

**The bush meat and conservation status of the African
dwarf crocodile *Osteolaemus tetraspis***

by

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DECLARATION

I, Roland Pier Zoer declare that the thesis, which I hereby submit for the degree MSc Wildlife Management at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE:

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07-02-2012

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ABSTRACT

Bush meat markets and habitat encroachment are on the increase, and the current demand for crocodylian bush meat is not sustainable. Of the three species of African crocodiles, the dwarf crocodile, *Osteolaemus tetraspis*, is by far the most heavily hunted. This preference is influenced by its small size and relatively non-aggressive nature, which facilitates easy capture, and further it stays alive while being transported to markets. The location of bush meat markets is determined by human population density and infrastructure. In general, a lack of infrastructure, whether it be a river or a paved road, implies only subsistence hunting. Many officially protected areas, where animals should be safe from depredation by humans, are not actually safe havens for *O. tetraspis*. There is often a lack of protection inside and around national parks in Central Africa, and when conducting research into this specific species, it was found that often more animals can be found per day in a bush meat market, compared with the same amount of effort in a national park. Crocodile mortality caused by people, both deliberate and inadvertent, must be controlled. However, conservation should be within the realms of politics, economics, ecology and social problems at a local level.

Keywords: African dwarf crocodile, bush meat, protected areas, infrastructure

PREFACE

The *Osteolaemus* project: the influence of bush meat trade on wild populations

Catching crocodiles at night in central African swamps requires a lot of dedication and effort. The collection of data would not have been possible without the four crewmembers Rogier de Boer, Jeroen Koorevaar, Daniel Peereboom and Stefan van Lieshout. From Cabinda in the South, until the northern border of Cameroon with Nigeria, many local people have helped this expedition. The different village chiefs, - guides and the several Non Governmental Organisations (WCS, Smithsonian Institute, CNPN, WWF Carpo, CENAREST, Cameroon Herpetology) are sincerely thanked for their help in data collection and acquisition of permits. Special thanks to Miss Gaelle Bal and Nathalie Breheret of Renatura in Congo Brazzaville, for their hospitality and expertise at the local bush meat market in Pointe Noire. Dr. Fritz Huchzermeyer originally suggested research into the dwarf crocodile. Dr. Terry Cullen gave valuable crocodile handling training in Florida. Dr. Llewellyn Densmore provided material for the collection of genetic samples. Mr. Franklin D. Ross explained crocodile morphology. Ashley Percy revised numerous drafts of this thesis. Thanks to all the numerous other people who helped with this project and did not receive a special mention. Financial assistance was provided by several organisations and funds, most importantly the Dutch Zoo Conservation Fund, the Prins Bernhard Cultuurfonds and the Stichting Fundatie van de Vrijvrouwe van Renswoude.



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LIST OF ABBREVIATES

CENAREST	Centre National de la Recherche Scientifique et Technologique
CITES	Convention on the International Trade of Endangered Species
CNPN	Conseil National des Parcs Nationaux
DRC	Democratic Republic of Congo
GPS	Global Positioning by Satellite
GSM	Global System for Mobile Communication
IUCN	International Union for the Conservation of Nature
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund

CHAPTER 1: GENERAL INTRODUCTION



Figure 1.0: Chordata, Vertebrata, Reptilia, Archosauria, Crocodylia, Eusuchia, Crocodylidae, Crocodylinae, *Osteolaemus*: an African specialty

INTRODUCTION

Crocodylians are implicated in positive effects on their environments as keystone species that maintain ecosystem structure and function by their activities. These activities include selective predation on fish and aquatic invertebrates, the recycling of nutrients and the maintenance of wet refugia during periods of drought (Thorbjarnarson 1992) - to mention but a few. Crocodylians are of great scientific interest as the only surviving members of the long extinct archosaurian reptiles, a group that included dinosaurs (Figure 1.0).

The subfamily Crocodylinae is split into two or three genera with surviving species: *Crocodylus*, the true crocodiles; *Osteolaemus*, the dwarf crocodile; and probably also *Tomistoma*, the False Gharial. *Osteolaemus* means 'bony throat', derived from *osteon* (Greek for 'bone') + *laimos* (Greek for 'throat'). The scientific name 'tetraspis' comes from the old Greek words τετρα (=four) and ασπις (=armor), referring to the extensive osteoderms (four bony plates or nuchal scales) found in the neck. It also has bone in its throat and belly scales. The name *osborni* (one of the two recognised subspecies) means 'of Osborn' (Meissner and Wermuth 1991). Different names for the same animal are: African dwarf crocodile, African caiman, bony crocodile, African broad-nosed crocodile and rough-backed crocodile (Villiers 1958). Currently two subspecies of the African dwarf crocodile are recognised: the West African dwarf crocodile *Osteolaemus tetraspis tetraspis* and the Congo dwarf crocodile *Osteolaemus tetraspis osborni* (formerly *Osteoblepharon osborni*).

In Trutnau (1994), *Osteolaemus tetraspis tetraspis* sizes are given as a maximum of 180cm (Villiers 1958), 150-180cm (Neill 1971) and 130-230cm (Wermuth and Fuchs 1978). Females are said to be much smaller, being only about 3-4 feet (0.9-1.22m) in length, and weigh far less than males (Neill 1971). Adults are black above and blotched or uniform black on the ventral surfaces. Young animals are blotched with brown above, and exhibit broad black cross bands on the back and tail. Some yellow vermiculations are visible on the sides of the jaws, body, and tail.

GEOGRAPHICAL DISTRIBUTION

African dwarf crocodile geographical distribution covers a vast span of land and, consequently, the animals can be found from the mangrove forests in the lagoons near the Atlantic Ocean to the freshwater tropical marshes in the northern edge of the Democratic Republic of Congo (DRC) (Brieger *et al.* 1997; Waitkuwait 1989; Jones 1991). African dwarf crocodiles are found in tropical climates in the southern part of West Africa (the northern border being Senegal) and Central Africa west of the great lakes (Waitkuwait 1989)(Figure 1.1). Although the African dwarf crocodile is the most terrestrial of the African crocodile species, it still needs pools of water in order to survive (Jones 1991).

Countries where *Osteolaemus tetraspis* are known to occur are: Angola, Benin, Burkina Faso, Cameroon (Webb 1978), Central African Republic (Honegger 1975), Congo (Thorbjarnarson 1992; Riley and Huchzermeyer 1999), Democratic Republic of Congo (Schmidt 1919; Inger 1948; Cott and Pooley 1972), Equatorial Guinea, Gabon (Mertens 1943; Villiers 1958), Gambia, Ghana (Steel 1989), Guinea, Guinea-Bissau, Ivory Coast (Waitkuwait 1989), Liberia (Taylor and Weyer 1958), Mali, Nigeria (Werner 1933; Ross 1998), Senegal (Wermuth 1953), Sierra Leone and Togo. The animal might occur in Uganda, Niger and Chad, but no information is available from those countries.



