r_{max}, leading to improved assessments of the sustainability of wild fauna resources. As a result of this approach, I uncovered inaccuracies of productivity values in previous studies used to calculate r_{max} for the blue duiker, which may have resulted in a possible overestimate of the maximum sustainable harvest. My study provides more realistic biological parameters for use in the estimation of hunting sustainability of the blue duiker in Bioko. However, it is important to consider that r_{max} is not a fixed value for a population and may vary over time. The r_{max} values obtained in this study can be used to assess the sustainability of blue duiker hunting in Bioko during the period when reproductive data were collected (2013-2014) and to compare them with the trends reported by Grande-Vega *et al*. (2016) for approximately the same period (2010-2013) using CPUE data. For instance, the Potential Biological Removal (PBR) index could be applied. The PBR

is the number of individuals of a species that can be sustainably removed per unit area per year (Wade, 1998). As discussed in Section 1.2.1.1, this index is more suitable than the Robinson and Redford's (1991) model (used in previous sustainability assessments of species mentioned in Table 5.2-1), as it incorporates uncertainty and is more precautionary, making it more applicable under realistic conditions. The PBR is calculated using the formula:

$$PBR = N_{min} \cdot (r_{max}/2) \cdot F_r$$

where N_{min} is a conservative estimate of population size and Fr is a recovery factor ranging from 0.1 to 1.0, depending on the conservation status of the species (with lower values assigned to more threatened species). With r_{max} available, only N_{min} needs to be calculated. Using CPUE and effort data, and knowing the extraction area, a model can be developed to relate CPUE to density and estimate N_{min}.

Using the data collected in this thesis, it would be possible to calculate the PBR for the same period during which Grande-Vega *et al.* (2016) evaluated CPUE. This could reinforce their findings and provide a better understanding of the impact of hunting during that period, when other recent studies also reported variations in the supply of the blue duikers in the markets (Mitchell *et al.*, 2024). However, this situation may have changed, and as discussed in Section 1.2.1.1, a prey population can only be considered sustainably exploited after sufficient time has passed to evaluate whether population estimators are sufficiently accurate, predictions are met, and the system remains stable. Therefore, to ensure the effective management of the Bioko blue duiker, I recommend repeating extraction, reproduction, and body condition studies over time, and monitoring fluctuations in the combination of these parameters and sustainability measures (PBR and CPUE), which would allow for quantifying changes occurring in the population-habitat system over time.

Collaboration between researchers, local communities, and managers facilitates the implementation of these studies with relative ease, directly linking science and management. The small size of the island further supports these collaborations. Both UNGE and INDEFOR-AP are headquartered in the capital, Malabo (the island's only urban centre), located just a few metres from each other. Additionally, the Pico Basilé National Park is only 15 km from the city, surrounded by well-connected villages with good road access to the city. The inclusion of longitudinal studies as part of university practical training, in collaboration with the management activities of INDEFOR-AP and with the participation of hunters and traders, represents a feasible and desirable strategy. This initiative would not only benefit blue duiker (and potentially other species) management but also strengthen the research capacity of the National University of Equatorial Guinea (UNGE), placing this knowledge at the service of sustainable management. Furthermore, as UNGE is the only university in the country, the technical staff of INDEFOR-AP is largely composed of former UNGE students, reinforcing the idea that these initiatives directly contribute to the training of future INDEFOR-AP personnel. Likewise, these activities would promote the participation and awareness of local communities, generating a positive impact on their relationship with biodiversity conservation. The progress achieved during the development of this thesis demonstrates that this approach is not only viable but could also be sustained over time as part of a long-term monitoring program for the sustainable management of the species.

Chapter 6: CONCLUSIONS

Overall, hunted wild meat was not a major source of protein in the diets of people living around the PBNP, who generally had access to domestic meat and fish, frozen and imported, and exceeded the recommended minimum daily protein intakes. Participation in commercial hunting did not lead to higher wild meat consumption, unless access to alternative protein sources was also limited.

Despite its limited role in nutrition, commercial hunting was a significant source of income and wealth for rural households, ranking among the most profitable livelihoods alongside wage employment and shop/bar trading. Although income from hunting was comparable to that from wage employment, local communities expressed a clear preference for formal jobs, as indicated by both statistical associations and interviews with hunters and traders. These preferences underscore their desire for economic stability and security, with hunting often serving as an alternative livelihood when employment opportunities are lacking.

The local economic landscape, shaped by rising unemployment and the broader economic crisis in Equatorial Guinea, raises concerns about increased overexploitation of wildlife on Bioko. If hunting is to be reduced, alternative income-generating activities for rural populations must be developed. These initiatives should be designed with consideration for the preferences and capabilities of the population, particularly those most involved in hunting. Basilé Fang, a key hunting village on Pico Basilé, deserves special attention in management plans. Many commercial hunters and traders expressed a willingness to switch to equally or more profitable alternatives, but those with more experience, who exerted the greatest impact, indicated this willingness only if they could remain connected to the forest, such as through roles as eco-guards or park guides. This openness to change presents a significant opportunity for conservation efforts, suggesting that it may be possible to shift away from hunting and toward more sustainable livelihoods with the proper support.

Ecotourism emerges as a promising solution. On one hand, it would create employment opportunities for the rural population, particularly for those who have a greater impact on wildlife, such as more experienced hunters who could transition into eco-guard roles. On the other hand, it would bolster the country's economy in the wake of the recession triggered by the decline in oil prices starting in 2014, a situation exacerbated by the COVID-19 pandemic. This economic recovery would, in turn, help sustain the level of food imports necessary to meet protein intake requirements without placing additional pressure on local resources, such as wildlife.

The potential for ecotourism is powerful on Bioko Island, which boasts rich biodiversity, striking landscapes, and existing conservation infrastructure. The PBNP, located near the capital city of Malabo, is ideally positioned to attract tourists, and therefore deserves proper attention. Additionally, conservation legislation and institutional frameworks, such as INDEFOR-AP, provide a solid basis for management. The potential for change is real, but it will require sustained commitment, collaboration, and financial investment.

While future efforts to reduce wildlife overexploitation should focus on achieving effective management of protedted areas, complementary initiatives to develop local animal protein sources must also be explored. Additionally, the training and awareness-raising activities of conservation groups, which are crucial for ensuring the long-term success of conservation efforts, must continue to be supported.

Collaboration between the UNGE and other external researchers, INDEFOR-AP staff, and local communities —particularly hunters and traders— has proven effective in gathering critical data for wildlife monitoring. This cooperative approache is crucial for obtaining productivity data on species like the Bioko blue duiker, which are essential for assessing the sustainability of hunting practices. Previous assessments of the blue duiker's hunting sustainability often overestimated sustainable yields due to reliance on productivity data from captive or non-local populations, emphasizing the need for more accurate, localized evaluations.

My research provides more accurate biological parameters for evaluating the sustainability of blue duiker hunting on Bioko and demonstrates the importance of long-term data collection to draw robust conclusions and inform sustainable management practices. I therefore propose the implementation of longitudinal studies on reproductive rates, body condition, and catch per unit effort (CPUE). These studies could be integrated into the practical training of UNGE students and included in the INDEFOR-AP's monitoring plans for the PBNP, to enhance understanding of population-habitat dynamics necessary for the species' sustainable management.

By applying the framework established for the blue duiker, these studies can be transferred to other ecologically and economically significant species of the island, enabling us to expand our understanding of population-habitat dynamics for multiple species and providing the foundation for sustainable and adaptive wildlife management across the island.

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Appendices

Appendix 2.1-1 Review of Legislation and Projects Related to the Environment and Development in Equatorial Guinea

REVISIÓN

DE LA LEGISLACIÓN Y PROYECTOS RELACIONADOS CON EL MEDIO AMBIENTE Y EL DESARROLLO EN GUINEA ECUATORIAL.

Revisión realizada para el proyecto *"Evaluación del problema de la caza en el Pico Basilé y plan para su gestión sostenible y monitorización continua a lo largo del tiempo".*

María Grande Vega
Malabo, Diciembre 2011

ÍNDICE

INTRODUCCIÓN

El objetivo de esta revisión es informar a conservacionistas y ejecutores de futuros proyectos presentando resumidamente la situación actual del Medio Ambiente en Guinea Ecuatorial y las experiencias pasadas, con el fin de situarlos en el contexto actual y darles a conocer los logros y fracasos obtenidos en los proyectos en este país realizados.

Los primeros en ser informados seremos nosotros mismos ya que este documento nos ayudará a tener una visión más clara de las posibilidades reales de gestionar una caza sostenible en el Pico Basilé, por lo que lo utilizaremos de apoyo para redactar las propuestas que son objetivo último de este proyecto y que haremos en los talleres de discusión previstos para este mismo mes.

El documento se compone de dos partes fundamentales: Por un lado el apartado primero que recoge los proyectos revisados y las entidades visitadas para la recogida de información y por otro, el apartado segundo, donde se expone y analiza brevemente toda esta información recogida.

1. DOCUMENTOS REVISADOS Y ACTIVIDADES REALIZADAS PARA LA OBTENCIÓN DE INFORMACIÓN

Previo a la realización de este análisis se estudiaron a fondo los siguientes:

A. Planes y proyectos nacionales:

- ***Plan Nacional de Desarrollo Económico y Social "Guinea Ecuatorial 2020", Agenda para la diversificación de las fuentes del crecimiento***. Ministerio de Planificación, Desarrollo Económico e Inversiones Públicas.

- ***Estrategia y Plan de Acción para la Conservación de la Biodiversidad en Guinea Ecuatorial.*** Ministerio de Pesca y Medio Ambiente. Aprobada mediante el Decreto Num. 171/2005, tras los compromisos adquiridos como Parte de la Convención sobre la Diversidad Biológica.

- ***Strengthing the National System of Protected Areas in Equatorial Guinea for the Efective Conservation of Representative Ecosystems and Globally Significant Biodiversity*****.** Ministerio de Pesca y Medio Ambiente, UNDP y Conservación Internacional. Proyecto que forma parte del programa estratégico de GEF para el manejo forestal sostenible en la Cuenca del Congo.

- Los **proyectos del Fondo de Desarrollo Social** (creado en 2006 a partir del Memorando de Acuerdo firmado por USAID y el Gobierno de la República de Guinea Ecuatorial para la implantación de proyectos sociales financiados por el Gobierno Guineano y con la asistencia técnica de USAID); en especial el ***Proyecto de Auto-Empleo de la Mujer Rural (PRAMUR),*** para el refuerzo de las agrupaciones femeninas agrícolas, del Ministerio de Asuntos Sociales y Promoción de la Mujer (MINASPROM).

La doctoranda María Grande Vega se reunió además con sus responsables para discutir los logros y dificultades de estos proyectos y las posibilidades de contribuir con los resultados de nuestro proyecto. En concreto con:

- Antonio Michá: Ministerio de Pesca y Medio ambiente y GEF operational Focal Point.
- Santiago Engonga: Director General de Medio Ambiente. Ministerio de Pesca y Medio Ambiente.
- Ligia Carvajal: Chief of Party, DAI USAID/Pat Equatorial Guinea.
-Valeriano Elías: Jefe del proyecto PRAMUR. Ministerio de Asuntos Sociales y Promoción de la Mujer.

También fue invitada por el Ministerio de Pesca y Medio Ambiente a asistir a:

1) Reunión de la Comisión local de Aprobación de los Proyectos (CLAP): AREAS PROTEGIDAS, APOYO A LA AGENCIA GUINEA ECUATORIAL 2020, DESERTIFICACIÓN, Y PROGRAMA NACIONAL DE DESARROLLO LOCAL. Celebrada en Malabo el 4 de Febrero de 2011.

La reunión consistió en la presentación de los 4 proyectos del marco de ejecución del Plan de Acción del Programa País (CPAP) 2008-2012, firmado entre el Gobierno de la República de Guinea Ecuatorial y el Progama de las Naciones Unidas para el Desarrollo (PNUD):

- Fortalecimiento del sistema nacional de áreas protegidas en Guinea Ecuatorial para la conservación efectiva de los ecosistemas representativos y de biodiversidad de importancia mundial.

- Apoyo a la Agencia Nacional Guinea Ecuatorial 2020 en la implementación del Plan Nacional de Desarrollo Económico y Solial (PNDES)

- Reforzamiento de las capacidades individuales, legales e institucionales para la Gestión Sostenible de Tierras y Bosques en Guinea Ecuatorial

- Apoyo al Programa Nacional de Desarrollo Local (PNDL)

Con su posterior debate (comentario y contribución del documento del proyecto, discutido por todos los invitados) y su posterior aprobación por la comisión.

Los participantes de esta reunión fueron miembros de:

- Ministerio de Planificación, Desarrollo Económico e Inversiones Públicas
- Ministerio del Interior
- Ministerio de Pesca y Medio Ambiente
- International Conservation (IC)
- Instituto Nacional de Desarrollo Forestal (INDEFOR)
- ONG ANDEGE
- Bioko Biodiversity Protection Program (BBPP)
- Ministerio de Sanidad
- Oficina del PNUD
- Ministerio de Asuntos Exteriores

2) Seminario-Taller de lanzamiento del proyecto; FORTALECIMIENTO DEL SISTEMA DE ÁREAS PROTEGIDAS EN GUINEA ECUATORIAL PARA LA CONSERVACIÓN EFECTIVA DE LOS ECOSISTEMAS REPRESENTATIVOS Y DE LA BIODIVERSIDAD DE IMPORTANCIA GLOBAL. Celebrado en Bata del 25 al 28 de abril de 2011.

El objetivo del seminario era apoyar a los diferentes actores implicados en el entendimiento y la apropiación de las metas y los objetivos del proyecto, así como a la aclaración de la estrategia de implementación durante toda la fase operativa del proyecto. Participaron: El Ministerio de Pesca y Medio Ambiente, Ministerio de Agricultura y Bosques, UNGE, INDEFOR, CI, la Sociedad Zoológica de Londres (ZSL), BBPP, las ONGs ANDEGE y ADMAD y líderes comunitarios de las diferentes áreas protegidas. Se realizaron activas discusiones y se hicieron varias recomendaciones las cuales fueron tenidas en cuenta para la mejora del proyecto.

Así pues, la comunicación y el intercambio de información con estas instituciones, y la profundización en el conocimiento de sus proyectos, en especial con el Ministerio de Pesca y Medio Ambiente, INDEFOR, ONG

ANDEGE, IC, ZSL y BBPP y especialmente en relación al proyecto FORTALECIMIENTO DEL SISTEMA DE ÁREAS PROTEGIDAS EN GUINEA ECUATORIAL PARA LA CONSERVACIÓN EFECTIVA DE LOS ECOSISTEMAS REPRESENTATIVOS Y DE LA BIODIVERSIDAD DE IMPORTANCIA GLOBAL.

B. Decretos y Leyes

Ley nº 8/1988, de fecha 31 de diciembre, Reguladora de la Fauna Silvestre, Caza y Áreas protegida.

Ley nº 4/2000, de fecha 22 de Mayo sobre Áreas protegidas en la República de Guinea Ecuatorial

Ley nº 7/2003 Reguladora del Medio Ambiente en Cunea Ecuatorial

Ley Num.72/2007, de fecha 27 de octubre, por la que se prohíbe la caza, y el consumo de monos y otros primates en la República Guinea Ecuatorial.

Decreto nº 172/2005 de fecha 8 se septiembre, por el que se regula el comercio de especies amenazadas de fauna y flora silvestres en la República de Guinea Ecuatorial

Además hemos revisado dos revisiones de la legislación, de las cuales nos informó CI:

- Situación legal del sector bosque-medio ambiente de Guinea Ecuatorial: Aplicabilidad, pluralismo y conflictos interinstitucionales. Por Diosdado Obiang Mbomio (Conservación de los Ecosistemas forestales de África Central- ECOFAC, IV Fase). 2008.

- Las leyes del sector bosque-medio ambiente de Guinea Ecuatorial: pluralismo y conflictos interinstitucionales. Por Crisantos Obama (ONG ANDEGE-CI-USAID). 2009.

C. Proyectos de entidades internacionales

- ***Working with local communities to evaluate, test and implement potencial bushmeat alternatives in Equatorial Guinea***. Zoological Society of London (ZSL).

- Programas y proyectos de ***Bioko Biodiversity Protection Programme (BBPP, www.bioko.org).***

- ***Proyecto de Apoyo a la Sociedad Civil (PASC)***, del 9º FED (Fondo Europeo de Desarrollo), enmarcado en el Programa de Buena Gobernabilidad que el Fondo Europeo de Desarrollo viene financiando desde el 8º FED y cuyo objetivo es apoyar las organizaciones de la sociedad civil.

- Borrador del ***Programa Nacional de Seguridad Alimentaria de Guinea Ecuatorial*** que está actualmente redactando la FAO por encargo del gobierno de Guinea Ecuatorial como parte de las acciones contempladas en el componente agrícola (conocido como CAADP) de la Nueva Alianza para el Desarrollo de África **(NEPAD)**, que fue lanzada por la Unión Africana.

- ***Proyecto de Rehabilitación del Sector del Cacao y diversificación del a producción***. Financiado por la Comisión Europea y la Cooperación Española (1993-2000)

Y nos hemos reunido también con sus responsables:

-Alberto Orrú Ati: Coordinador del PASC. Comisión Europea.
-Dr. Noëlle Kümpel: Directora de *Bushmeat and Forests Programme* de la Sociedad Zoológica de Londres (ZSL).
-David Gill: Director del proyecto "*Working with local communities to evaluate, test and implement potencial bushmeat alternatives in Equatorial Guinea*", Zoological Society of London (ZSL)

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-Heidi Ruffler: Directora en Guinea Ecuatorial de Conservación Internacional (CI).
-Fidel Esono Mba: Director de INDEFOR-AP (Instituto Nacional para el Desarrollo Forestal de Guinea Ecuatorial).
-Elizabeth Congdom: Directora del "Research Moka Wildlife Center" de BBPP (www.bioko.org).
- Dr. Athman Mravili, representante de la FAO en Guinea.
- Luís Acevedo González: actual director de Casa Mallo S.A (la única empresa privada que a día de hoy continúa explotando cacao) y coordinador del *Proyecto de Rehabilitación del Sector del Cacao y Diversificación de la Producción,* en sus dos fases (1993-1997 y 1998-2000)

D. Proyectos de Cooperación

Por último recopilamos también información sobre *los proyectos financiados por la Cooperación Española* (a parte del arriba mencionado*)* en el presente y en el pasado, especialmente los relacionados con el Medio Ambiente, reuniéndose con miembros de la AECID y con miembros de las entidades ejecutoras de dichos proyectos, en concreto:

- Lucía Longil: Coordinadora de Programas (AECID).
- Carlos Contreras: Director del Centro Cultural Español de Malabo (MAEC-AECID).
- Ramón Castelo Álvarez: profesor de la Facultad de Medio Ambiente (FMA) de la UNGE y coordinador de: (1) ***'Programa de Investigación y Conservación de la naturaleza en Guinea Ecuatorial'*** (1985-1992), AECI-ONG Amigos de Doñana (AAD), y (2) ***'Conservación y Ecodesarrollo en el Sur de la Isla de Bioco II (Guinea Ecuatorial)'*** (1996-2002), AECI-UE-Fondos Canadienses-AAD.
- Rigoberto Esono Anvene: Jefe del Departamento de Estudios Técnicos Medio Ambientales de la FMA de la UNGE y miembro de la ONG local Amigos de la Naturaleza y Desarrollo de Guinea Ecuatorial (ANDEGE).

De los proyectos de la Asociación Amigos de Doñana obtuvimos toda la información que pedimos, sin embargo de la Granja de Musola de la Cooperación Española no se encontró toda la información debida. En cuanto a los proyectos realizados por la Cooperación Alemana (Granja de Basilé Bubi) y la Cooperación Sudafricana (Proyecto de explotación ganadera de vacas sudafricanas en Moka) fue imposible recopilar información por parte de las entidades ejecutoras. Por un lado la Cooperación Alemana nos informó de haber borrado los informes del proyecto al haber sido realizado hacía más de 15 años. Por otro lado nos fue imposible dar con la persona adecuada de la Cooperación Sudafricana. Sin embargo (y al igual que para la Granja de Musola) pudimos recoger información a partir de la gente que participó en dichos proyectos y vivió su puesta en marcha, su desarrollo y su decadencia. Por lo que pudimos recopilar valiosa información.

2. ANÁLISIS

2.1. Proyectos relacionados con la conservación

Como ejemplos de éxito tenemos:

2.1.1. Los proyectos llevados a cabo por la Asociación Amigos de Doñana (1985-2000)

Cuando esta asociación comenzaba a funcionar, Guinea Ecuatorial se restablecía después de sufrir una larga dictadura en la que los temas relacionados con el medio ambiente, la conservación de la naturaleza y su uso sostenible habían estado totalmente relegados. Así pues había mucho por hacer y mucho se hizo: investigación científica, creación de un Museo de Historia Natural, de una legislación medioambiental actualizada, establecimiento de una red de áreas protegidas, participación de Guinea Ecuatorial en los foros internacionales, formación de personal, educación ambiental, desarrollo del ecoturismo, organización de equipos de vigilancia y control en la áreas protegidas, experimentación de cría de especies silvestres,

economatos, granjas, conservación de las tortugas en el sur de Bioko, etc. Todos estos proyectos dieron grandes resultados. Hasta el 21 de enero de 1998, fecha en la que se produjo un levantamiento armado de carácter político-étnico en el sur de la Isla de Bioko, con varios muertos y multitud de detenidos que dificultaría en adelante todos los movimientos de la Asociación. Ello hasta el punto de tener que abandonar por completo todas las actividades en el año 2000. A ello contribuyó también la falta de apoyo de la Administración del país que desde el comienzo de las explotaciones petrolíferas comenzaron a desinteresarse por las actividades relacionadas con el medio ambiente. La Cooperación Española también centro más su financiación para Guinea E. en proyectos culturales, educativos y, en menor medida, sanitarios. Todo ello contribuyó al declive total de todas estas actividades, sin embargo se sentaron las bases y se dejó a gran número de personal formado.

2.1.2. Proyecto de Conservación de los Ecosistemas Forestales en África Central (ECOFAC)

Este amplio proyecto que, financiado por la Unión Europea y a partir de 1999 cofinanciado por la Agencia Española de Cooperación Internacional, englobaba varios países y acogió en 1992 a una de las áreas protegidas de Guinea Ecuatorial: Monte Alén (posteriormente declarada Parque Nacional). Ello previa confección y aprobación de la ley nº 8/88 sobre la fauna y especies protegidas, en la cual se proponía, que junto con otras áreas, Monte Alén fuera declarado Parque Nacional. Esta ley fue resultado de uno de los proyectos llevados a cabo por la Asociación Amigos de Doñana. ECOFAC dotó de infraestructuras al parque (oficinas, laboratorios, viviendas para los trabajadores e investigadores, campamentos en el interior del parque y un pequeño hotel para visitantes). Gran parte de los trabajadores que se contrataron habían sido cazadores. Se realizaron estudios y apoyaron trabajos de investigación para el mayor conocimiento del parque. Se realizaron programas de apoyo a la población como la apertura de economatos, la cría en cautividad de especies autóctonas, el transporte de productos agrícolas a los mercados de Bata, y un programa de salud pública (construcción de dispensarios). El hotel y los campamentos impulsaron el turismo y Monte Alén se convirtió en un punto de visita obligada para cualquier persona que residiese o acudiese a Guinea Ecuatorial. Se había creado además un centro de interpretación. Para el año 2000 el parque producía suficientes ingresos para su propio mantenimiento, hasta dos escuelas se llegaron a hacer con fondos del parque. Hasta esa fecha el parque estuvo financiado en un 80% por la UE y en un 20% por el Gobierno de Guinea Ecuatorial. La idea era ahora ir reduciendo los fondos y traspasando la gestión a la parte nacional. Por lo que las siguientes fases del proyecto ECOFAC (2002-2004 y 2006-2009) tuvieron una menor dotación económica. La UE sugirió la privatización del Hotel, pero esto no se hizo. A partir de aquí la gestión de los fondos comenzó a presentar serios problemas y a dificultar las actividades. El turismo se mantuvo hasta el año 2006 pero después desapareció por completo. Las actividades se fueron reduciendo. En la III y la IV Fase se mantuvo algo de patrullaje, seguimiento ecológico, sensibilización y apoyo al desarrollo agrícola. También se promovió el desarrollo de INDEFOR y se aclararon sus funciones (sería el encargado de velar por la protección de las áreas protegidas) y se dio capacitación y apoyo. Pero en Julio de 2009 se termina la IV fase y finaliza la financiación. Para la V fase de ECOFAC Guinea E. fue excluida del programa. Actualmente muchas de las infraestructuras se han perdido pero desde Julio de 2011, fecha en la que el Parque ha vuelto a recibir unos fondos del Gobierno de Guinea Ecuatorial los trabajos de recuperación han comenzado.

A pesar de este declive, el proyecto de ECOFAC ha demostrado el éxito de una buena gestión de un Parque Nacional en Guinea Ecuatorial. El proyecto ha dejado también a un gran número de personas capacitadas e ilusionadas a la par que valiosas, tanto en el Parque como en INDEFOR. La misma población recuerda con nostalgia el proyecto y hace patente su deseo de que vuelva a funcionar. Muchos de los cazadores que trabajaron como guardas forestales preferirían recuperar su trabajo. Parece que casi ninguno ha perdido la esperanza de obtener los medios y el apoyo suficiente, por parte del Ministerio de Agricultura y Bosques, para volver a ponerlo todo en marcha.

Así pues podríamos decir que hasta el año 2000 fue la época dorada de la conservación en Guinea E. Pero a partir de aquí cabe mencionar también los proyectos que resumimos en los siguientes apartados.

2.1.3. Los proyectos de Bioko Biodiversity Protection Programme (BBPP).

BBPP es un programa conjunto entre la Universidad de Drexell (EEUU) y la Universidad Nacional de Guinea Ecuatorial-UNGE (en sus orígenes lo fue entre Universidad de Arcadia-EEUU- y la UNGE), que ha tomado el relevo de muchas actividades iniciadas por la Asociación Amigos de Doñana en el Sur de la Isla y que junto con la UNGE desarrolla otras nuevas relacionadas con la formación, Investigación y conservación (www.bioko.org) todas ellas realizadas en el Sur de la Isla donde se encuentra la Reserva Científica de la Caldera de Luba.

2.1.4. Los proyectos de Sociedad Zoológica de Londres (ZSL)

ZSL, a través de su Instituto de Zoología, y junto con Imperial College London, ha estado llevando a cabo investigaciones desde el año 2002 relacionadas con el tema de la carne de bosque. En concreto se han llevado a cabo tres tesis y tres maestrías. El objetivo se centra en la búsqueda de alternativas viables para la caza. Su trabajo ha estado siempre localizado en la región continental. Desde Marzo de 2010 y en colaboración con CI y la ONG ANDEGE ha puesto en marcha 6 iniciativas de generación de ingresos en 5 poblados: dos de cría de cerdos, dos de cría de cabras, una de horticultura y 1 de agroforestería. Los resultados no han sido los esperados y han anunciado continuar con la investigación antes de poner en marcha nuevas iniciativas.

2.1.5. Los proyectos de CI

Conservación Internacional ha trabajado también desde el año 2002 en Guinea Ecuatorial. Sus actividades se han localizado también en la región continental y han seguido tres puntos fundamentales: formación, conservación y apoyo institucional. Por un lado ha formado a más de 20 licenciados de la UNGE y a siete técnicos del sector bosque-medio ambiente financiándoles cursos de formación sobre la planificación y gestión de áreas protegidas en la Universidad Estatal de Colorado y en Costa Rica. También ha formado a técnicos del sector de medio ambiente, UNGE y ONGs a través de seminarios impartidos en Guinea Ecuatorial sobre distintos temas de conservación, acuerdos con las comunidades locales y cambio climático. Por otro lado en cuanto a la conservación ha financiado la elaboración del Plan de Manejo para el Parque Nacional de los Altos de Nsork, realizado por la ONG ANDEGE y ha asistido en la elaboración del plan de manejo para el Parque Nacional de Monte Alén (financiado por ECOFAC) y Río Campo (Financiado por RAPAC). Ha llevado a cabo además dos importantes proyectos de conservación en los que se ha formado de nuevo a técnicos y estudiantes de la UNGE. Estos son: Estudio del conflicto hombre-elefante (CI/ANDEGE) y Estudio de primates grandes y elefantes donde se censa a los gorilas, chimpancés y elefantes de la región continental. Por último CI ha apoyado a la ONG ANDEGE donándole un espacio físico para sus oficinas, al igual que a ZSL a quien a acogido en sus instalaciones. También ha apoyado a la financiación del Parque Nacional de Monte Alén asumiendo el pago de los salarios de los 6 guardas de la zona sur y a apoyado a INDEFOR, suministrándole material informático (ordenadores, impresoras, GPS, etc.). CI es parte ejecutora también del proyecto que mencionamos en el siguiente punto.

2.1.6. El proyecto del MPyMA

El proyecto del Ministerio de Pesca y Medio Ambiente (en adelante MPyMA) y CI, financiado por PNUD: *"STRENGTHENING THE NATIONAL SYSTEM OF PROTECTED AREAS IN EQUATORIAL GUINEA FOR THE EFFECTIVE CONSERVATION OF REPRESENTATIVE ECOSYSTEMS AND GLOBALLY SIGNIFICANT BIODIVERSITY",* es parte del programa estratégico de GEF para el manejo forestal sostenible en la Cuenca del Congo. El Objetivo de este ambicioso proyecto es hacer del sistema de áreas protegidas de Guinea Ecuatorial, un sistema efectivo en la protección de la Biodiversidad a nivel de especies y ecosistemas. Para ello se centrarán en tres puntos: 1) Mejora de la legislación medioambiental 2) Mejora de la capacidad institucional e individual del sector del medioambiente 3) Demostración de un manejo sostenible para las áreas protegidas y la biodiversidad guineana de manera efectiva y eficiente en cinco sitios (uno de ellos el Parque Nacional de Pico Basilé). Aunque la puesta en marcha de este proyecto ha sufrido algunos retrasos, el MPyMA espera darle comienzo en el próximo mes de Mayo.