Figure 1.1: Geographical distribution of the African dwarf crocodile (*Osteolaemus tetraspis*) in Africa (Britton 2008)

Informative demographics of dwarf crocodiles is lacking and in most countries the status is unknown, although it appears to be generally widespread (Ross 1998). Where survey data are available, populations appear to be somewhat depleted (Riley and Huchzermeyer 1999; Waitkuwait 1990a). Populations in the Gambia (Jones 1991), on the northern edge of the species distribution, and in Liberia (Kofron and Steiner 1994) are reported to be severely depleted. Countries thought to have major populations, by virtue of their large area and extensive wetlands, are Ivory Coast, Ghana (Lake Volta), Nigeria (Niger and Benue rivers), Gabon (Ogoue river), Congo and the Democratic Republic Congo (Congo/ Zaire and Ubangi rivers) (Waitkuwait 1990a; Riley and Huchzermeyer 1999). Pooley's (1982) report of a population in the northern Central African Republic appears discontinuous to the remainder of the range and is in the internal drainage of Lake Chad via the Chari River. Distribution of the subspecies *O. t. osborni*, reported from the upper Congo River, remains relatively unknown (Riley and Huchzermeyer 1999).

HABITAT

The African dwarf crocodile inhabits permanent pools in swamps and areas of slow moving freshwater in rain forest areas, preferring swamps beside the open water systems and water pools remaining in periodically flooded swamp forests (Pauwels *et al.* 2007) and it stays in burrows beside the waterline (Penny 1991). These results are confirmed by night-counts in different biotopes of the Ivory Coast (Waitkuwait 1989).

Unlike other crocodylians, the nocturnal dwarf crocodile does not spend long periods basking in the sun. As the dwarf crocodile lives in habitats covered by dense vegetation, insolation- the normal source of heat for other reptiles- is reduced (Waitkuwait 1989). Dwarf crocodiles prefer appropriate water levels above other considerations (Jones 1991), mainly for digging burrows just above the waterline, which can extend for many feet and eventually end in a den, or chamber (Riley and Huchzermeyer 1999; Penny 1991). According to Waitkuwait (1990b) and Riley and Huchzermeyer (1999), dwarf crocodiles are known to make extensive nocturnal terrestrial forays, especially following rains. Crocodiles emerge usually at night and forage either close to the water or extensively on the land along well-defined trails. (Waitkuwait 1989).

DIET

Dwarf crocodiles are primarily opportunistic predators, eating fish, amphibians, crustaceans and possibly other terrestrial prey (Meissner and Wermuth 1991; Riley and Huchzermeyer 2000). As with most animals, diet may vary according to season (Luiselli *et al.* 1999). Fish are consumed during the wet season, when river flooding brings fish into the marshy habitat occupied by the dwarf crocodile (Brieger *et al.* 1997); during the dry season, when the fish are not available, the crocodiles survive primarily on crustaceans, and their dietary intake is generally reduced (Luiselli *et al.* 1999; Magnusson *et al.* 1987). Snakes, millipedes, burrowing skinks, and frogs may be captured at night during terrestrial foraging forays, and agile prey such as mammals and birds may be ambushed by submerged crocodiles (Riley and Huchzermeyer 1999).

REPRODUCTION

Rarely are numbers of dwarf crocodiles found together in the wild, although pairs come together prior to the nesting period, which appears to be concentrated in May and June, at least on the Ivory Coast (Alderton 1991). Tryon (1980) states that both sexes of *Osteolaemus* mature at five years of age. King and Dobbs (1975) stated that sexual maturity for most crocodylians is 10-15 years of age. These figures may hold true for the larger species but are apparently lower for smaller species (Tryon 1980). Copulation peaks during March and April (Luiselli *et al.* 1999). Nest construction starts at the end of the dry season (May-June) when the most fallen leaves are available for nest mounding, so the subsequent nesting period covers principally the season of high rainfall (Behra 1990). The dwarf crocodile nests by constructing mounds of damp vegetation, a structure about 1.5m (5ft) across, near water. The nest is dependent upon the heat generated by the decaying vegetation to incubate its small clutch of eggs (Agnagna *et al.* 1996). According to Pitman (1952), termites should be absent, for these insects are the rapid transforming agency of dead vegetable matter into humus. These invertebrates can therefore negatively affect the decaying process. Tryon (1980) estimated the clutch size to be between five to 15 eggs; Alderton (1991) and Penny (1991) estimated the number of eggs laid ranging from about 10 up to 20. The incubation period lasts between 85 to 105 days and hatchlings measure around 28cm.

During the nesting and hatching period both parents enter into a very close relationship (Waitkuwait 1989), where the male is the much more active partner in defending the nest hill and young (Beck 1978; Teichner 1978). The mother dwarf crocodile is alerted by the calling of the young (Figure 1.2) and is stimulated to excavate the nest and to help in hatching the young (Alderton 1991). For this she picks up the neonates partly emerged from the eggs, rolls them between her jaws until the eggshells have been removed, and transports the neonates in her mouth into water (Engelmann 2001; Böhme and Nickel 2000)(Figure 1.3 and 1.4). Baby crocodiles live a perilous life from the moment they hatch (Klemens and Thorbjarnarson 1995). They are eaten by birds, fish, small predators such as mongooses and civets, and even larger crocodiles (Knoepffler 1974), and parental care is vital to survival for hatchling dwarf crocodiles.



Figure 1.2: Hatchling dwarf crocodile is remarkably small and relatively defenseless

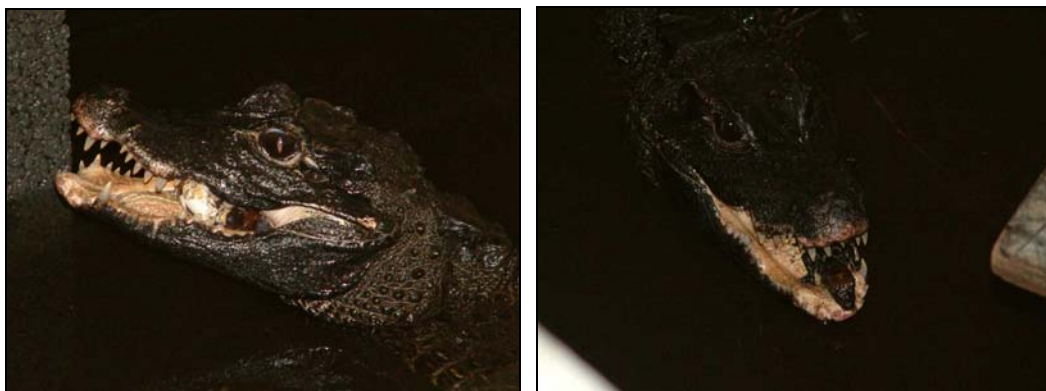


Figure 1.3 and 1.4: Egg and hatchling in the protective and nurturing mouth of mother dwarf crocodile (Photos courtesy Eddy Even)