De ser bien ejecutado, este proyecto podría suponer para 5 áreas protegidas lo que ECOFAC supuso para Monte Alén.

2.1.7. Proyectos de la UPM, Asocición Ecotono y UNGE

En la parte norte de la Isla prácticamente no se habían realizado investigaciones. Nuestros proyectos han sido pioneros en este sentido. Los datos que hemos sacado, de 2009-2010 con el proyecto "Equilibrando la demanda de nutrición y la conservación de la vida silvestre en la región del Pico Basilé, Bioko, Guinea Ecuatorial", y de 2010-2011 con el proyecto "Evaluación del problema de la caza en el Pico Basilé y plan para su gestión y monitorización continua a lo largo del tiempo", no se habían tomado nunca. Creemos que toda esta información, así como los vínculos creados especialmente con la UNGE, pero también con otras entidades como CI, BBPP, MPyMA, IDEFOR y ANDEGE, serán de gran valor para cualquier proyecto o acción relacionados con la conservación del Parque Nacional del Pico Basilé. Esperamos además que, concretamente, nuestras propuestas y nuestras investigaciones sean un importante apoyo al proyecto del MPyMA (apartado 2.1.6) a la hora de elaborar el plan de manejo para el Parque Nacional del Pico Basilé. Creemos también haber apoyado a la formación y desarrollo de la investigación en la UNGE y favorecido el clima y las bases para continuar haciéndolo.

2.1.8. Conclusiones

Aunque, como ya hemos comentado anteriormente, tras la época dorada de 1985-2000, los proyectos de conservación y el apoyo del gobierno al sector del medioambiente se han visto reducidos, no por ello se ha dejado de avanzar a pesar de las dificultades.

Cabe destacar por ejemplo: 1) la creación de la Facultad de Medio Ambiente en el año 2005 y todos los proyectos que ésta ha llevado a cabo, bien sola bien con otras instituciones y 2) también todos los demás proyectos anteriormente mencionados que han llevado a cabo ONGs y Universidades extranjeras, en los que se ha formado a numeroso personal, se ha apoyado a instituciones nacionales relacionadas con el medio ambiente y se ha obtenido relevante información científica. Además sigue habiendo planes muy interesantes para el futuro como: el proyecto del MPyMA previsto para mayo del presente año, cuyas consecuencias para el medio ambiente hemos comentado en el apartado 2.1.6, y 2) Los proyectos de la UNGE con otras instituciones, para continuar investigando, entre los que se encuentra el nuestro (UNGE/UPM/ECOTONO/UMA/DWCT) para estudiar los periodos reproductivos y hábitats de las especies presa.

A partir de nuestra experiencia personal creemos que todo apoyo económico para seguir fomentando la formación y la investigación en materia de conservación en Guinea Ecuatorial será bien aprovechado. Y la apertura y las ganas de la UNGE para realizar proyectos conjuntos con otras instituciones y el potencial que presenta en materia de investigación y conservación es un importante punto de apoyo y un hecho que no debemos dejar de atender.

2.2. Proyectos relacionados con el desarrollo de la agricultura y la seguridad alimentaria

2.2.1. Proyectos de Cooperación

En cuanto a la información obtenida de los proyectos de la Cooperación Alemana, Española y Sudafricana: Granja de Basilé, Granja de Musola y Explotación Ganadera de Vacas Sudafricanas respectivamente; en todos los casos la puesta en marcha y el funcionamiento ha sido exitoso siempre que la Cooperación en cada caso ha estado presente. El declive por tanto no ha sido nunca la falta de productividad y resultados sino la mala gestión posterior cuando todos estos proyectos han pasado a manos de la administración.

2.2.2. Proyectos nacionales

En cuanto a los proyectos del Gobierno de Guinea E. para reforzar las agrupaciones agrícolas (ya hayan sido financiados por ellos mismos o por otras entidades, pero ejecutados por la parte nacional) los resultados tampoco han sido buenos. Ha sido difícil (casi imposible) encontrar documentación sobre los resultados de estos proyectos. Pero por lo hablado con algunas personas, y lo averiguado en el terreno, en algunos casos parece que los proyectos han quedado solo en papel, gastando el dinero en las fases previas a la ejecución, y en otros casos sí se ha destinado el dinero a las agrupaciones pero no se ha supervisado ni continuado con el apoyo necesario, por lo que este dinero o bien ha sido malgastado desde el principio por las mismas asociaciones o bien lo han empleado bien pero no han podido continuar desarrollándose.

2.2.3. Proyecto de la Comisión Europea para la reactivación del sector del cacao

En cuanto al sector del cacao, hay que decir que ha sido un sector clave en la economía y la sociedad de Guinea Ecuatorial sobre todo en la Isla de Bioko. Hasta su independencia en 1968, la producción de cacao en Guinea Ecuatorial experimentó un crecimiento más rápido que el de la producción mundial, pasando de unas mil toneladas en 1901 a un máximo superior a las 40000 en la campaña 1967/68, de las cuales 38000 provenían de la Isla de Bioko. Pero mientras la producción mundial siguió creciendo, en Guinea Ecuatorial cayó hasta menos de ocho mil toneladas en 1990/91 (nivel similar al de 1925). Medidas de la política interna de la época de Macías-expulsión de mano de obra extranjera, expropiaciones- y la coyuntura internacional, sumieron al sector en una crisis y Guinea Ecuatorial pasó a ser un productor marginal, representando un 2‰ o 3‰ del mercado. Cualquier variación de su producción no tendría influencia sobre los stocks mundiales o el precio del cacao. En 1993 la Comisión Europea financiaba el ***Proyecto de Rehabilitación del Sector del Cacao y Diversificación de la Producción,*** cuyo objetivo era el rejuvenecimiento de parcelas y el aumento de la capacidad operativa de agricultores, empresarios y exportadores. Todo ello con el fin específico de recuperar una parte del potencial productivo del sector del cacao. El proyecto se llevó a cabo en dos fases 1993-1997 y 1998-200, esta última financiada también por la Cooperación Española. El objetivo se alcanzó con creces y a la finalización del proyecto se habían replantado 2000 hectáreas de cacao. Sin embargo la producción del cacao no ha aumentado y a día de hoy se han producido (cosecha 2011/2012) 775 toneladas en toda la Isla. Pocos son los agricultores que quedan y solo una empresa privada, Casa Mallo S.A., explotando el cacao. Hablando con gente del sector nos comentan que la falta de subvenciones y apoyo estatal adecuado y la falta de mano de obra están llevando a la total desaparición de este sector. Los guineanos consideran que trabajar el cacao es una tarea dura y mal pagada. El desarrollo del sector petrolífero les ha dado además la oportunidad de encontrar otro tipo de empleos mejor remunerados. Por otro lado las dificultades para la contratación de extranjeros siguen siendo notables.

El Gobierno Guineano está igualmente desinteresado en este sector desde el desarrollo del sector petrolífero y aunque dentro de sus propósitos está el de diversificar su economía, reflejado en el Plan Nacional de Desarrollo Económico y Social "Guinea Ecuatorial 2020", de momento no ha realizado el esfuerzo necesario para la reactivación de este sector.

2.2.4. Proyectos de la FAO

En cuanto a la seguridad alimentaria, la FAO se encuentra actualmente elaborando un ***"Programa Nacional de Seguridad alimentaria de Guinea Ecuatorial (PNSA)"*** por petición del Gobierno Guineano. Al estar aun en fase de elaboración no hemos podido obtener toda la información deseada pero si sabemos que hubo anteriormente otro programa, el PESA (Programa Especial para la Seguridad Alimentaria), cuyo diseño y primera ejecución iban bien encaminados a la cobertura y desarrollo del sector agropecuario pero la interrupción de las actividades del Programa causó más daños y prejuicios al sector, puesto que se desmoronaron las expectativas de los diferentes actores involucrados. El PNSA tiene un doble compromiso, no solo debe cubrir las actividades y fase de ejecución que el PESA no pudo implementar sino que también para el éxito en su implementación es necesario recuperar de nuevo la confianza de agricultores y agentes que integran el sector agropecuario. Para ello es clave un fuerte compromiso por parte del Gobierno en el cumplimiento íntegro de la ejecución del Programa.

2.2.5. Otras iniciativas privadas

Por otro lado cabe mencionar que en el último año la comunidad china está adquiriendo terrenos y plantando huertos de hortalizas (tanto autóctonas como algunas procedentes de china) que están dando muy buenos resultados. Otros pequeños y medianos productores privados tanto extranjeros como guineanos están obteniendo también buenos resultados en este tipo de cultivos.

2.2.6. Conclusiones

En conclusión a este apartado nos surge que la idea de que apoyar al sector privado parece, tras las experiencias conocidas, que podría dar buenos resultados para favorecer el desarrollo de la agricultura.

2.3. Legislación medioambiental

2.3.1. Legislación sobre caza y áreas protegidas

En el año 1988 (y como resultado de uno de los trabajos de la Asociación Amigos de Doñana) se aprueba la Ley 8/1988 Reguladora de la Fauna Silvestre, Caza y Áreas Protegidas. En ella se prohibía la caza en un nuevo sistema de áreas protegidas (el primer sistema fue establecido en la época colonial y abandonado después con la independencia) constituido por nueve zonas identificadas como las áreas más significativas para la conservación y protección de la biodiversidad que totalizaban alrededor de 340.000 ha (8,2% del territorio terrestre del país).

Después con el proyecto CUREF (Conservación y Utilización Racional de los Ecosistemas de África Central- 1996-2001), financiado por la UE, se aprobó la Ley 4/2000 sobre Áreas Protegidas en la República de Guinea Ecuatorial, que ampliaba la anterior, incluyendo un total de 13 áreas que integraban el Sistema Nacional se Áreas Protegidas (SNAP), (18,5% del territorio nacional). Este sistema fue creado con todas las garantías científicas por diferentes estudios, biológicos, sociales, económicos y culturales. En él quedaron establecidas las figuras de protección, detallando los límites precisos de éstas, el régimen de protección y el régimen sancionador. Se creo también el Instituto Nacional de Desarrollo Forestal (INDEFOR) como organismo autónomo dentro del Ministerio de Agricultura y Bosques (MAyB) para manejar el SNAP y apoyar la investigación en materia forestal y en biodiversidad, y se elaboró un plan de gestión para el manejo del SNAP. Aunque hay que señalar que solo una de estas áreas, el Parque Nacional de Monte Alén (en la región continental) recibió un trato adecuado como área protegida, gracias a que en él se implantó el proyecto de Conservación de los Ecosistemas Forestales de África Central (ECOFAC, ver apartado 2.1.2). Para el resto de las áreas el SNAP nunca llegó a ser funcional.

Fue después de la aprobación de la ley 4/2000 cuando se creo, como nuevo ministerio, el Ministerio de Pesca y Medio Ambiente. Los aspectos medioambientales y de pesca fueron entonces transformados en leyes sectoriales correspondientes al Departamento de Pesca y Medioambiente, algunos a partir de la derogación de otros, que existían en los momentos en que los dos Ministerios (MAyB y MPyMA) estaban unidos. Este es el caso de la ley 4/2000 sobre áreas protegidas y la ley 8/1988 Reguladora de la Fauna Silvestre, Caza y Áreas Protegidas, las cuales fueron derogadas por la Ley 7/2003 Reguladora del Medio ambiente en Guinea Ecuatorial. En general, esta Ley establece las mismas categorías definidas en la derogada Ley 4/2000, basada en el sistema de UICN, pero no establece dichos espacios en el contexto territorial nacional, ni define las medidas de gestión. Tampoco se apoya de estudios específicos de terreno sino de bibliografía nacional e internacional y además incluye una nueva categoría, Paisaje Protegido, excluido en la Ley 4/2000, por no ser útil en el contexto cultural de Guinea Ecuatorial. Esta ley también traspasa la tutela legal de las áreas protegidas al Ministerio de Pesca y Medio Ambiente y crea el Instituto Nacional de Conservación del Medio Ambiente (INCOMA) para que se encargue de la gestión de las mismas. Sin embargo, en la práctica las áreas protegidas siguen siendo gestionadas, según términos legales por el Instituto INDEFOR-AP (creado por el decreto numero 60/2002), el cual es dependiente del Ministerio de Agricultura y Bosques. Creándose así un conflicto entre ambos Ministerios.

2.3.2. Conclusiones

Ante las deficiencias que presenta la Ley Reguladora del Medio Ambiente y la confusión de competencias entre el MPyMA y el MAyB, nuestras conclusiones no son distintas a las ya expresadas en:

Obama C. 2008. Las leyes del sector bosque-medio ambiente de Guinea Ecuatorial: pluralismo y conflictos interinstitucionales. Amigos de la naturaleza y el desarrollo de guinea ecuatorial (ANDEGE), Bata-Guinea Ecuatorial:

> *"Teniendo en cuenta estas deficiencias, se propone algunas medidas esenciales:*
>
> ***Primera**. Se propone establecer mecanismos de difusión de esta Ley de modo que sea conocida y apropiada por todas las partes implicadas.*
> ***Segunda**. Preparar el reglamento de aplicación y todas normas complementarias definidas, para aplicabilidad de la Ley y el seguimiento de las propuestas legales.*
> ***Tercera**. Revisar las normas orgánicas que regulan los Ministerios de Agricultura y Bosques y el Ministerio de Pesca y Medio Ambiente, de modo a definir marcos claros de cooperación y colaboración entre estos dos Ministerios.*
> ***Cuarta**. Fusionar los sectores de Bosques y Medio Ambiente en un solo Ministerio.*
> ***Quinta**. O en su caso, crear un Ministerio específico de Medio Ambiente y ajustar su reglamento orgánico como un Ministerio que solo actúa como asesor técnico en cuestiones de medio ambiente y no como ejecutor de programas medio ambientales sobre el terreno. De modo que las cuestiones medio ambientales relativas a la explotación de minas e hidrocarburos, por ejemplo, sean de responsabilidad del Ministerio de Minas, y las que afectan a bosques, agricultura, pesca, etc, correspondan al Ministerio correspondiente, de tal forma que el Ministerio de Medio Ambiente solo y exclusivamente actúe de asesor y control de las leyes medio ambientales en su conjunto."*

Obiang M.D. Las leyes del sector bosque-medio ambiente de Guinea Ecuatorial: pluralismo y conflictos interinstitucionales. Segunda Parte. ECOFAC IV FASE, Consultaría sobre análisis de la legislación forestal-Medio Ambiente:

> *"Como conclusión, y sin necesidad de determinar la culpabilidad a este conflicto latente entre estos dos Ministerios, se cree necesario que el arbitraje se haga desde las altas esferas de la administración a través de una conferencia nacional, que debería ajustar las atribuciones de cada Ministerio en base a sus respectivos reglamentos orgánicos (Obama, 2006 en Obama 2008), o simplemente volver a fusionar los componentes bosques y medio ambiente en un solo Ministerio o en su defecto ajustar los instrumentos legales de acuerdo a los objetivos de cada Ministerio. Por otra parte, a nuestro juicio se debe prevalecer la Ley 4/2000, sobre las áreas protegidas en Guinea Ecuatorial."*

Appendix 2.1-2 Research and cooperation projects supporting the fieldwork for this thesis

The projects were carried out between March 2009 and December 2015. These projects not only encompassed the research objectives developed in this thesis but also included numerous activities related to training, awareness-raising, and management support that are not detailed in this document (but see links on page 214). All of these activities were aligned with the ultimate goal of the thesis: to support the government's conservation management plans, particularly in the management of PBNP. These activities contributed to understanding the country's reality and institutional context, provided training and raised awareness where it was most needed, and involved working closely with local populations and administrations. The outcome was the development and the implementation of the first management measures for PBNP in 2015 (see details in Sections 1.2.7.3 and 2.1.7.4).