SPECIES STATUS

Kofron and Steiner (1994) stated that the African dwarf crocodile is one of the most critically endangered crocodylians in the world. The dwarf crocodile is listed as an Appendix I species under the Convention on International Trade in Endangered Species (CITES) and vulnerable (VU A2cd) in the IUCN Red Book (IUCN 2009) due to a suspected decline in population size caused by habitat loss and exploitation (Ross 1998). The dwarf crocodile is now regarded as rare throughout its range (Riley and Huchzermeyer 1999); however, there is insufficient data to adequately determine the population size of the dwarf crocodile in any part of its range (Ray *et al.* 2000). Further study is clearly warranted to determine population size and threats to those populations. Once this information has been collected, a better picture of the ecological status of these animals can be determined, the effects of hunting and deforestation can be better assessed and with additional data, the implementation of species survival plans for these animals could be improved.

PROJECT AIM

The instigation of national parks in Central Africa is on the rise. However, so is the rise of urbanisation, resulting in increased logging concessions, bush meat activity and infrastructure. This study enquires about the national parks in Central Africa acting as accessible supplies of dwarf crocodiles for poachers to the bush meat trade.

Objectives:

- 1) To assess the effect of bush meat markets on wild populations of dwarf crocodiles
- 2) To assess infrastructure of national parks for accessibility
- 3) To highlight the conservation implications of the study and to provide management recommendations.

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CHAPTER 2: LITERATURE REVIEW: BUSH MEAT MARKETS IN AFRICA WITH SPECIAL CONCERN TO THE AFRICAN DWARF CROCODILE



Figure 2.0: Jaws muzzled and bodily hung from above by its wrists and ankles tied behind its back, an *Osteolaemus* suffering in the sunshine but still alive

BUSH MEAT

Bush meat, the meat of wild animals, has long been a part of the staple diet of forest-dwelling peoples in Africa (Fa *et al.* 2000). Although this meat is still important to many rural people, it is now also a major source of protein for many of tropical Africa's large numbers of town and city dwellers (Feer 1993). Approximately one billion kilos of bush meat animals are shot on a yearly basis (Akani *et al.* 1998a). This might only be a fragment of the total animals shot because the intensive hunting practices come with much inefficiency, with up to 80% of the catch ending up unsuited for sale, due to decay (Clarke 2003).

Of the three species of African crocodiles, the dwarf crocodile is by far the most heavily hunted because its size and non-aggressive nature facilitates capture and transport to markets (Behra 1990). According to Nathalie Kpera (2003), who conducted research on crocodiles in Benin, dwarf crocodiles are considered to be harmless and are regularly eaten by the local people in Benin and neighbouring countries. Sparse data from Congo (Hutton 1991) and Cameroon (Behra 1993a and b) suggests that tens of thousands of dwarf crocodiles are sold in local markets annually for consumption.

Reptiles possess low energy requirements and tend to have high reproductive rates (Pough 1980). These life-history traits make them especially well-suited for management as a food resource, and indeed throughout the lowland tropics, many reptiles have served as an important source of protein for human communities (Mittermeier *et al.* 1992). In many areas reptiles represent an ephemeral resource that can be easily over-harvested, particularly when exploitation is commercially oriented (Akani *et al.* 1998a). In areas of abundant swamp and seasonally-flooded forest, dwarf crocodiles constitute as much as 25% of the non-fish biomass in the African bush meat harvest (Auzel and Wilkie 2000).

Economic incentive of bush meat

Rural people, moving from a subsistence lifestyle to a cash economy, have relatively few options for generating income (Nasi *et al.* 2008). They can sell agricultural or pastoral produce, work for a cash wage in agriculture or industry, or sell retail goods in local or regional marketplaces. However for rural people, without access to capital, land or livestock, the harvest of wildlife resources may offer the best return for labour input. Cash income from the sale of wildlife products can be highly variable, even

when the same resource category is considered. The returns from hunting are generally higher than average local wages (Gally and Jeanmart 1996, Ntiamoa-Baidu 1997, Bennett and Robinson 2000).

Declines in world prices for some agricultural crops have driven many farmers to seek alternative sources of income, and many have become part-time or full-time hunters. However, the factors that determine whether a household farms or hunts are complex. For example, bush meat hunting is likely to be more profitable than farming in enclave areas without easy access to roads, as the price to weight ratio of bush meat is typically higher than for any agricultural crop, and only small quantities of goods can be transported on foot to markets (Nasi *et al.* 2008). In the short term, hunting is likely to be preferred to farming in recently opened forested areas because wildlife is abundant, communities might not yet have a tradition of commercial farming, and tree crops may take several years before they are ready for harvest. However in the long term, farming is likely to be preferred over hunting in communities that have been residing in a given forest area for a long time because local bush meat levels are already likely to be depleted. Still, wildlife hunting is carried out at an often large and unsustainable scale, and protective legislation is often circumvented or ignored by educated and wealthy game hunters, and in many remote areas it fails to take into account the basic survival needs of the poor local people.

Since the 1950s, a growing demand from urban areas, combined with larger populations, has generally catalysed the trade in wildlife resources. The result is that resources are increasingly being drawn from forested areas (including agriculture and secondary forest mosaics) into towns and cities, as favoured or inexpensive sources of animal protein (Nasi *et al.* 2008). From first harvest to final sale, the trade in bush meat for local, national or regional trade now forms an important part of the informal sector's hidden economy and although access to markets is a key factor in realising economic values of wild products, the determination of people to access markets, if there is sufficient economic incentive to do, so should not be underestimated (Neumann and Hirsch 2000).

Taking into account the Gross Domestic Product (GDP) per capita (the national output, divided by the population, expressed in US Dollars per person for the latest year for which data is published), for the three central African countries in which the research took place, one can expect that especially rural people in Cameroon and

Congo might be economically motivated to create an additional income through the bush meat trade (per capita GDP Cameroon: \$ 1,199; per capita GDP Congo Brazza: \$ 1,931). As we have seen before, Gabon has a highly urbanised build-up of its population, therefore less people live close enough to the wild habitats to take part in the first part of the bush meat trade (catching the animals). On top of this, the Gabon per capita GDP is also considerably higher (per capita GDP Gabon: \$ 9,987) than that in Cameroon and Congo Brazzaville. The per capita GDP of The Netherlands, in comparison to the African countries, is \$ 39,000 (Anonymous 2010).