The Guinean counterparts were: UNGE (since the beginning) and INDEFOR-AP (since Project 2). Other Guinean and foreign entities collaborated at various stages, as detailed in each of the projects.

The projects were always recognized as being carried out under the "**Convenio Marco de Colaboración Académica Científica y Cultural firmado en 2008 entre la UNGE y la Universidad Politécnica de Madrid (UPM)"**.

I was the primary person responsible for the execution of all the projects, as well as for securing and justifying the funds, which were requested either through me as an individual or through the entities I belong to: Asociación Ecotono (a Spanish NGO) and the SILVANET Research Group (UPM). The proposal for Project 4 was a joint request between INDEFOR-AP and Ecotono.

In addition to the funds indicated for each project, I also received support through the "Ayudas en el Marco del Programa Propio del Personal Investigador en Formación para la Realización del Doctorado en sus Escuelas, Facultades, Dentros de I+D e Institutos Universitarios (RR01/2011)", between 2011 and 2015 (4 years).

The projects were conceived by:

Project 1: Prof. Julia E. Fa (Durrel Wildlife Conservation Trust-DWCT)
Project 2: Prof. Julia E. Fa (DWCT), María Grande Vega (UPM/Ecotono), Bruno Carpinnetti (National University of Misiones, Argentina-UNM), and Juan Gómez Soto (Ecotono).
Project 3: Prof. Julia E. Fa (DWCT) and María Grande Vega (UPM/Ecotono). Conceived during the workshop-seminar for Project 2, in which several Guinean and foreign institutions related to conservation participated (see Appendix 3.2-8).
Project 4: María Grande Vega (UPM/Ecotono), Paloma Ferrer (Consultant for MPyMA), Antonio Grunfeld (WakaFilms), and Rocío Cadahía (WakaFilms).

The details of the projects are as follows:

1. **Project title:** Equilibrando la Demanda de Nutrición y la Conservación de la Vida Silvestre en la región de Pico Basilé, Bioko, Guinea Ecuatorial (Balancing local population nutrition demands with conservation of wildlife in the Pico Basilé Region, Bioko Island, Equatorial Guinea)
   Funding: Zoo de Barcelona (9,000€), Rufford Small Grants Foundation (6,000 £), Ayudas de Viaje en Cooperación de la UPM (1,200 €)
   Duration: August 2009-September 2010 (one year and two months)
   Applicant and responsible: María Grande Vega (UPM)
   Other institutions involved: UNGE, DWCT

2. **Project title:** Evaluación del Problema de la Caza en el Pico Basilé y Plan para su Gestión Sostenible y Monitorización Continua a lo largo del Tiempo
   Funding: Zoo de Barcelona (12,000 €), Subvenciones y Ayudas para Acciones de Cooperación Universitaria para el Desarrollo de la UPM (18,000 €), Fundación Biodiversidad (25,880 €), Carlson Family Foundation (4,463€).
   Duración: January-December 2011 (1 year)
   Applicants: María Grande Vega, Asociación Ecotono, Grupo de Investigación SILVANET (UPM)
   Responsable persons: María Grande (UPM/Ecotono), Juan Gómez Soto (ECOTONO), Antonio García Abril (UPM)
   Other institutions involved: INDEFOR-AP, DWCT, universidad Nacional de Misiones de Argentina (UNM)

3. **Project title:** Estudio de los Ciclos Reproductivos de las Especies más Cazadas en la Isla de Bioko. (A Study of the Basic Reproductive Biology of Tropical Forest Mammals to Aid Sustainable Hunting)
   Funding: Rufford Small Grants Foundation (6,000£), Zoo de Barcelona (9,000€), INDEFOR-AP (14,442 €).
   Applicant and responsible: María Grande Vega (UPM/Ecotono)
   Other institutions involved: UNGE, DWCT, Universidad de Málaga (UMA).

4. **Project title:** Apoyo a la Gestión y Conservación de los Recursos Biológicos del Parque Nacional del Pico Basilé (Support to the Management and Conservation of the Biological Resources of the Pico Basilé National Park).
   Funding: Funds of the Contenido Nacional para el Desarrollo Social de Guinea Ecuatorial (Ministerio de Minas Industria y Energía) managed through Marathon Oil EG Production Limited (135,185,719 XAF/206,089 €) and Marathon Oil Production Limithed (4,408,878 XAF/ 6,700 €)
   Applicants: Asociación Ecotono and INDEFOR-AP
   Responsable persons: María Grande Vega (UPM/Ecotono) and Fidel Esono (INDEFOR-AP).
   Other institutions involved: UNGE, Ecoguinea[12], UMA, Manchester Metropolitan University (MMU), WakaFilms, Centro Cultural de España en Malabo (CCEM), Centro Cultural de España en Bata (CCEB), Institut Culturel d'Expression Française (ICEF) at Malabo, Centro Cultural Papaya (Malabo), Centro Cultural de Rebola (Rebola), Jesús María School (Malabo), Cinematographic Association of Equatorial Guinea (ACIGE), Radio y Televisión Nacional de Guinea Ecuatorial (RNGE, TVGE), Asonga TV, Ministerio de Pesca y Medio Ambiente en Guinea Ecuatorial, United Nations Development Programme (UNDP) in Equatorial Guinea.

[12] Ecoguinea was initially the name given to the project's awareness program, which eventually became synonymous with the project itself. When the project was nearing its final phase, the project team officially created an NGO with this name, which continued to support the implementation of the first management measures in the PBNP after the project ended.

Numerous audiovisual materials were also produced to inform and raise awareness among the population and authorities including:

- Documentary "The Hunters of Basilé" (https://vimeo.com/36072647)
- Documentary "The Secret of the Forest," which received several international awards (https://www.youtube.com/watch?v=8dUIzBWUL3E&t=619s
- Television spots (https://www.youtube.com/watch?v=5I8RBKVvrKU&list=PLxA0wRQ4GyeugvGWPWV5cX0FBqIENZ11c)
- Reports on Biodiversity Week[13] (https://www.youtube.com/watch?v=EB8MEvrcadc&list=PLxA0wRQ4GyesDFo6OIbECXK8CsvuJJJku)
- Informational video about our project (https://www.youtube.com/watch?v=XGfOoB8MLZI)

The training, awareness-raising, and management support activities of the final project are available on the website http://ecoguinea.com/

[13] One of the successes of these projects has been the creation and promotion of 'The Biodiversity Week'. This is a week of meetings for all institutions involved in the conservation of Equatorial Guinea's biodiversity (governmental and non-governmental, local and international), as well as the general public. The first one was organised in 2012 by the then director of CI, Heidi Ruffler, the research director of UNGE, Dr. Maximiliano Fero Meñe, and myself, in collaboration with the Spanish Cultural Centre in Malabo (CCEM) and its director, Patricia Picazo. The objectives were 1) to bring together as many national and international institutions working on biodiversity conservation in Equatorial Guinea as possible, so that they could present their projects and results to the people of Bata and Malabo; 2) to carry out environmental education activities for young people; and 3) to organise the II Biodiversity Round Table (following the first one in 2002) to define urgent and priority conservation measures for the whole country. The success of this initiative lies in the fact that it has become a consolidated event through subsequent projects and, despite our departure, continues to be held every year (even during the COVID pandemic, it was carried out as best it could, partly in a virtual format), with the support of numerous governmental and non-governmental institutions related to the environment.

During the IV Biodiversity Week held in Malabo in 2015, biologist Luis Arranz was invited to deliver several lectures and participate in discussion workshops. Luis Arranz was responsible for the ECOFAC project in Equatorial Guinea from its inception in 1992 until 2000. After managing Monte Alén National Park during this period, he went on to direct several parks in Africa: Zakouma (Chad, 2001–2007), Garamba (DRC, 2007–2014), Dzanga Sangha (CAR, 2017–2024), and Salonga (DRC, 2022–present). His extensive experience in park management across Africa is remarkable, as is his knowledge of Equatorial Guinea, where he lived for 14 years. The lecture in which he discussed the potential contribution of ecotourism to Equatorial Guinea can be viewed at https://www.youtube.com/watch?v=1OtWpbCNgOA&list=PLxA0wRQ4GyesDFo6OIbECXK8CsvuJJJku&index=3, and the manifesto drafted after the discussion by all groups can be found at https://www.youtube.com/watch?v=iOPz2AzFl74

Appendix 3.2-1 Census datasheet

In blue is shown an example of what would be the data noted.

Fecha: 5/5/2009 Pueblo: Bososo Código familia: Calletano y Julia

Miembros	**Edad**	**Sexo**	**Estudios**	**Lugar de estudios**	**Origen**	**Etnia**	**Actividad principal para ganarse la vida**	**Otras actividades**
Papá	54	H	4º Esba		Añisok	Fang	Caza (escopeta y trampa)	Finca, destajos
Mamá	50	M	6º Primaria		Bata	Fang	Comerciante (caza, productos finca) y Bar	
Tio	30	H	2º primaria		Bata	Fang	Cantera	Destajos y caza
Hijo 1	16	H	2º Esba	Malabo	Malabo	Fang	Solo estudia	
Hijo 2	12	M	1º Esba	Malabo	Malabo	Fang		
Hijo 3	10	H	5º Primaria	Bososo	Malabo	Fang		
Hijo 4	8	M	3º Primaria	Bososo	Malabo	Fang		
Sobrino1	3	H	----		Bata	Fang		

Appendix 3.2-2 Questionnaire on past activities and motivations for change

Familia:
Individuo:
Fecha:

1. Destinos y actividades pasadas

	Pueblo		
Origen	llegada	Actividades actuales	Actividades pasadas

Destino anterior 2		
Fechas	Lugar	Actividades

Destino anterior 3		
Fechas	Lugar	Actividades

Destino anterior 4		
Fechas	Lugar	Actividades

2. Motivo del cambio/de los cambios

3. Llegada a la Isla y motivo

4. Situación actual ¿mejor o peor?

5. Planes

6. Comentarios

Appendix 3.2-3 Socioeconomic interview data sheet – (a) household expenses, (b) household income and (c) wealth indicators - including examples and instructions for research assistants.

The socioeconomic interview has three parts: a) household expenses, b) household income and c) wealth indicators. In the same interview the three blocks were asked one after the other. In blue is shown an example of what would be the data noted. In green is the explanation I prepared for the UNGE research assistants who conducted these interviews in Malabo so that they would understand how to formulate the questions, write down the answers and perform the calculations.

SECTION A: HOUSEHOLD EXPENSES

A.1 Educación.- matrícula, material escolar (uniforme, cuadernos, lápices/bolis, cartera, etc), transporte (si no es coche propio) y dieta o alojamiento **(**en caso de haberlos). Estimar gastos anuales.

Miembro	Matrícula / frecuencia	Transporte / frecuencia	Otros gastos		Total
			En	Cantidad/frecuencia	
Hijo 1	35.000/año	0	Uniforme	5000/año	5.000
			Cuadernos	200 (hasta ahora)	200
			Bolis y lápices	500/año	500
Hija 1	10.000/año	0	Uniforme	5000/año	5.000
			Lápiz	200/año	200
			Boli	150/año	150
			Mochila	2500/año	2.500
			Desayuno	500/2 veces x sema	1.000 X 52
					=52.000
Hijo 2	15.000 / año	200/ día	APA	3000/año	3.000
			Uniforme	10000/año	10.000
			Bolis y lápiz	500/año	500
			Cartera	4000/año	4.000
Todos			Libros	0	
			Zapatos	5000/niño/año	15.000
			Alojamiento	1500/mes (todos en	1.500 x 12
				la misma casa)	=18.000
			Luz	18700/mes	224.400
			Parabólica	10000/mes	120.000
			TOTAL POR	**AÑO**	**454.750**

EXPLICACIÓN:
Poned el precio final del uniforme, es decir, tela más costurera (si lo ha cosido la mamá, solo tela).

En cuadernos a veces me dicen solo lo que se han gastado hasta ahora, es posible que compren más, hay que hacer una estima del gasto anual, lo mismo en el resto de material.
Cuando los niños asisten en Malabo en una casa familiar anotamos los gastos de luz y parabólica.

A.2 Otras ayudas.- Gastos de los cabeza de familia en los miembros que viven en la casa (como paga, teléfono, ropa, viajes, otros) o en otros familiares u otras personas de fuera de la casa a los que han ayudado de alguna manera este año. También se ha de poner aquí los gastos en 2ª (o +) mujeres e hijos que se tienen con ésta. En definitiva cualquier persona en la que se gasten dinero, sea de la familia o no. Recoger la cantidad gastada en 1 año.

Miembro en el que gastan (C: si es de la casa y F, si es de fuera)	Motivo (paga, teléfono, ayuda esporádica, otros)	Cantidad gastada	Frecuencia (si 1 vez/año indicar mes)
Hijo F	Ayuda	20.000	1 vez al año
		25.000	2 veces al año
Hija F	Ayuda	100.000	1 vez al año
Hijo del marido F	Comida	150.000-200.000	Por mes
Hijos C	paga	2.000(para todos)	Por mes
Hijo 1 C	Saldo movil	10.000	año

TOTAL POR AÑO = 20.000 + (25.000 X 2) + 100.000 + (175.000 X 12) + (2.000 X 12) + 1.000 = **2.295.000**

EXPLICACIÓN: A un hijo que vive fuera de casa, en Camerún, le han mandado en el último año una ayuda de 20.000 (una vez) y otra de 25.000 (2 veces). Puedes ponerlo así o puedes sumarlo todo y ponerlo como en la hija la cantidad total. El marido tuvo un hijo con otra mujer anterior y le paga mensualmente entre 150.000 y 200.000 F. cfa. A los hijos que viven en casa les dan además unos 2.000 cfa a repartir entre todos al mes y a uno de ellos, al hijo 1 por sacar buenas notas le dieron 10.000 de saldo.

A.3 Luz.- pago a Segesa + combustible motor (si hay) / frecuencia

Segesa 18700/mes/2casas (una de las casas en la que están los hijos que asisten)
motor 10000/mes

EXPLICACIÓN: Tiene tres casas, una en la que viven los padres, otra alquilada donde están los niños que asisten y un barracón que alquilan. En las dos primeras, en cada una paga 18700/mes, pero como una de ellas es la de los niños y ya lo habíamos puesto arriba lo indicamos aquí para no contarlo luego dos veces, el motor lo tienen en la casa en la que viven ellos. En el barracón no pagan luz porque la pagan los inquilinos, por eso no ponemos nada)

A.4 Comida fuera de casa.- si hay miembros que comen fuera habitualmente, por trabajo o cualquier motivo, hay que pregustar lo que se gastan a la semana en comer fuera o al mes (como les sea más fácil calcularlo). Si comen en el trabajo y no lo tienen que pagar no se pone. También, si les gusta salir a comer fuera de casa de vez en cuando, que hagan una aproximación semanal o mensual del gasto).

Miembro Gasto

EXPLICACIÓN: no comen fuera de casa

A.5 Combustible.- El de la luz ya se puso en el 3) así que aquí no se incluye; ahora se trata de vehículos u otros gastos en combustible, como por ejemplo infiernillo o lámparas. Ojo! Para vehículos es gasolina, para lámparas petróleo, distinguir pues tiene distintos precios. O si gastan en aceite para el motor, se pone aquí también.

Gasolina 5.000/ mes (para vehículo)
Petróleo 50 litros / 2 meses (para lámparas e infiernillo) 1 litro= X F.cfa.

A.6 Teléfonos.- poner gasto y frecuencia del teléfono fijo y móviles de los cabezas de familia (de los demás de la casa no se ponen a no ser que se lo paguen los cabeza de familia y no se haya puesto en la tabla 2)

20.000 / mes

EXPLICACIÓN: tienen dos teléfonos, uno el padre y otro la madre y suelen gastarse ambos 10 000 al mes, luego 20000 en total. Hay dos hijos de los que están estudiando, es decir de los que aun dependen de los padres, que también tienen teléfono pero no lo ponemos porque se pagan ellos el saldo con sus ahorros.

A.7 Televisión e Internet.- gasto y frecuencia

8.000/mes por canal TV

A.8 Renta.- gasto y frecuencia del alquiler o hipoteca

71.500 / mes (casa de 10 mill)

EXPLICACIÓN: se están comprando una casa de 10 millones en Buena esperanza y pagan esa cantidad mensualmente.

A.9 Reformas.- Gastos en reformas de la casa en este año.

Se han gastado pero no sabrían calcularlo

EXPLICACIÓN: si pueden decir una cifra aproximada mucho mejor claro, o si les puedes ir preguntando tú: "¿más de 100 000? ¿más de 500000? ¿Pero menos de 1 millón? Etc" para intentar estimar una cantidad). En esta casa no viven luego no tiene gastos de luz ni de nada.

A.10 Viajes-. Gastos en viajes en este año (los pagados por la empresa no cuentan)

Miembro	Destino	*Motivo del viaje	Gasto
Mujer e hijos	continente	ver familia	50.000
Papá	continente	ver familia	30.000
Mujer e hijos	continente	dar a luz	24.000
Hermanito papá	Bata	trabajo	0

EXPLICACIÓN: esta familia hizo dos viajes este año,
- En el primer viaje se fue la mamá y algunos de los hijos en barco y la ida costó 50 000 en total, unos días más tarde se fue el padre y la ida y la vuelta le costó 30 000, a la mamá y los niños la vuelta no les costó nada porque se lo pagaron sus familiares.
- En el segundo viaje solo viajó la mamá y algunos hijos para dar a luz y el viaje les costó 24 000, siguen allí.

Por otro lado el hermanito del padre (que es miembro de la familia pues vive en la casa con ellos y lo teníamos en la hoja de estructura familiar) hizo un viaje a Bata pero no le costó nada porque era de trabajo por eso no lo ponemos o lo podemos poner y poner gasto 0.

* visita familiares, trabajo, ocio/turismo, compras/material otros….

A.11 Otros.- Otros grandes gastos (individuales o de la casa; puntuales o fijos) que no se hayan mencionado (ej: fiestas, compras, trabajadores, etc).

- 100 000 para comprarle cosas al bebé
- 1 hombre todo el año para cultivar la tierra: 60.000 / mes
- Otras veces llevan a más hombres pero de vez en cuando: De media: 3 hombres 3 veces a la semana todo el año = 9 jornales / semana = 36 jornales / mes
  (1 jornal = 2.000) → 36 x 2 = 72.000 F cfa / mes

Total al mes= 60.000 + 72.000 = 132.000 / mes
Total anual = 100.000 + (132 000 x 12) = 1.684.000 F.cfa.

EXPLICACIÓN: Podría ser que unos meses del año como hay más cosecha se contrate a mas y otros meses a menos, entonces se calculan por separado y luego se suman, lo que nos interesa es conocer el gasto total en el último año.

SECTION B: HOUSEHOLD INCOME

B.1 Salarios/ganancias en la casa-. Se anotan todas las actividades y ganancias de los cabeza de familia y de otros miembros en caso de que cooperen también de alguna manera en los ingresos de la familia. Si no tienen salario fijo intentar aproximar unas ganancias **restando los gastos** en material/ compras o viajes/transporte necesarios para realizar dicha actividad. Incluir venta de productos de la finca, pesca o caza, en caso de que se realicen (preguntarlo por si a ellos se les olvida o no lo consideran como actividad principal). Si los hay, pero solo para consumo familiar, ponerlo por escrito debajo de la tabla. Es decir, hay que recoger todas las actividades que realizan (mayores y pequeños) y calcular las ganancias netas (restando los gastos; ver puntos explicativos a continuación). Se pregunta por las principales, pero luego insistir: "¿hacen alguna otra cosa más para sacar algo de dinero o comida?, por ejemplo venta de buñuelos o caza o pesca los fines de semana, o en vacaciones, venta de productos de la finca?

EXPLICACIÓN:

- Si van a la finca y venden los productos en el mercado se les pregunta cuanto suelen ganar por un día de venta, si te contestan que varía mucho, entonces que te digan lo que ganan en un día bueno y lo que ganan en los días malos y preguntar si suele haber el mismo número de días buenos que de días malos. A lo mejor también depende de la época. Hay mamás que en unos meses venden más que en otros, o que en unos meses venden y en otros no. Se pregunta entonces cuales son los meses en los que venden más y cuales son en los que venden menos y luego lo mismo para cada bloque de meses: cuánto en los días buenos y cuánto en los días malos, para los meses buenos y cuánto en los días buenos y cuanto en los días malos para los mese malos. Después de haber respondido a estas preguntas hay que restar lo que se gastan en transporte (por cabeza y por carga) y por estar en el mercado. O cualquier otro gasto que tengan. Por ejemplo si compran ellas los productos y luego los venden, a lo que ganan habrá que restarle lo que han gastado en comprarlos. También si tiene personas contratadas para chapear. Se les pregunta cual ha sido el gasto en ellas en el último año.

- Si tienen un bar y no llevan la cuenta de sus ganancias netas, mensuales o semanales o anuales, será difícil calcularlo pero hay que intentarlo. Habrá que preguntarle cuanto ganan los días buenos y cuántos suelen ser los días buenos (por ej si son los fines de semana o los viernes y sábado) y cuanto los malos (y si hay muchos malos) o cuantos normalmente. Y luego habrá que preguntar cuantas compras hacen al mes para abastecer el bar y cuánto se suelen gastar. Algo así, lo que se te ocurra que sea más preciso.

- En caso de que cace o pesque preguntar qué método utiliza (igualmente hay que restar los gastos en material: cartuchos, alambre, nylon, transporte hasta la zona de caza) y dónde va (y frecuencia, claro, para poder calcular ganancias). Si van a la finca preguntar donde la tienen. Si la tienen en el pueblo y le mandan los productos, de nuevo restar todos los gastos. Preguntar qué productos tienen en la finca y cuáles son para consumo de la familia y cuáles para venta (o ambas cosas). Preguntar si tienen animales y como los utilizan. Esto irá todo en el punto 3.

- Apuntar en su sucio, utilizando el espacio que sea necesario y luego pasar a limpio. Puede ser en otra hoja y se grapa al final.

Miembro	Actividad	Ganancias /Salario* (indicar frecuencia**)	Plus/es (indicar frec.)
- Mamá	Finca	15.000 – 20.000 / día de venta Vende 2 días/ semana todo el año	
- Mamá e hijas	Bar	En los días buenos 100.000 – 150.000 (suelen ser los sábados y vísperas de fiesta), días malos 10.000. Un día normal 25 000 – 30.000. Dicen que puede haber1-2 días malos/ semana y 1-2 días buenos/ semana y el resto normales.	
- Familia	Inquilinos	2 x 25.000 y 1 x 60.000 / mes (desde Mayo hasta Noviembre 09) 2 x 25.000 y 4 x 60.000 (desde Diciembre 08 hasta Abril 09) EXPLICACIÓN: Tiene un total de 4 + 2 = 6 habitaciones, 4 de 60.000 y 2 de 25.000 en un barracón que construyó él hace tiempo, pero a partir de mayo está haciendo reformas en algunos de ellos y no los tiene alquilados, por eso lo hemos puesto así)	
- Papá	Jubilación	200.000 / mes	
- Hermanito de papá	Salario (albañil)	150.000 / mes (desde enero, antes en paro)	
	Caza	50.000 – 75.000/ día de caza / 2 veces al mes (cuando estaba paro, es decir en Diciembre de 08)	
	Finca	Acaba de empezar a plantar y no ha vendido nada aun, salvo pimientos que vendió solo una vez y ganó 4.000 fcf	

* Si no quiere responder a los ingresos que ganan preguntar si podría indicar el rango en el que se encuentran sus ganancias en la tabla de rangos. Anotamos entonces el código en ganancias / salario. Si tiene un puesto de trabajo bien definido en el que luego nosotros podemos averiguar cuanto gana, por ejemplo "Sargento 1º con 5 años de servicio en ese puesto), entonces podemos ahorrarnos la pregunta en caso de que veamos que no procede o que se van a molestar.

**o nº de meses pagados o de trabajos pagados, el caso es calcular las ganancias (netas) de esa actividad en el periodo de un año.

Tabla de rangos de salario o ganancias

A1	A2	B1	B2	C1	C2
0- 50.000	50.000 – 100.000	101.000 – 150.000	151.000 – 200. 000	201.000 – 250. 000	251.000 – 300. 000

D1	D2	E1	E2	F1	F2
301.000- 400.000	401.000 – 450.000	451.000 – 500.000	151.000 – 200. 000	201.000 – 250. 000	251.000 – 300. 000

G1	G2	H1	H2	I1	I2
301.000- 350.000	351.000 – 400.000	401.000 – 450.000	451.000 – 500. 000	501.000 – 550. 000	551.000 – 600. 000

J1	J2	K1	K2	L1	L2
301.000- 350.000	351.000 – 400.000	401.000 – 450.000	451.000 – 500. 000	501.000 – 550. 000	551.000 – 600. 000

M1	M2	N1	N2	O1	O2
601.000- 650.000	651.000 – 700.000	701.000 – 850.000	851.000 – 900. 000	901.000 – 950. 000	951.000 – 1.000. 000

P1	P2	Q1	Q2	R
1.000.000- 1.500.000	1.501.000- 2.000.000	2.00.001- 2.500.000	2.501.000 – 3.000.000	3.000.000 - más

B.2 Otros ingresos en la casa.- ¿Reciben los cabeza de familia (o miembros participantes en los gastos o la familia en general) algún otro ingreso o ayuda?. Por ejemplo:

- otras compensaciones que se tengan en el trabajo o en los negocios que no se hayan mencionado antes
- otras ayudas por parte de **otros familiares** que viven fuera de la casa pero que ayudan a la familia de alguna manera o a algunos de los miembros de la familia (pagando estudios de alguno, regalando alimentos de vez en cuando, etc)
- Otras casas o locales, o habitaciones de la misma vivienda u otras posesiones que se tengan alquilados a otras personas

Nota: si no se quiere poner el motivo por confidencialidad, no es necesario pero decir el ingreso (o el rango nuevamente en la tabla) sería de gran ayuda.

Miembro que recibe la ayuda	Motivo y/o procedencia de la ayuda	Cantidad de la ayuda	Frecuencia

Solo lo que ya se había dicho del hermanito del papá que vive en la casa, que aportaba algo de comida y petróleo pero que no lo ponemos porque es un poco lo comido por lo servido.

INGRESOS NETOS ANUALES

EXPLICACIÓN: Ahora vamos a calcular los totales restando los gastos (puedes haber apuntado los gastos antes y luego restarlos, puedes apuntar las cosas como quieras y donde quieras pero lo importante es que quede todo bien claro y se puedan calcular bien los totales. También puedes apuntarlo en sucio en esta primera página para no tardar mucho cuando estés con la familia y luego al llegar a casa pasarlo a limpio. Creo que hay suficiente espacio, puedes utilizar si te hace falta la última hoja en blanco. No hace falta que borres lo de sucio, si hay espacio suficiente.

- Total finca:
  Media de ingresos por día de venta= (15 000 + 20 000) / 2 = 17 500
  Gasto mensual (2 veces / semana = 8 días al mes) = 17 500 x 8 = 140 000
  Gasto anual = 140 000 x 12 = 1 680 000
  No tiene gasto de transporte porque son los hijos los que se encargan de eso, ellos van a recoger la comida para venderla y para comer ellos y el dinero indicado es el que le dan a la madre después de la venta

- Total Bar:
  Media día normales = (25 000 + 30 000) / 2 = 27 500
  Media días buenos = (100 000 + 150 000) / 2 = 125 000
  Media semanal (bruto)= (10 000 x 2) + (125 000 x 2) + (27 500 x 3) = 352 500

Suelen realizar una compra a la semana (para abastecimiento del bar), cuando compran poco porque hay poco que reponer o poco dinero para comprar, se gastan 15 000 y cuando hacen una compra grande 50 000 → Media gasto de compra/ semana = (15000+50000)/2 = 32 500
Media semanal (neta) = 352 000 – 32 500 = 319 500

- Total alquiler de habitaciones:
  Mayo 09 – Nov 09 (7 meses) → (50 000 + 60 000) x 7 = 770000
  Dic 08 – Abril 09 (5 meses) → (50 000 + 240 000) x 5 = 1 450 000
  TOTAL ANUAL: 770 000 + 1 450 000 = 2 220 000

- Total jubilación papá = 200 000 x 12 = 2 400 000

- Total hermanito papá:
  - Total sueldo= 150 000 x 11 (de enero a noviembre 09, pues desde nov 08 a enero no ganó nada, estaba en paro) = 1650000 en este último año
  - Total caza
    - Media ingresos caza = (50 000 + 70 000) / 2 = 62 500 / día de caza → 62 500
    - Ingresos brutos caza = 62 500 x 2 (2 días el mes de diciembre) = 125000 / año
      Cada vez que fue a cazar compró una caja de cartuchos de 20 000 (25 cartuchos/ caja = 25 disparos) y se gastó 1000 en ir y volver a 15 (una vez en 15 sube andando, no paga para que le suban en coche más arriba). Como fue dos días el total por este ultimo año gastado es: 40 000 + 2 000 = 42 000
    - Ingresos netos caza = 125 000 – 42 000 = 85 000

EXPLICACIÓN: Dicen que el hermanito suele colaborar un poco en la casa comprando comida y petróleo a veces (pero no colabora en los gastos de las matrículas de los niños y demás gasto que tienen los cabezas de familia). Por otro lado tampoco los cabezas de familia se gastan en el nada salvo en la comida. Así pues este miembro digamos que más o menos aporta a los cabezas de familia lo mismo que ellos se gastan en el, así que en definitiva no aportaría ingresos pero tampoco supondría gastos luego para calcular los ingresos totales familiares no lo vamos a tener en cuenta. Así mismo para los gastos tampoco vamos a tener en cuenta sus gastos (los de la casa que se está construyendo).