The demand of local people for subsistence hunting is likely only true in the isolated parts of the animal's range. At least one recent study (De Merode *et al.* 2003) has shown that although wild meat does not necessarily play a major role in the nutrition of poor forest households, it is clear that hunting often plays an important food security role during the lean season. An economics study (Fa *et al.* 2002a) has suggested that if bush meat harvests were reduced to a sustainable level, all central African countries except Gabon would be dramatically affected by the loss of wild protein supply. In general, wildlife poaching is mainly an extra source of income, and accomplishes an enlargement of the person's local status (Hutton 1991; Clarke 2003). The actual poachers of the animals usually do not consume the animals themselves (Clarke 2003). The crocodiles are sold and transported to bush meat markets where large numbers of people congregate (Thorbjarnarson 1992). Many animals eventually end up being served to the public in restaurants in the bigger cities, where dwarf crocodile is put on the menu, although it is officially against the law in most of the African countries (Dia Malanda¹ and Endameyo², pers. comm.). A professional hunter can earn between US\$300 and US\$1000 a year, which is a substantial amount in Central Africa. African dwarf crocodiles ending up at bush meat markets are ordinarily brought there by middlemen, who purchase these animals at river ports, and along the side of the road, and bring the whole batch to the markets in the bigger cities (Clarke 2003).

Behra (1990) suspected that because *Osteolaemus* males are more naturally aggressive, they are captured more easily than females. This was confirmed by

1 Dia Malanda, T.H. President Congolese association of young chefs. BP: 95, N° 554 rue Lenine –Ouenzé, Brazzaville, Republic of Congo. Personal communication 22 August 2006

2 Endameyo, J.F. Responsable commercial restaurant Maison Glamour Prestige ('dum ebete akok'). Situe entre l'immeuble decage et porte jaune, Douala, Cameroon. Personal communication 15 December 2006

Klemens and Thorbjarnarson (1995), who found that the bush meat sex ratio was distinctly male-biased (15 males: 7 females). Such bias in the sex of collected animals could have an adverse effect on wild populations of dwarf crocodiles, and result in serious conservation issues.

Most *Osteolaemus* are brought to bush meat markets after capture. In the process they may be tied up on poles by the side of the road (Figure 2.1), for sale to any passer by who is willing to pay the price (Klemens and Thorbjarnarson 1995). Many crocodiles are restrained in direct sunlight (Figure 2.0) and are unable to control their body temperature, and most of these die from overheating as a result. Legs are often not just bound behind the back of the animal, but sometimes pulled forward over the head; an unnatural position for a crocodile, resulting in dislocated joints or broken bones (Figure 2.2). Due to stress endured by the crocodile, when caught, in transport and during the weeks before it is slaughtered, the animal suffers from osteoporosis (Huchzermeyer³, pers. comm.). However, humane treatment of animals is not logical in bush meat markets as they are to be slaughtered. By storing the animal, instead of killing it immediately, the seller can keep it alive longer as fresh meat. If an animal is still alive, then (in theory) its flesh has not yet started to decay.



Figure 2.1: Ventral view of dwarf crocodile roadside bush meat suspended alive by one front and one hind limb

³ Huchzermeyer, F.W. Member IUCN Crocodile Specialist Group Veterinary Board. Onderstepoort Veterinary Institute, Private Bag X5, Onderstepoort 0110, South Africa. Personal communication, 27 June 2006



Figure 2.2: Portrait of a muzzled bush meat market dwarf crocodile with its forelimbs tied together over its head

LOCATION OF BUSH MEAT MARKETS

The location of bush meat markets is determined by human population density and infrastructure.

Access by water and road

In the nation of Congo, dwarf crocodiles are hunted in rural areas and transported alive on riverboats to the Impfondo and Brazzaville markets for sale (Klemens and Thorbjarnarson 1995). Most of the specimens coming to markets in Brazzaville originated in forests bordering the Oubangui and Congo Rivers in the north (Behra 1990). Dwarf crocodiles are more easily captured in Congo from the end of June until the end of November, when they move from the main rivers into the forest and settle in small streams (Riley and Huchzermeyer 2000). It has been estimated that during these annual five months of exploitation along the Oubangui, Sangha and Congo Rivers, about 3500 *Osteolaemus tetraspis* were brought on the Impfondo market for food (Behra 1990).

In Gabon, animals are transported by boat along the Ogooue River to the city of Lambarene (Pauwels⁴, pers. comm.) (Figure 2.3). Dwarf crocodiles are either bound and transported to markets live or killed and quickly transported to the Omboue and Port Gentil markets where they can be stored on ice for much longer periods (Waitkuwait 1989; Thorbjarnarson 1992). Outboard motors and ice are more readily available in Gabon than in other central and west African countries.



Figure 2.3: Gabon with trading points Libreville, Lambarene and Port Gentil (Google Maps 2009)

Where there are no rivers leading to large cities, animals are transported by road. It seems that a lack of infrastructure, (whether it be a river or a paved road), implies only subsistence hunting, whereas locations next to rivers and/ or roads allow for easier sale of animals (Luiselli *et al.* 1999; Akani *et al.* 1998b). There have been few studies on linkages between bush meat consumption and human dietary preferences. Most have focused on calculating volumes of meat consumed (Fa *et al.* 2002a) or on analysing declared preferences for the available meats (Fa *et al.* 2002b). Benin City, Benin, where 263 crocodiles were counted for sale in the market during a typical 8-week period (Dore undated), and separately Libreville, Gabon, are among the cities, which depend on the supply of their bush meat via roads.

4 Pauwels, O.S.G. Gabon Country, Manager Smithsonian Institution, Monitoring and assessment of biodiversity program. B.P. 48 Gamba, Gabon. Personal communication, 29 November 2006

Effect of logging on movement and trade of crocs

Wildlife, particularly dwarf crocodiles, are adversely affected by the industrial extractive sector (such as logging, mining and oil-drilling), because in the course of their activities, companies a) directly destroy critical habitat, disturb movement patterns and alter behaviour, and b) indirectly facilitate hunting by building roads and/or providing transportation for hunters (Nasi *et al.* 2008). These industries usually establish camps for their employees near the extraction site, and the workers enjoy significantly higher living standards than in the surrounding villages. Industries often act as a magnet on local people, and often increase local population density. The presence of relatively rich people generates changes within local communities that further exacerbate the impact on wildlife and increase the volume of the harvest (Nasi *et al.* 2008). Increased income allows hunters to take advantage of new hunting technologies (such as cartridges, guns, snare wires, outboard motors, and headlamps), which in turn allows for more efficient harvests. As industrial activities stimulate the local economy, the increased level of income generally raises the demand for wild meat. For example, per capita harvest rates in local communities adjacent to logging or oil-drilling infrastructures can be three to six times higher than in communities remote from such roads and developments (Robinson *et al.* 1999, Auzel and Wilkie 2000, Auzel 2001, Thibault and Blaney 2003). As a result of these changes local forest communities are increasingly drawn into a market economy involving wildlife.

In many African countries habitat modification is seen as the major potential threat to crocodile survival (Groombridge 1982; Thorbjarnarson 1992). After oil and minerals, the timber industry is the most profitable source of external income for many west and central African countries (Hutton 1991). In the last three decades especially, large-scale commercial logging and also the small-scale felling of the ancient forests have removed the vast majority of suitable habitat (greater than 95% in the Gambia and Senegal) (Jones 1991). Loss of ground cover has also led to increased aridification and a drastic decline in the water table in West Africa. In the 1980's aridification saw the general disappearance of the small forest pools, thus denying dwarf crocodiles their optimal habitat and further by concentrating their prey animals around larger, open pools, inhabited by Nile crocodiles *Crocodylus niloticus* (Waitkuwait 1989; Jones 1991). In West Africa, dwarf crocodiles are nowhere abundant, and there is an apparent absence of adults due to this environment alteration.

Deforestation is occurring rapidly by foreign timber companies, and also by the slash-and-burn agriculture practised by the largely rural population. In Central Africa, Chinese companies are involved in a big percentage of the operations (Waitkuwait⁵, pers. comm.). Logging activities in several central African countries have resulted in logging roads into formerly pristine areas, opening up new hunting grounds for poachers (Agnagna *et al.* 1996, Klemens and Thorbjarnarson 1995; Hardin 1994) and therefore increased infrastructure means increased hunting pressure. The constant transport of timber also allows for extra bush meat cargo. The demand for *Osteolaemus* meat is also increased by logging employees (Ona⁶, pers. comm.). Salaried employees and their extended families that live in company camps within or bordering concessions constitute a significant local source of demand for proteins (and therefore bush meat) (Nasi *et al.* 2008). The combination of the above factors has apparently depleted the crocodile populations in African countries (Kofron 1992).

Cultural and social values

Consumption of reptile meat is often intertwined with social values and cultural beliefs (Brooks *et al.* 2002). Important social and cultural values are linked to foods and medicines derived from wild resources. The sale of dwarf crocodiles and other bush meat within the village or the community appears as a new market, creating monetary networks of exchange between villagers. Such a sale could well represent a new social obligation, as it did in the past with the sharing or giving of wild meat. The trend is therefore toward an increased commercialisation of bush meat, with all of its associated negative consequences (Nasi *et al.* 2008).

Throughout history, crocodiles have been both feared and respected by people. The ancient Egyptians believed crocodiles were a river god that had to be appeased by the annual sacrifice of a beautiful virgin (Graham and Beard 1973). The art of some African peoples depicts crocodiles as water spirits and messengers to the supernatural world (Smith and Marais 1992). The religious role of crocodiles is also important and has contributed to their protection in Benin. Kpera (2003) has observed a water pond inhabited solely by dwarf crocodiles, where other species are

5 Waitkuwait, W.E. Chef de projet PSVAP : Délégation de la commission Européenne (DCE), Quartier Bas de Gue Gue Loitissement des Cocotiers, Libreville, Gabon. Personal communication, 14 November 2006

6 Ona, M. Country director : Brainforest, 127, rue Barro, place Raponda Walker, quartier Louis. Libreville, Gabon. Personal communication, 22 November 2006

not permitted. In that pond, the crocodiles are sacred. Her study shows that human ethnic groups, the religious role of crocodiles, and also traditional methods of conservation are the main factors to consider in the management of crocodiles populating Benin's water reserves. These considerations are also relevant in the case of the Bazoulé (Burkina Faso) crocodiles (Toonen 2003).

Local witchdoctors attribute supernatural powers to the crocodile, such as the ability to bring rain (Kpera 2003). Crocodile fat is supposed to hold lightning at bay (Kpera 2003). Crocodile liver is considered to be a deadly poison (Clarke 2003). The desiccated and powdered brain of a crocodile is considered by some individuals to ward off attacks if sprinkled in the river (Thorbjarnarson 1992). It is also said that grinded crocodile bone is an aphrodisiac (Kpera 2003). In Benin, most parts of a crocodile's body (e.g., the heart, lung, head, and teeth) are used in traditional medicine to cure diseases (Kpera 2003) and also in other African countries crocodiles have been used for medicinal purposes (Clarke 2003).

Sacred rituals sometimes also involve crocodile parts. Natives use crocodile parts as a part of their culture for decorations on ceremonial accessories. Crocodile parts have also been used on a small scale by natives in sacrificial rites. However, as with religious beliefs, it should be mentioned that cultural and medicinal rituals play a lesser role in modern African society, and that role is diminishing each year, especially in urban areas (Kpera 2003). The members of the younger generation of Africans are more interested in increasing their personal status by selling crocodiles as bush meat, compared with upholding the ancient rituals of their ancestors and maintaining respect for their cultural heritage. The strain of bush meat is much greater on wild populations of dwarf crocodiles than it had been under only the traditional use of the animal in sacred rituals and religion. The hunting of *Osteolaemus* provides meat and income, and it can also be an important social and cultural tradition for many local peoples, provided that hunting levels are sustainable.

Role of taste

The extent to which taste is driving the demand for wild meat is unclear. It is commonly believed that people in tropical forest countries often prefer the taste of wild meat over that of domestic animals, and that wild meat consumption is a deeply-rooted tradition that is highly resistant to change. These views are supported by the continuing demand for wild meat by formerly rural people now newly living in middle-class urban or even overseas environments, from Jakarta, Libreville and Brazzaville

to London and New York. In these cases, wild meat is consumed as a luxury item to artificially maintain a sentimental link with a departed lifestyle, and items such as crocodiles are not a staple source of animal protein.

Scientific data to determine how important a role taste plays in the overall demand for wild meat is scarce. Most studies of preference have often simply documented that consumers noted 'meat hunger' when their diet is composed primarily of starches, or have focused solely on which species of wildlife consumers prefer. They have not established that consumers have clear taste preferences for wild meat relative to the meat of domesticated animals. In a recent study in Gabon, consumers were asked to select which of two plates of meat they preferred. Only poor rural people showed a measurable preference for bush meat. In this case, of the 42 subjects who stated a preference for domestic poultry, 78% avoided bush meat when given the choice between porcupine or chicken. Overall, results suggest that taste is not the primary determinant of consumer demand for wild meat (Schenck *et al.* 2006).

Commercial trade in skin and souvenirs and selected parts

Anthony Pooley concluded in 1981 that in the 30 years from 1950 to 1980 at least three million African crocodiles had been slaughtered for their skins. Mostly they would have been Nile crocodiles and slender snouted crocodiles, although these have become so scarce that the dwarf crocodiles are now being taken by hide-hunters, despite the commercially inferior skins of this latter species (Pooley 1982). The quality of *Osteolaemus* leather is reportedly low (Ross 1998). Other parts of the dwarf crocodile, like its bones, teeth, toes and skulls are being traded as souvenirs for the richer inhabitants of the various African countries, and for international tourists. Since the skin is less profitable to the tanning industry compared to the other species, *Osteolaemus* is usually sold stuffed, provided that the head and hide are still fairly intact. Skeletal bones and osteoderms of the region's crocodiles are being used for nutritional supplements in agriculture and animal feeds, and the teeth and claws have been sold primarily to tourists as curios (Kpera 2003).