TOTAL INGRESOS NETOS FAMILIA / AÑO = 1 680 000 (venta productos finca) + 319 500 (bar) + 2 220 000 (alquiler de habitaciones) + 2 400 000 (sueldo papá) = 6 619 500

Ningún otro miembro de la casa realiza ninguna otra actividad, los hijos/as no van a la finca, y la mamá no hace otra cosa ni vende nada, a parte del bar y la finca. De las hijas que colaboran en el bar: una solo hace eso (no trabaja en otra cosa ni estudia), la otra va al colegio y coopera un poquito en el bar por las tardes (solo tiene clase por las mañanas).

B.3 Productos de la finca y animales / anotaciones sobre caza y pesca.-

Productos cultivados	Lugar	Utilidad V ó C	Datos temporadas	Plantado por ellos
Malanga	F	V y C		
Plátano	F	V y C		
Banana	F	V y C		
Ñame	F	V y C		
Papaya	P	V y C		
Malanga de país	F	V y C		
Atanga	F	V y C		
Mango	F	V y C		
Aguacate	F	V y C		
Caña	F y P	V y C		
Piña	F	V y C		
Picante	P	V y C		
Verduras de Malanga	F	V y C		
Green	F y P	V y C		
Vitalif	F y P	V y C		
Topepán	F	V y C		
Berilahualé	F	V y C		

EXPLICACIÓN: la F quiere decir que lo tienen plantado en la Finca y la P en el Patio, esto es, al lado de casa, también podría ser H en una huerta. Y también se puede poner V o C si es para venta o consumo, así como la temporada. Todo esto tu verás lo que puedes poner y lo que no, ya sabes que yo te pongo todo lo ideal y luego tu haces lo que puedes o debes si la familia se cansa o se molesta. Sin embargo si es una actividad principal entonces rellenarla puede resultarte muy útil para calcular bien los ingresos.

Animales

Tiene 4 gallinas y un gallo, aunque otras veces han tenido más pero ahora les han desaparecido bastantes (quizá por los gatos o perros de la zona), no recogen los huevos para que se hagan pollitos y solo las matan en ocasiones especiales. EXPLICACIÓN: Hay que anotar las clases de animales, la cantidad de cada uno, el lugar donde están y la alimentación y cuidado que tiene. También la finalidad de la cría (para comer en ocasiones especiales, para vender…) y si crían gallinas hay que especificar si recogen los huevos.

Caza

El hermanito caza sobre todo antílopes y también, aunque menos, puercoespín, dice que aunque ya sale rentable gastar un cartucho en un gronbif no les suele tirar (solo usa escopeta). Suele ir a cazar cuando lo necesita. Cuando tiene empleo no suele ir, prefiere descansar los fines de semana. Pero antes que no vivía en casa de su hermano si cazaba también cuando trabajaba porque necesitaba el dinero. Va siempre a Basilé Fang a cazar y empieza a las 7 de la tarde o por ahí y está toda la noche hasta el amanecer. (Es importante saber si caza al amanecer, cuando ya hay luz del día, porque es a esas horas cuando los monos se empiezan a mover; si solo caza cuando es de noche y no hay luz, entonces no caza monos). Sube hasta el Km 4 y allí empieza a cazar por el lado derecho de la carretera hasta el Km 8, luego baja andando por la carretera o si pasa un coche a veces le bajan pero no le cobran. Deja un antílope en la barrera para poder subir. (Esto quizá lo digan si les preguntas: ¿Tienes que pagar algo o dejar algo para subir al pico?, pero siempre hay que intentar intuir antes de preguntar si es una pregunta que les va a molestar o no, de todas formas se les puede recordar a mitad de la entrevista lo que se les dice al principio, que lo que no quieran contestar que no lo contesten pero que no digan algo que no es cierto)

SECTION C: WEALTH INDICADORES

C.1 Casas.-

¿La casa donde viven pertenece a los cabeza de familia?
Sí

¿Fue comprada/construida por la familia que vive en ella o ha sido regalada o cedida por algún familiar?
Construida por el papá (que es albañil)

En caso de haber sido comprada ¿Cuánto costó?; en caso de haber sido construida ¿puede aproximar su valor?
Primera fase 1 500.000
Techo 6000 x 20 = 120000
1 000 000 – 1 500 000 otros
Ejemplo: Se acordaba de que al principio se gastó 1 500 000 XAF de golpe en material y transporte porque era lo que tenía ahorrado para la casa. Después contamos las placas del techo que tenía, pues cada una costaba 6 000 XAF y tenía 20. Luego él calcula que el resto fue otro millón o millón quinientos.

Anotar también (puede hacerse sin preguntar o ayudándose con preguntas, como se quiera) los materiales con los que se ha construido: paredes, tejado, suelo, etc, todo lo que tu veas, puedas o quieras apuntar y comentarios o impresiones que te de la casa: ej, grande o pequeña para el número de personas que son, buen estado, degradada, lo que sea. Se puede describir: barracón, casa, piso antiguo, etc. También se pueden hacer comentarios sobre el barrio, si está situada en una zona asfaltada o no, etc)

Es una casa de cemento con techo de chapa barata (3000/chapa), tamaño medio, con el bar formando parte de la casa, con baño y cocina dentro de la casa. Suelo de cemento, baldosas en la pared de la cocina y el baño. Los muebles están en bastante buen estado y tienen de todo (sofá, dos sillones, mesa para comer grande con cuatro sillas, ventanas de cristal, camas, puertas, 1 estantería grande en el salón. El bar tiene un porche asfaltado con 4 mesas de plástico con 3 sillas cada una.

¿Tienen más casas los cabezas de familia? Decir precio o valor de cada una (y materiales de construcción)

La casa que están comprando y la casa alquilada que, ambas ya mencionadas antes.

C.2 Bienes.- Indicar nº, precio de cada uno y año de compra de cada uno

Generador eléctrico: 900 000 (4 años)
Si el motor no lo ha comprado él pero tiene luz siempre, anotar que no le falta la luz.
Agua corriente (si o no): no
Agua que llega hasta la casa o hay que salir fuera a buscarla: llega hasta la casa
Calentador: ---------

Televisores: 112 000 (2009, segunda mano) 300 000 (hace 5 años) (el de segunda mano lo compraron para los niños que están en Malabo de alquiler, lo ponemos porque son bienes del núcleo familiar, hay que poner aquí los bienes que tengan en todas sus casas)
Teléfonos móviles: 30 000 y 50 000 (los dos año pasado) y dos más que tienen 2 hijos pero no saben cuanto les ha costado porque se lo han pagado ellos con sus ahorros.
DVD o similar: 1 (regalado)
Cámaras de fotos: --------- el hermanito tiene una, pero como no vamos a incluir ni los gastos ni los ingresos de este miembro en los gastos e ingresos de la familia, por los motivos antes mencionados, pues no ponemos nada)
Cámaras de video: --------
Videojuegos: ----------
Cadena de música: 1 (300 000) y 1 pequeña con 2 altavoces (regalo) (tienen una en casa de los padres, que compraron ellos, y otra en la que están los hijos que se la regaló un tío)
Altavoces (a parte del aparato de música): ----------
Radio: 12 000 (2002)
Ordenadores: ----------
Frigorífico: 500 000 (hace 5 o 6 años)
Congelador: 1 (400 000) y 1 (110 000)
Lavadora: ---------
Secadora: ----------
Plancha eléctrica: 120 000 (de hace muucho, no se acuerda cuando)
Vehículos (coches, notos, bicis, otros): 1 (4 millones, de segunda mano comprado hace 7 años, Suzuki Vitara)

Medios de cocina (también nº, precio y año de compra, donde preceda):

- Infiernillo: 1 (50 000)
- Leña: ------
- Gas: ------
- Vitrocerámica: --------
- Microondas: --
- hornillo: 80 000 (2009)
- otros

Appendix 3.2-4 Food diary sheet

An illustrative example of the annotated data is provided in blue. This card corresponds to one day. A total of seven cards were given to households.

Fecha: 9/07/2009 **Pueblo:** Bososo **Familia:** Gervasio Lopeo

Comidas principales	**Artículo/especie.**	**Estado (vivo, fresco, ahumado, congelado, enlatado, etc)**	**Cantidad**	**Precio**	**Lugar de obtención: mercado, bar, tienda, bosque granja, etc**	**Miembros que comieron y edad**
Desayuno	huevos		2	700/media docena	Tienda	Solo yo- 29
	Panes		2	100/pan	Tienda	
Comida mediodia: pata de cerdo con caracoles	Berengena europea		Media		Huerto	Mi marido-36 Mi sobrinito- 4 3 amigas (más de 30 y menos de 40) Yo-29 Mi niña-2 Mi hermanita-12 (tomo su plato a la hora de cenar)
	Tomate	En lata	2 frutas de 1 lata	500/lata	Bar	
	Cebolla		1 pequeña	100	Mercado	
	Ajo		3 dientes	50/cabeza	Mercado	
	Caldo		2 grandes	50/caldo	Super	
	Aceite		Chorrito	1300/ botella	Bar	
	Pata de cerdo	congelado	1 kg	1500/Kg	Abacería	
	Caracoles		Montón de 1000 CFAs	1000	Mercado	
Cena	Leche	Polvo	3 cucharadas	bote grande/2800	super	Mi marido-36
Otras	Atanga		Monton de 4 a 5 frutas	500	Mercado	Mi marido-36 Yo misma-29
	Sal		Una pizca	100/bolsa	Super	
Otras	Caña de azucar		Media		Bosque	Mi sobrinito 14 Su amigo 14

Appendix 3.2-5 Offtake datasheet

An example of what the annotated data would be is shown. To better understand the example, blue and green colors separate two hunting batches from two different hunters; dark and light colors indicate sales and non-sales, respectively.

Date	Specie	Sex M/F	Age A/J	Trader	Hunter	Price (for the trader)	Place where hunted (Km. Pico road)	Method	Sales location	Price (for the client)	State A/F/S	Hunting trip duration and num. of traps
6/7/2013	Antílope	M	A	Angelina	Chiqui	10000	22	Trap	Malabo	14000	F	Departure day and time 6 -6:00 Arrival day and time 8-17:00 150 traps reviewed
6/7/2013	Antílope	F	A	Angelina	Chiqui	13000	22	Trap	Road	16000	A	
6/7/2013	Venado	F	A	Angelina	Chiqui	18000	22	Trap	Malabo	20000	F	
6/7/2013	Venado	F	J	Angelina	Chiqui	15000	22	Trap	Road	17000	F	
6/7/2013	Venado	M	A	Angelina	Chiqui	18000	22	Trap	Malabo	20000	A	
6/7/2013	Damán	M	A	Angelina	Chiqui	8000	22	Trap	Road	8000	F	
6/7/2013	Antílope	M	J	Chiqui	----	----	----	Trap	Eaten	----	----	
6/7/2013	Puercoespín	M	A	Mónica	Emeterio	18000	7	Gun	Malabo	20000	F	6 - 8:00 6 - 16:00
6/7/2013	Rata	F	A	Mónica	Emeterio	3000	7	Gun	Malabo	4500	A	
6/7/2013	Cola roja	M	J	Mónica	Emeterio	13000	7	Gun	Malabo	17000	F	
6/7/2013	Rata	F	A	Mónica	Emeterio	3000	7	Gun	Malabo	5000	F	
6/7/2013	víbora	----	----	Mónica	Emeterio	-----	Pueblo	Gun	Home	----	----	
6/7/2013	Coronado	F	J	Emeterio	----	------	7	Gun	Gift for militars	----	----	
6/7/2013	Drill	M	J	Mónica	Emeterio	-----	7	Gun	Home	----	----	

Appendix 3.2-6 Questionnaire for Basilé Bubi and Basilé Fang before the offtake survey (2010)

At the beginning of the offtake survey, in August 2010, following the completion of interviews on livelihoods, consumption, past activities, and reasons for change, I conducted detailed interviews with 22 hunters out of the 37 active hunters in BF at that time. Specifically, I asked them about the details of their hunting activities (method, season, area), their effort (number of hunting trips per week, hours per day, number and type of traps), their catches (most commonly hunted animals with each hunting method), and the relative abundance of species in their hunting area. If the hunter had more than one hunting area, a separate survey was conducted for each area. They were also asked if they had recently changed hunting areas, and if so, why. In such cases, the survey was repeated for the previous area. If the hunter had been hunting in the area or on the peak for an extended period, they were asked about their perception of changes in species abundance or distribution, as well as their hunting effort. In Basilé Bubi, the same survey was also conducted with two of the five farmers who set traps on their land.

SECTION A: DATA ON HUNTING ACTIVITY AND SPECIES ABUNDANCE AND DISTRIBUTION IN THE HUNTER'S AREA.

Cazador: Fecha entrevista:

Método		**Ubicación**			**Esfuerzo**			**Animales más cazados**		**Animales más abundantes**		
Metodo	**temporada**	**Km inf**	**Km sup**	**Descripción zona**	**nº de trampas**	**horas de caza**	**días por semana**	**grado**	**animales más cazados**	**grado**	**Animales más abundantes**	**Zona**

¿Has notado cambios en la capturas o esfuerzo de caza? Comenta como era en el pasado
animal nº cazado esfuerzo zona

¿Dónde cazabas antes?
Si el sitio es diferente preguntar por qué ha cambiado de sitio y rellenar tabla anterior con respecto a la zona pasada

Método		**Ubicación**			**Esfuerzo**			**Animales más cazados**		**Animales más abundantes**		
Metodo	**temporada**	**Km inf**	**Km sup**	**Descripción zona**	**nº de trampas**	**horas de caza**	**días por semana**	**grado**	**Animales más cazados**	**grado**	**Animales más abundantes**	**Zona**

SECTION B: SPECIFIC DATA ON PRIMATE HUNTING, ABUNDANCE AND DISTRIBUTION IN THE HUNTER'S AREA AND IN PICO BASILÉ

During these interviews, I noticed that hunters did not differentiate between primate species; instead, they grouped them together and responded simply with 'monkey.' To avoid prolonging the interview, I left it as it was. However, I later conducted a new survey with 18 of the 24 hunters previously interviewed (16 in Basilé Fang and 2 in Basilé Bubi), asking them specifically about the location and relative abundance of different primate species in their hunting areas or, for the more experienced hunters, across Pico Basilé as a whole.