Effects of bush meat markets on wild populations

Due to the lack of distribution data, it is very difficult to assess the effects of bush meat markets on wild populations. Mathew Dore conducted an extensive investigation into the distribution and present status of crocodiles throughout Nigeria between September 1992 and September 1993. Although quantitative surveys were

not conducted, total population was said to be low. Surveys by Luiselli *et al.* (1999) confirmed Dore's observations that dwarf crocodiles are by far the most traded crocodile species in Nigeria. Alarming, local hunters in the Congo noted they had to move deeper into the swamp each year to find dwarf crocodiles (Brieger *et al.* 1997). It can be stated that no other reptile species, including monitors, *Varanus niloticus ornatus* and pythons, *Python sebae*, is subjected to as high a hunting pressure as that on dwarf crocodiles (Luiselli *et al.* 1999).

EFFECT OF CITES AND OTHER LAWS ON TRADE

There usually are rules and regulations concerning the capture and trade of dwarf crocodiles in the separate countries, but those laws are rarely enforced due to a lack of resources and the absence of organised government involvement. A law that is not enforced undermines the authority of the government, and a law that can only be enforced at great cost and difficulty might need to be revised. There is much work to be done in order to tackle this issue in most tropical countries (Nasi *et al.* 2008).

A major institution, actively taking part in the conservation of endangered animals, is CITES (Convention on International Trade in Endangered Species). The dwarf crocodile is listed as an Appendix I species by CITES, and is classified as vulnerable (VU A2cd) in the IUCN Red Book (Crocodile Specialist Group 2008; Ross 1998; IUCN 2009). The CITES laws have made the most strict regulations involving the international transport of animals.

In the case of the African dwarf crocodile, merely the regulation on international transportation is not enough. The captured animals are predominantly destined for the domestic market for consumption or profit. The tough skin of the dwarf crocodile makes it less useful for tannery purposes than the skin of Nile crocodiles or slender-snouted crocodiles, and the absence of ice in most countries makes it impossible to have the raw meat shipped over long distances. Dwarf crocodiles can be kept alive for a long period of time though, without food, and this makes it possible to transport them to big cities within the country of origin for higher profit (Waitkuwait 1989).

CITES does not actively regulate domestic activities. National laws should provide for that, but they are seldom upheld due to lack of stable governments or funding. Ghana is one of the few exceptions, with active national legal enforcement against the bush meat trade. The law enforcement officers actively track down poachers,

sellers, and even buyers of endangered animals. Other countries simply tolerate the bush meat markets, often despite their own laws. With the exception of the occasional shipment of live bush meat *Osteolaemus* to Bioko Island (Equatorial Guinea) from Cameroon (Fa *et al.* 2000), there is hardly any international transport of dwarf crocodiles taking place in Africa. Thus, *in situ* work is usually more effective at the protection of habitat and animals than CITES (Clarke 2003).

In 1988 Olivier Behra was able to collect historical information on the export of crocodile skins from the Congo. Nine exporters were operating during an eight year period, and were sending skins year round, with no seasonal irregularity, to fifteen importers in Europe. The exports increased up to 1974, when they reached more than 20.000 skins/year (Figure 2.4). The number then declined to a low point of 588 skins exported in 1978, the last year of export. These figures suggest that Congo's crocodiles have been overexploited. This appears to be particularly true when the 1975 CITES export ban for the main African countries is taken into account, causing a high demand from tanners. The 1978 figure of 588 skins exported could be an indication that the crocodile population of Congo had been severely reduced.

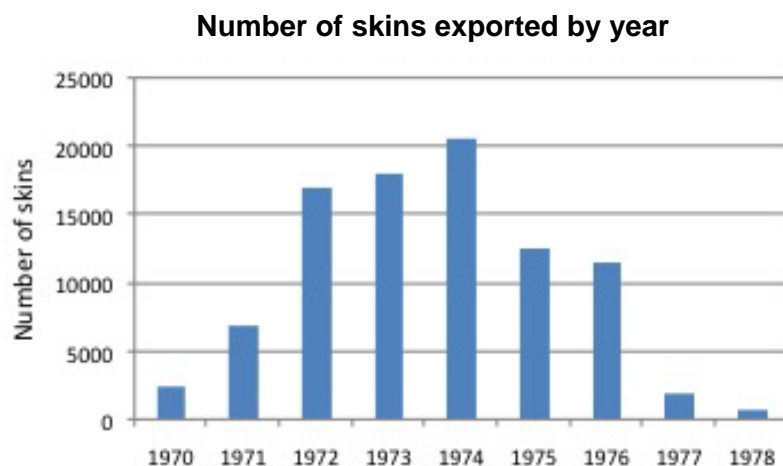


Figure 2.4: Exported crocodile skins from the Congo (modified from Behra 1990)

EFFECTIVE PROTECTION (FARMS AND SUSTAINABLE USE)

The 1980's were an important transitional period in crocodile conservation in many parts of the world. Producer nations began to manage their crocodile populations as a resource to earn valuable foreign exchange, and in the process, conservation efforts returned several endangered species of crocodile to their former abundance

(Kievit 2003). The key to many successes in crocodile conservation has been the promotion of sustainable-use projects.

In the developing world, wildlife is competing with humankind for limited resources. Developed countries usually make decisions on trade in wildlife products from positions of affluence and are influenced by protectionist and animal rights groups. Developing countries usually make decisions from a position of poverty and are influenced by the immediate needs of their inhabitants. This predisposes them towards conservation solutions that allow people to benefit from the use of wildlife (Kievit 2003). It is important that the economics and behaviour associated with the interaction between people and their environment in the tropics are understood, and especially when wildlife species are particularly vulnerable to overharvest (Robinson and Bodmer 1999). Additionally, as Thorbjarnarson (1999) has cautioned, crocodile conservation programmes based solely on the sustainable utilisation of its skin are potentially subject to the vagaries of the exotic reptile leather market. As Child (1995) suggested, if wildlife conservation is to succeed, "it must avoid the double standards borne of the conflict between emotions and pragmatism". Any conservation programme in developing countries designed to enhance the long-term survival of a species, must be justifiable in terms of its value in tangible benefits to people at the local level (Child 1995). Crocodiles have a poor image, and hence as Gorzula (1987) pointed out, their long-term survival in the wild will depend on the attitude and tolerance of the local people (Santiapillai and de Silva 2000).