B.1. Primates in your hunting area
In blue is shown an example of what would be the data noted.

Área de caza (indicar km y lado de la carretera): Andrés, km 22,5 lado izquierdo

Nombre vulgar	**Nombre científico**	**Nombre en Fang**	**Presente en tu área**	**Abundancia relativa (según capturas)**
Colobo negro	*Colobus satanas satanas*	Nvuan	si	+
Cola roja	*Cercopithecus erythrotis erythrotis*	Nguem Chogo	si	++
Guenon de preus	*Cercopithecus preussi insularis*	Ecafum	si	+++
Nariz blanca	*Cercopithecus nictitans martini*	Avem		
Colobo rojo	*Procolobus pennantii pennantii*	Muan-ntang		
Mono coronado	*Cercopithecus pogonias pogonias*	Essuma		
Drill	*Mandrillus leucophaeus poensis*	Essegue		
Gálago elegante del norte	*Euoticus pallidus*	Emam		
Gálago de Allen	*Galago alleni*	Nseñ		
Gálago enano	*Galagoides demidoff poensis*	Odjäm		

¿La escopeta es tuya? ¿Cuánto te “cuesta” alquilarla? ¿A quien se la alquilas? ¿Qué piezas le dabas antes? ¿Y ahora que no puedes cazar monos?

¿Alguno de tus hijos/familiares caza de vez en cuando? ¿Dónde? ¿Con qué frecuencia? ¿Qué representa la caza en sus ingresos/actividades?

B.2. Primates on Pico Basilé

In blue is shown an example of what would be the data noted.

Nombre vulgar	**Nombre científico**	**Nombre Fang**	**Presente en Pico**	**Abundancia relativa (según conocimientos cazador)**
Colobo negro	*Colobus satanas satanas*	Nvuan	si	++
Cola roja	*Cercopithecus erythrotis erythrotis*	Nguem-chögo	si	+++
Guenón de preus	*Allochrocebus preussi insularis*	Ecafum	si	++
Nariz blanca	*Cercopithecus nictitans martini*	Avem	si	+
Colobo rojo	*Procolobus pennantii pennantii*	Muan-ntang	No	0
Mono coronado	*Cercopithecus pogonias pogonias*	Esuma	si	+
Drill	*Mandrillus leucophaeus poensis*	Esegue	si	+
Gálago elegante del norte	*Euoticus pallidus*	Emam	si	+++
Gálago de Allen	*Sciurocheirus alleni*	Nseñ	si	++
Gálago enano	*Galagoides demidoff poensis*	Odjäm	si	++

Appendix 3.2-7 Questionnaire for Basilé Bubi and Basilé Fang hunters during the follows (2011)

In blue is shown an example of what would be the data noted.

Los cazadores que usan tanto escopeta como trampa deben contestar a todo.

A) Questions for trappers

1. Preguntar al cazador la cantidad de trampas que tiene en esta zona
   En la zona de "UNGE": 324 trampas de Pie grueso (Pg)
2. Anotar después de seguirle cuántas tiene realmente

   UNGE: 299 Pg
   Diferencia: 25 menos en la realidad

3. ¿Cuándo fue la última vez que revisaste tus trampas?

4. ¿Cada cuanto tiempo revisas las trampas?
   Cuando está en el bosque pasa 2 días pero cuando está en el pueblo pasa 1 semana

5. Preguntarle la clase de trampas que construye.
   En la zona de la Unge tiene Pg

6. ¿Trampas todo el año?
   No trampa todo el año pero si que cambia las trampas cada 6 meses para que resistan la lluvia

7. ¿Cuántas llegas a poner de máximo?
   Dice que quiere poner como máximo 350 trampas

8. ¿Pones todas tus trampas este recorrido que te he acompañado?
   Sí las pone en el mismo recorrido
9. ¿Cuánto tiempo llevas trampando en esta zona?
   Comienza a trampar en la unge desde 2008 hasta ahora
10. ¿Has utilizado otros tipos de trampa?
    Desde 2009 pone Pg porque antes ponía Pf pero no resistía y cambió.
11. ¿Has trampado en otras zonas?
    Sí en Km 2 y 5
12. ¿Por qué has cambiado de zona?
    He cambiado de zona porque ya no cazaba tanto porque entraban otros cazadores en la misma zona y estuvo en esas zonas desde 1999 a 2004.
13. ¿Qué cazas con mayor frecuencia?
    1. Antílope; 2. venado. Antílope puede cazar unos 10 al mes si tiene mucha suerte y al año más de 100. Y wl año anterior, es decir los primeros años, cazaba mucho más (empezó a cazar allí en 2008, la entrevista se hizo en 2011). Venado caza unos 3 a 5 al mes, y en los años atrás con mayor frecuencia).
14. ¿Qué otras especies hay en tu zona, amas de los que cazas?

En esta zona no captura otras cosas, solo cuando usa la escopeta

B) Questions for gun-hunters

1. ¿Cuándo cazas con escopeta?
   Cuando está en la cabaña no tiene días fijos, sale a cazar con escopeta cuando quiere, puede ir de día o de noche. Caza todo el año, salvo si le cogen la escopeta por un evento nacional (a veces las han requisado temporalmente).
2. ¿Dónde?
   En la UNGE que es donde tiene ahora la cabaña
3. ¿Desde cuándo?
   2008
4. ¿Has cazado en otros sitios con escopeta?
   No, antes cazaba en Km 5 pero no con escopeta
5. ¿Qué especies cazas de día?
   1. Preus (200) o más al año
   2. Cola roja (100-120/ año)
   3. Colobus satanas (30/ año)
   4. Damán (5 al año)
6. ¿Qué especies cazas de noche?
   1. Antílope (20 al año)
   2. Gálago (14 al año)
   3. Venado (10 al año)
7. ¿Qué otras especies hay en tu zona?
   Ardilla pero no lo caza
8. ¿Es tuya la escopeta o la alquilas? ¿Cuánto te cuesta?
   La escopeta no es suya y paga 30.000 al mes

C) Common questions

1. ¿Tienes una socia a la que le vendes?
   Sí, suele encontrar a su cliente especial en el pueblo o bien le envía los animales
2. ¿Tienes que dar piezas como pago por subir por la carretera?
   A veces da carne a los coches pero no siempre. A la semana puede ofrecer al conductor 1 turaco y al mes un antílope
3. ¿Hay más cazadores en tu zona de caza? Sí
4. ¿Con qué frecuencia vendes carne?
   A la semana envía por lo menos dos embarques que pueden llegar a ser de 60.000 y entonces a la semana ganar 120.000, pero las cifras cambian. Manda venados, antílopes monos y turacos si es posible.
5. ¿Haces alguna otra actividad a parte de cazar? Actualmente no
6. ¿Qué te da más dinero? La caza es mi principal fuente de ingreso
7. ¿Cuándo aprendiste a cazar/trampar? En Bata cuando era niño
8. ¿Te gustaría dedicarte a otra cosa?
   Le gusta el bosque, podría dedicarse a otras cosas pero sin dejar de cazar. Está acostumbrado y no puede dejarlo

Appendix 3.2-8 Report on the general topics discussed and proposals presented at the "Seminar-Workshop: Assessment of the Hunting Issue in Pico Basilé and Plan for its Sustainable Management and Continuous Monitoring over Time".

INFORME

SOBRE LOS TEMAS GENERALES DISCUTIDOS

Y

LAS PRPOUESTAS PLANTEADAS

EN EL SEMINARIO-TALLER

EVALUACIÓN DEL PROBLEMA DE LA CAZA EN EL PICO BASILÉ Y PLAN PARA SU GESTIÓN SOSTENIBLE Y MONITORIZACIÓN CONTINUA A LO LARGO DEL TIEMPO.

Celebrado en la Universidad Nacional de Guinea Ecuatorial, en Malabo, el 16 y 17 de diciembre de 2011.

María Grande Vega
23 de marzo de 2012

ÍNDICE

1. Introducción

El siguiente informe está dividido en tres partes. El primer punto "Resumen ejecutivo" cuenta brevemente como se llevó a cabo el seminario-taller de discusión, en relación al programa propuesto (ver programa en Anexo I). El segundo punto recoge las discusiones y propuestas dadas en el mismo. Y el tercero es una tabla resumen de estas propuestas.

2. Resumen ejecutivo

El seminario-taller transcurrió con éxito, ajustándose en gran parte al programa inicial. La apertura tuvo lugar con la emisión del documental: Los cazadores de Basilé (disponible en la web (https://sites.google.com/site/asociacionecotono/videoteca/los-cazadores-de-basile). Tras él comenzaron a darse las ponencias previstas en el programa (ver anexo I), salvo la segunda (de Don Antonio Michá) y la cuarta (de Don Jesús Mbá) a cuyos ponentes surgieron imprevistos que hicieron imposible su asistencia por lo que tuvieron que suprimirse. Para el resto de las ponencias tras cada una hubo media hora de preguntas y debate, donde fueron surgiendo ideas. Así pues pudimos conocer y debatir el funcionamiento y los proyectos llevados a cabo por BBPP, UNGE, INDEFOR y ANDEGE. Aunque no hubo ponencia sobre el proyecto del Parque Nacional de Monte Alén este fue muy comentado en los debates.

El segundo día comenzó con la exposición del Proyecto *"Evaluación del problema de la caza en el Pico Basilé y Plan para su gestión y monitorización continua a lo largo del tiempo*" y la discusión de sus resultados, que fue algo más extensa de lo previsto. Tras ella 20 asistentes del seminario-taller se trasladaron al pueblo de Basilé Fang. El cual había sido informado con anterioridad de nuestra visita, por lo que un amplio número de cazadores y mujeres comerciantes de carne de bosque nos esperaban. El debate fue moderado por Fidel Esono (Director de INDEFOR) quien hizo además de traductor en múltiples ocasiones. Comenzamos con la presentación de cada uno de los participantes. Después les expusimos nuestra preocupación sobre el problema de la caza y nuestra intención de escuchar sus opiniones (especialmente el por qué de esta actividad) y sus preocupaciones ante posibles restricciones. A continuación comenzó el dialogo donde tanto cazadores como comerciantes participaron activamente extendiéndose bastante más de lo previsto.

Tras la clausura de este encuentro en Basilé. Los asistentes volvieron a la UNGE. La jornada de la tarde comenzó con la exposición de Conservación Internacional sobre sus último proyecto realizados en la Región Continental en el que además participaron 4 estudiantes finalistas de la FMA de la UNGE. Así pues fuimos de los privilegiados en obtener la valiosa información preliminar del estado de los gorilas, chimpancés y elefantes en la región continental.

Llegado el momento de los trabajos en grupo, la hora de la tarde era ya muy avanzada, por lo que se decidió pasar directamente a la discusión general. Aquí se recordaron y resumieron brevemente las ideas más importantes que habían ido saliendo. Pero se acordó hacer un informe más extenso que fuera enviado por mail a todos los participantes (se trata de este informe que enviamos ahora) así como a aquellos invitados que no pudieron venir, para que, además de tener todas las propuestas surgidas, pudieran aportar nuevas ideas que les surgieran tras su reposada lectura.

3. Discusiones y propuestas

3.1. Regulación temporal de la caza

El hecho de que en el Pico Basilé existan diferentes hábitats y especies de distintas tasas de reproducción y niveles de extracción, y la idea compartida de que no se busca la prohibición total de la caza en el Pico, sino su extracción sostenible; dio lugar a plantear la **necesidad** que habría **de establecer periodos de veda y cuotas de extracción**.

Ante esto surgió sin embargo el problema de la **falta de datos que hay en cuanto a información poblacional** (dinámicas de población, modelos de productividad, etc), necesarios para establecer estos periodos y cuotas. Tras un breve debate se planteó como solución a este problema crear un **laboratorio en la UNGE para el análisis de las entrañas de animales** muertos. El equipo de investigación del proyecto "Evaluación del Problema de la Caza en el Pico Basilé" planteó que aprovechando la buena relación con los habitantes de Basilé Fang, y en especial con los dueños de uno de los restaurantes que sirven carne de bosque diariamente, no sería difícil recoger las entrañas y trasladarlas a la UNGE para su posterior análisis (y de paso formación de alumnos en estas técnicas). La idea fue acogida con entusiasmo y los investigadores: John E. Fa, Bruno Carpinetti y María Grande Vega, junto con la FMA de la UNGE y la EUEAPF ya están dando los primeros pasos para la puesta en marcha de este proyecto.

3.2. Alternativas para los cazadores y comerciantes

Tras la exposición de los resultados del proyecto, quedó claro el diferente impacto que se produce en las áreas en las que se da una caza como actividad de subsistencia del que se produce en las que se da como actividad comercial. También quedó claro que **en el Pico** y especialmente en Basilé Fang, **se da una extracción comercial, la cual representa una actividad generadora de ingresos para las familias**, y en la mayoría de los casos la principal fuente de ingresos. Así pues **si se restringe la caza habría que pensar en dar alternativas** a estos grupos para los cuales representa su principal o único medio de vida. Esto es fundamental para lograr que tenga éxito esta posible restricción y para que se cumplan las políticas de conservación que se decidan aplicar. Tras varios debates, se llegó a la conclusión de que **la mejor alternativa es integrar a la población dentro del mismo proyecto de conservación**. Por ejemplo como guardas forestales, guías, como ayudantes de investigación, etc, según el tipo de proyecto. En casos de proyectos donde haya turismo habría más posibilidades de distintos puestos de trabajo (cocineros, mozas, etc.). Se pusieron como ejemplos: la gestión del Parque Nacional de Monte Alén en la que un gran número cazadores se convirtieron en trabajadores del parque, y la participación del pueblo de Ureca en el proyecto de conservación de las tortugas llevado a cabo tanto en el pasado por la Asociación Amigos de Doñana como en el presente por BBPP.

Esta solución daría trabajo a unos cuantos pero no a todos los cazadores y comerciantes de carne de monte. Ello porque seguro habrá más cazadores y comerciantes que puestos de trabajo y por otro lado porque no todos estarán cualificados o querrán trabajar en los puestos que se les ofrezca.