The basic premise of assigning economic value to wildlife is that appropriately valued natural resources are not wasted. Sustainable use programmes can provide revenue for underfunded and understaffed governmental wildlife management activities while addressing the economic needs of the rural poor (Klemens and Thorbjarnarson 1995). However, the widespread and often indiscriminate promotion of sustainable use programmes as a type of 'win-win scenario' has raised expectations often far in excess of biological realities (Klemens and Thorbjarnarson 1995). Many countries actually lack the resources to plan and implement wildlife management programmes, particularly those involving the killing of wild animals. The start-up costs of many of these programmes are considered to be prohibitively high, especially when the tangible benefits are not clear (Waitkuwait 1989). Illegal hunting and trade often continue and compete with sustainable use programmes, and this has been the focus of much criticism aimed at wildlife conservation efforts based on solely managed wild harvests (Klemens and Thorbjarnarson 1995).

Nowhere in Africa can crocodiles be said to have a flourishing future in the wild, and often African crocodile farms have had limited success (Leslie 2001). Only in Zimbabwe and in South Africa have these enterprises looked at all promising (Pooley 1982), but even in these two countries the scale of operation does not begin to meet the demand for crocodile skins (Thorbjarnarson 1999). As a result, poaching, often with the aid of an official 'blind eye' in response to financial favours, is a highly profitable activity throughout Africa (Steel 1989).

The actual population status of the African dwarf crocodile is unknown, even though thousands are captured annually (Behra 1990; Agnagna *et al.* 1996). Because of the relatively poor quality of the hide of dwarf crocodiles, intensive commercial hunting has not been a serious problem, and in turn there has been little incentive for management programs based on sustainable use. Togo is reported to have a legal harvest system, but this program does not appear to be in effect (Behra 1993b). Congo had a CITES approved quota of 500 *Osteolaemus* in 1987, and again in 1988, but did not renew its request for a quota in 1989.

Plans were under discussion for the establishment of captive breeding programs for conservation, tourism and possible meat production in Togo, Cameroon (Behra 1993a and b) and Nigeria (Dore 1991), but unfortunately none of these programmes proved to be a success. As it stands now, there is limited information to determine population size, which inhibits accurately assessing harvesting methods for this species.

CONCLUSION

The decline of dwarf crocodiles appears to have resulted from a combination of killing for hides and meat, and from an extensive resettlement of people and their activities such as industrialisation and the pollution of rivers. Human population growth, modern hunting techniques and improved transportation infrastructure in Central Africa have resulted in increased commercial trade of dwarf crocodiles and other bush meat species within the region and, increasingly also to satisfy expatriate markets outside of Africa (Milius 2005).

Crocodile conservationists have a major task to justify their beliefs in the value of these reptiles as an integral part of tropical ecological systems and also as objects of

special scientific interest in their own right. Crocodile farming may be the key in larger species, generating profits that will alone keep some species of crocodiles from dying out. The availability of legally marketed skins will of course maintain a demand for crocodile products and thereby tend to encourage poachers. The creation of legally protected reservations that functionally preserve natural crocodilian habitat, in which wild populations can breed, must today be an urgent priority.

In the case of the African dwarf crocodile, base-line surveys are required, particularly in areas now reported to hold secure or adequate populations, in order to enable future changes to be monitored. The fact that these crocodiles live in remote swamps, out of sight in the forest, does not justify their abusive exploitation (Agnagna *et al.* 1996). While more information is required concerning the volume and other technicalities of the trade in live dwarf crocodiles for meat consumption, there remains a need for investigating this reptile's habitats, population densities and reproductive potential with a view to formulating recommendations for the effective conservation and sustainable use of this species.

Crocodile mortality by people, both deliberate and inadvertent, must be controlled. Conservation of crocodilian populations is therefore highly dependent upon providing incentives to maintain crocodiles and their habitats in a relatively undisturbed state, and a willingness to accept management practices that allow crocodiles and humans to co-exist. The recommended actions include: status surveys, the identification and protection of important populations and habitat; the enhancement of the conservation and management capacities of national authorities; the development of national management plans for crocodilian conservation; captive breeding and restocking programs; and the development of economic incentives for crocodilian conservation through well-regulated sustainable use (Thorbjarnarson 1999; Waitkuwait 1989; Jones 1991; Clarke 2003; Behra 1993a; Eaton *et al.* 2009).

Ecological research into population dynamics should also provide valuable information for sustainable-yield programs. Biological and social problems at a local level, particularly in Africa, must be taken into consideration (Leslie 2001). Dwarf crocodiles are vulnerable throughout most of their natural range because of the hunting pressure that they have sustained for a number of decades, and because they are threatened at all of those many sites where the destruction of essential habitat is ongoing. For this reason conservation efforts, with the support of science, need to create functional and practical measures that will ensure the protection of

Osteolaemus in its natural habitat. It is a harmless genus found only in Africa (cover photo, and Figure 1.0).

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CHAPTER 3: THE PERSISTENCE OF THE BUSH MEAT MARKET IN CENTRAL AFRICAN COUNTRIES



Figure 3.0: Examination of wild dwarf crocodiles often confirmed the locality data from vendors

INTRODUCTION

The central African indigenous people have traditionally consumed wild animals as part of their diet (Akani *et al.* 1998; Pauwels *et al.* 2007; Schenck *et al.* 2006). Hunting provides between 30 to 80% of the overall protein intake of rural households in Central Africa (Koppert *et al.* 1996) and nearly 100% of animal proteins. Recent studies (Takforyan 2001; De Mérode *et al.* 2008) show that most people in tropical forests hunt, and that meat sales within individual villages can be significant (30% in Cameroon, up to 90% in the Democratic Republic of Congo). In Central Africa the various hunting rules and regulations (often part of the forestry laws) authorise hunting by license holders ('*permis spéciaux*' in the Congolese legislation, '*permis de chasse*' in the Gabonese forestry code). Hunting is therefore not an illegal activity *per se*. If one holds one of these licenses, and provided that one does not hunt protected species or in protected areas, one can hunt and even, with the right official paper, commercialise the catch. Furthermore, the laws recognise user rights for the local populations and allow for traditional hunting and fishing. However, at the same time most laws forbid, among other things, hunting during the night, the use of metallic snares or traps, of nets, of fire, etc. All this makes illegal most of the hunting practiced by the local communities (Yadji Bello 2003).

The bush meat trade has gone from former sustainable use, to a new and modern situation where animals struggle to produce offspring due to indiscriminate hunting (Nasi *et al.* 2008). Hard data on the actual number of animals traded per year are lacking for large parts of Africa (Happold 1995). However, several expeditions in the last 15 years (Riley and Huchzermeyer 1999; Thorbjarnarson 1992; Eaton 2009; Behra 1990; Waitkuwait 1989) have indicated that the species composition of traded animals within national borders has changed and increased towards more dwarf crocodiles, and is now having a bigger effect on wild populations of *Osteolaemus tetraspis*.