Ante esto lo mejor era hablar con los afectados, en nuestro caso nuestra área de estudio fue Basilé Fang. Así pues un grupo de los asistentes a los seminarios se trasladó allí y se tuvo un debate con los habitantes del pueblo. Surgieron varias ideas:

"Había un hombre con deseos de recibir ayudas para desarrollar una pequeña explotación ganadera, la cual ya había comenzado a hacer por su cuenta. Otros sin embargo alegaban que eso no sería solución para todos los habitantes del pueblo, ya que a muchos no les gusta la ganadería. Otras mujeres comentaban sin embargo que harían cualquier cosa (mencionaron concretamente que incluso limpiar cuatros de baño) si ello les fuera más rentable que el comercio de la carne de bosque. Sin embargo otros decían que no harían cualquier cosa aunque les fuese más rentable, si no era algo que también les gustase. Así pues quedaron claras dos opiniones: un grupo haría lo que fuese, siempre que fuera más rentable que la caza o el comercio de ésta; y otro no haría cualquier trabajo, dependería de si encajase dentro de sus gustos y habilidades"

Tras este debate con la comunidad de Basilé Fang surgieron varias ideas:

¿Se podría hacer una pequeña explotación ganadera o agrícola en el pueblo?

El problema que encontramos aquí es el de conseguir una explotación rentable y rentable en el tiempo. En muchos países la agricultura y la ganadería está subvencionada ya que no es rentable. En Guinea Ecuatorial conocemos algunos proyectos que se han llevado a cabo y que han fracasado al no perdurar en el tiempo, por ejemplo: **La granja de Basilé** (puesta en marcha por la Cooperación Alemana), **la granja de Musola** (puesta en marcha por la cooperación Española), **la explotación ganadera de vacas sudafricanas en Moka** (puesta en marcha por la Cooperación Sudafricana). Aunque no hemos hecho un análisis detallado del motivo de sus fracasos (por falta de información de las instituciones que los llevaron a cabo) de lo hablado con los que lo vivieron de cerca, parece claramente más un motivo de mala gestión posterior a la puesta en marcha que de poca productividad.

Por otro lado han existido también proyectos para reforzar las agrupaciones agrícolas, como: el ***Proyecto de Auto-Empleo de la Mujer Rural (PRAMUR)***, para el refuerzo de las agrupaciones femeninas agrícolas, llevado a cabo por el Ministerio de Asuntos Sociales y Promoción de la Mujer (MINASPROM) y financiado por el Fondo de Desarrollo Social del Gobierno de Guinea Ecuatorial; o el ***Proyecto de Apoyo a la Sociedad Civil (PASC)***, del 9º FED (Fondo Europeo de Desarrollo), cuyo objetivo es apoyar las organizaciones de la sociedad civil, dentro de las cuales se encuentran las agrupaciones agrícolas. Tampoco ha sido posible obtener una información clara de los resultados de estos proyectos, pero en el terreno se han descubierto pocos avances. Se sabe también que en muchos casos el gobierno ha dado financiación a los pueblos, pero sin planificación alguna, por lo que el dinero ha sido mal empleado y gastado con rapidez.

Así pues ¿Puede la UNGE crear una granja que de trabajo a los del pueblo y sirva a su vez de negocio y de lugar de prácticas para los alumnos de agricultura?

Sería algo novedoso en cuanto que sería un proyecto puesto en marcha por una Universidad y mantenido en el tiempo por ella, no solo como negocio sino como centro de estudios para los estudiantes de agricultura y como centro de formación y empleo para la población local.

Pero como acabamos de comentar, ya muchos proyectos han sido llevados a cabo en Guinea tanto por instituciones extranjeras, como por el propio gobierno o por comunidades locales, con malos resultados. Así pues quedamos en que previo a otro proyecto sería necesario hacer un estudio muy detallado de todo lo necesario para que tenga éxito y en especial de la gestión que se va a llevar y de la productividad que se podría obtener.

También se comentaron algunas ideas para los jóvenes de estos pueblos cazadores. Se dijo que sería bueno informarles de otras opciones, como becas del gobierno, de otras entidades, etc. para realizar estudios o formación. Pero no se concretó como se podría hacer (en la tabla resumen aportamos una idea).

3.3. Alternativas para los consumidores

Tras la exposición de los resultados de nuestro proyecto surgió como idea para la reducción del consumo de carne de bosque el **desarrollo** de una mejor **carne doméstica** de la que hay en la actualidad (prácticamente inexistente con casi toda la carne importada y congelada). En este caso nos topamos con las mismas dificultades que las arriba mencionadas. Por lo que igualmente haría falta un estudio más detallado de las posibilidades de desarrollar este sector.

Por otro lado se comentó la posibilidad de cría de especies silvestres pero se recordaron las dificultades obtenidas en el pasado. Sin embargo el Decano de la FMA nos habló de su proyecto personal de cría de caracoles, que está llevando a cabo en su propia casa con un significativo éxito (algunos de los asistentes ya lo conocían y había ido a visitarlo).

3.4. Sensibilización a los consumidores

El destino de la carne de la carne de bosque y los consumidores, se encuentran en su gran mayoría en la ciudad de Malabo. Así pues se concluyó, la necesidad de sensibilizar a estos consumidores para la reducción del consumo de carne de bosque en general y para el cese total de consumo de productos ya prohibidos (como primates y tortugas).

Aunque en los talleres tampoco se mencionó cómo y quién podría encargarse de esta tarea. Cabe mencionar que actualmente el Centro Cultural Español de Malabo (CCEM), se ha puesto en contacto con nosotros (el equipo investigador del proyecto), con CI y con BBPP para solicitar nuestra participación en una **Semana de la Biodiversidad** prevista para el mes de septiembre. Se harían actividades en el CCEM y también en diversas escuelas de Malabo. Las actividades están aun por determinar y se concretarán con las ideas y el apoyo de todas las entidades participantes. Así pues tenemos la oportunidad de diseñar un pequeño programa de difusión de información y educación medioambiental para esa semana tanto para adultos como jóvenes y niños de la ciudad de Malabo. El CCEM está abierto además a más instituciones que quieran participar.

3.5. Sensibilizar a las autoridades

También se propuso sensibilizar a las autoridades y nos referimos a:

1. Las que alquilan sus escopetas a los cazadores o venden sus municiones
2. Las encargadas de velar por el cumplimiento de las normas existentes
3. Las encargadas de firmar visados, permisos, etc para el desarrollo de los proyectos.

Como solución inmediata a este problema se propuso **invitar a este tipo de seminarios a representantes de estas autoridade**s. Con el objetivo de sensibilizarles.

3.6. Otras cuestiones

Al hablar de las áreas protegidas surgió la inquietud por parte de algunos asistentes de la falta de participación de INDEFOR y ANDEGE en la región insular y la multitud de actividades realizadas en la región continental. La razón clara que fue dada fue: la falta de fondos. Se comentó sin embargo el proyecto del MPyMA de Fortalecimiento del Sistema Nacional de Áreas Protegidas, en el que sí se encuentra incluido el Parque Nacional de Pico Basilé.

Se planteó entonces que tanto la **UNGE** como **INDEFOR**, que son instituciones independientes con capacidad de firmar acuerdos, podrían aunar esfuerzos y trabajar juntas o **coordinar actividades** en algunos campos. Así pues tanto el Director de INDEFOR Fidel Esono, como el Decano de la Facultad de Medio Ambiente, José Manuel Esara, se comprometieron a firmar un acuerdo para solucionar esta falta de coordinación.

Por otro lado el profesor Severo Meñe, propuso también una relación **UNGE-INDEFOR** en temas de formación de **cartografía**. Quedando en hablar de ellos tras los talleres entre el Director de INDEFOR y Severo.

Una alumna alertó también de la importancia de conseguir **compatibilidad** entre las **decisiones** del gobierno y las **acciones** de las instituciones encargadas de la conservación en el territorio.

4. Tabla resumen de propuestas

HECHO	NECESIDAD	PROBLEMA	SOLUCIÓN/PROPUESTA	ENTIDADES QUE VAN A PONER EN MARCAH LA SOLUCIÓN	FECHA
La caza en el Pico Basilé no está regulada. Estudios previos en la Isla demuestran la reducción de las especies y el aumento de la caza. Muchas especies se encuentran amenazadas. No se pretende prohibir la caza sino regularla de manera que sea sostenible	Es necesario zonificar y establecer periodos de caza para algunas especies.	No hay suficientes datos sobre la dinámica de poblaciones y los periodos de reproducción, para poder establecer estas cuotas y áreas.	Montar un pequeño laboratorio en la UNGE para analizar las entrañas de los animales presa con el fin de estudiar los periodos reproductivos y el contenido estomacal. Estos datos, junto con los que ya tenemos de extracción, nos permitirán saber en qué casos y cómo debemos establecer las cuotas y zonificación.	FMA de la UNGE/ E.U.E.A.P.F/equipo investigador	2012
La única carne fresca que se consume en Bioko es la carne de bosque.	Una carne doméstica de Calidad producida en el país.	El sector ganadero no se encuentra desarrollado y los problemas en gestión de proyectos de cooperación pasados, los llevaron al fracaso	Recopilar más información sobre proyectos pasados y de empresarios y pequeños agricultores de la isla. Llevar a cabo un análisis más profundo de las posibilidades de éxito para fomentar el sector ganadero y agrícola de la mejor manera posible (quizá más enfocado hacia el sector privado, quizá un proyecto dependiente de la UNGE).	**¿?** (de momento el equipo investigador, que ya se puso en contacto con el Centro de estudios rurales y de agricultura internacional (CERAI), va a volver a tener una reunión para hablar de posibilidades).	2012
Muchas familias basan su economía en la caza o el comercio de la carne de bosque. La reducción de esta actividad, por su regulación, supondría un problema para estas familias.	Dar trabajo alternativo a las familias que se vieran afectadas	Sería difícil dar trabajo (y trabajo rentable) a todos, ya que además cada uno tiene sus habilidades y gustos. Además de las posibilidades de integrarlos en un proyecto de conservación habría que buscar otras alternativas: becas y formación para los jóvenes, desarrollo agrícola y ganadero para los interesados.	¿Se puede ayudar a informar y a fomentar una formación profesional o académica para estos jóvenes? Idea: ¿se podría crear una organización/grupo encargado de informar a los jóvenes de posibilidades de estudios y becas, capaz también de motivar a las empresas que destinan dinero a proyectos sociales y becas, para apoyar a este sector?	**¿?** (el equipo investigador va a ponerse en contacto con Pilar Vázquez, la directora del Centro de FPO 12 de octubre que se está poniendo en marcha en Malabo. Ello con el objetivo de ver posibilidades conjuntas de motivar a los jóvenes a formarse en distintos oficios.	2012

El comercio y consumo de algunas especies está prohibido sin embargo se siguen vendiendo y consumiendo. La población rural utiliza este recurso como medio de vida, mientras que la población urbana lo compra para consumo.	Disminuir la demanda de carne de bosque y evitar que se consuman las especies cuyo comercio está prohibido, como primates y tortugas.	La tradición y el gusto por el consumo de carne de bosque están muy arraigados en la población.	Informar y sensibilizar al consumidor (niños, jóvenes y adultos) de la situación de las especies silvestres, especialmente de las más amenazadas, y el problema de su demanda para consumo.	CCEM-UNGE-Equipo investigador-CI-BBPP “Semana de la Biodiversidad”	Sept. 2012
En muchos casos proyectos aprobados por el mismo gobierno no reciben el apoyo necesario de las autoridades para su correcto desarrollo	Conseguir un mayor apoyo de las autoridades	Falta de coordinación e información en muchos casos	Invitarlas a los seminarios y talleres que se hagan para que estén al tanto de las actividades y las necesidades de los proyectos, así como de las dificultades que presenta su falta de apoyo.	Todos las participantes al seminario	Previsto para futuros semina-rios/reu-niones/ talleres.
INDEFOR (encargado de la gestión de las áreas protegidas) no opera en la Isla. Las disciplinas relacionadas con el medio ambiente de la UNGE se encuentran en la isla y no en el continente.	Coordinar las actividades y esfuerzos de ambas instituciones.	Falta formalizar y detallar como será esta colaboración.	El Director de INDEFOR y el Decano de la FMA de la UNGE se proponen firmar un acuerdo de colaboración.	INDEFOR/UNGE	2012

Appendix P: Photo captions of the various Chapters

Chapter 1: Introduction

From top to bottom and left to right: a hunter from the village of Basilé Fang gutting a black colobus; a Basilé Fang trader carrying blue duikers (*Philantomba monticola*) to sell at the city market; an African Pouched Rat (*Cricetomys emini*) caught in a foot snare and a hunter preparing another foot snare; mosoon forest in the SRCL; detail of the same area showing a Bioko drill (*Mandrillus leucophaeus*) eating fig fruits; Preuss's monkeys (*Allochrocebus preussi)* captured in Pico Basilé; aerial view of Miserga, a small mainland village surrounded by forest, reflecting the typical situation of villages in the country

Chapter 2: Study area

Mount Pico Basilé as seen from the National University of Equatorial Guinea in Malabo, with Hassan II Avenue visible on the right (top). Mount Pico Basilé as seen from the Sampaka cocoa plantation, clearly showing the Bondjoma Caldera (center); the most hunted primates in Pico Basilé: the red-eared monkey (*Cercopithecus erythrotis)* and the Preuss's monkey (*Allochrocebus preussi)*, along with the threatened Ogilby's duiker (*Cephalophus ogilbyi)* (bottom).

Chapter 3: Methodology

From top to bottom and left to right: household consumption surveys; weighing a bundle of "verduras" (edible wild plants); following a shotgun hunter who has just hunted a crowned monkey (*Cercopithecus pogonias)* and interviewing him during a break in his cabin; Pastor Cham and Kouassi Messan Ague (student and professor from UNE) examining blue duiker sperm samples; Ambrosio Ondo and Josefa Mikue (assistant and student from UNGE) measuring a blue duiker in Basilé Fang; and a seminar-workshop held in Basilé Fang.

Chapter 4: Results

Images representing various rural livelihoods. From left to right and top to bottom: a cocoa dryer; small-scale family livestock (chickens and goats); a fisherman with his catch of seafood (*bilolá*); women wrapping fermented cassava for sale at the market; a small stall in the city's main market displaying whole and cleaned snails (in the bowl); and traps placed around crops and along the fence by a subsistence hunter.

Chapter 5: Discussion

From left to right and top to bottom: INDEFOR-AP staff placing informational signs for hunters in the PBNP; the first group of Eco-guards from the PNPB and members of the NGO Ecoguinea, who organized the initial training project; informational signs for tourists in the PNPB; collection of plant samples for the "Flora of Equatorial Guinea" project (CSIC-UNGE); UNGE field practice bus in Pico Basilé; audience attending the IV Biodiversity Week (see footnote 13 on page 214) at the Spanish Cultural Center in Malabo; representatives from the government, INDEFOR-AP, UNGE, and NGOs after the reading of the IV Biodiversity Week Manifesto; snail sales stall in Basilé Fang; bird sampling in Pico Basilé.