The demand for bush meat has grown due to increasing urban populations and the arrival of foreign businessmen and tourists (Nasi *et al.* 2008). In most central African countries the human population is unequally distributed; with cities and coastal areas being more densely populated than the vast expanses of land in the interior (Robinson and Bennett 2000). As people living near the coast have access to fish resources from the sea, they rely less heavily than interior people on bush meat (Koppert *et al.* 1996; Watson and Brashares 2004). Therefore it would appear that

the consumption of bush meat varies with geographic location, as well as with population densities.

The bush meat trade is different from the trade of wildlife fauna products in the sense that its international component is still very limited (Inamdar *et al.* 1999). The bulk of this commercial trade transpires within the borders of the relevant nation, and is generally directed towards the supply of urban centers or extractive industry camps in the forest (Nsosso 2003). The patterns of bush meat trade reveal some distinctive features: it is often linked to other commodities, and it only becomes economical on a large scale when existing infrastructure lowers costs significantly (i.e. logging roads) (Robinson *et al.* 1999; Auzel and Wilkie 2000; Auzel 2001; Thibault and Blaney 2003). Taking into account the widespread and regular presence of *Osteolaemus tetraspis* at bush meat markets in the region, one would expect to collect more data in these bush meat markets than from excursions into the natural habitat. However, huge differences are to be found between bush meat markets within different countries when it comes to infrastructure, the demography of human population settlement patterns, and relevant crocodile abundances.

This expedition went out to collect data on African dwarf crocodiles, both in the wild (Figure 3.0) and on bush meat markets. Whilst it is not always an absolute certainty as to which area the bush meat animals originated, derivations from the infrastructure and conversations with sellers were found to generally validate assumptions. Information from various bush meat markets can potentially be used as barometers of hunting pressure to monitor trends in target species, especially when long-term data is available. In this study, visits to bush meat markets were not long-term, but wherever possible were followed up by original habitat visits. These habitats were selected on the basis of conversations with sellers and by examining the infrastructure (transport by road or over water). Information is presented for the central African countries of Congo, Gabon and Cameroon during the study period from August 2006 to and including January 2007.

Potential *Osteolaemus* habitat in the Republic of Congo, Gabon and Cameroon was visited, along with trips to local markets for locally obtained dwarf crocodiles (Figure 3.1 and Appendix 1). Smaller bush meat markets can usually be found in small cities that cannot easily be reached due to a lack of tarred roads or rivers nearby. In these places, bush meat is generally for subsistence purposes. Whenever possible, these markets were also visited for data collection.



Figure 3.1: Locations of bush meat markets and locations where wild-caught animals originated (basemap from CIA worldfactbook)

As bush meat markets continue to thrive within the political boundaries of individual nations, thus evading CITES jurisdiction, the probability of decreasing wild populations of the already endangered *Osteolaemus tetraspis* is raised. Combine hunting pressure with the increasing habitat destruction of logging, including increasing access to remote areas with infrastructure necessary to maintain a logging business, and the decline in *O. tetraspis*, despite efforts by CITES and TRAFFIC, is inevitable.

Congo

The Republic of the Congo, also known as Congo-Brazzaville, or just Congo, is bordered by Gabon, Cameroon, the Central African Republic, the Democratic Republic of Congo (DRC; the former Zaire), the Angolan enclave of Cabinda and the

Gulf of Guinea. The biggest cities are the capital Brazzaville (on the bank of the Congo River opposite the DRC capital Kinshasa), and Pointe Noire on the coast. The southwest of the country is a coastal plain for which the primary drainage is the Kouilou-Niari River. The tropical jungle areas in the north of the country are virtually uninhabited, and almost 85% percent of the approximately four million Congolese live in a few urban areas. From the jungles in the north, the Congo, Oubangui and Sangha Rivers flow south toward the cities of Brazzaville and Kinshasa.

Of the three central African countries the expedition visited during this study, the Republic of the Congo has the most flourishing trade in bush meat, and in some areas dwarf crocodiles contribute almost a quarter of non-fish volume to the harvest (Eaton 2009). The biggest bush meat markets in this country are found in Pointe Noire, Impfondo and Brazzaville. Most crocodiles at markets at the latter two originate from the jungles in the north (Likouala), whereas the Pointe Noire crocodiles are usually harvested in the Bas Kouilou area around the coast (Bal⁷ and Cameron⁸, pers. comm.).

Gabon

Gabon is bordered by Equatorial Guinea, Cameroon, the Republic of Congo and the Gulf of Guinea. The capital is Libreville, situated at the coast, and the largest river is the Ogooue (1200km). The total population of Gabon is around 1.5 million. Omar Bongo Ondimba, president of Gabon since 1967 until his death in June 2009, nominated more than 11% of the nation's territory as national park in 2002. Although the bush meat trade in Gabon seems to be less prevalent than in neighbouring Congo, it is still present (Lee *et al.* 2006).

Gabon's biggest centers of trade are the coastal cities of Port Gentil and Libreville, and separately in the interior is Lambarene on the banks of the Ogooue River (Figures 2.3 and 3.1). Dwarf crocodiles at the Lambarene market originate from the Ogooue tributaries (including Lope National Park), while the ones at the coastal cities originate from the Ogooue River and Come River estuaries (including the northern

7 Bal, G. Country director : Renatura Association de Conservation de la Biodiversité, B.P. 414, Pointe Noire/ Republic of Congo. Personal communication, 5 August 2006

8 Cameron, K. N. Veterinary: WCS field veterinary program. B.P. 14537 Brazzaville, Republic of Congo. Personal communication, 8 August 2006

part of Petit Loango National Park) (Waitkuwait⁹, Pauwels¹⁰ and Eaton¹¹ pers. comm.).

Cameroon

Cameroon is bordered by Nigeria, Chad, the Central African Republic, Equatorial Guinea, Gabon, the Republic of Congo and part of the Gulf of Guinea and the Atlantic Ocean. Its largest cities are the capital of Yaoundé, Garoua and the coastal town of Douala. The human population is around 18 million. In Cameroon the Campo Ma'an National Park (in the south) and the Korup National Park (in the north) were visited to collect data on wild dwarf crocodiles.

When it comes to enforcing laws against the illegal trade in wild animals and plants, Cameroon does make a serious effort, especially in comparison with the Congo. Police frequently confiscate animals, including many dwarf crocodiles, which are either released into the wild or, if not possible, placed in asylums like the Limbe Wildlife Centre and the Yaoundé Zoo (Auzel 2001).

Subsistence hunting does take place in remote areas, but the combination of the lack of good infrastructure and the effective law enforcement seem to discourage the bush meat trade in Cameroon (Foguekem¹² and LeBreton¹³ pers. comm.). Articles have reported that dwarf crocodiles of Cameroon origin can arrive at the Equatorial Guinean island of Bioko, having been transported there because of more lenient law enforcement (Fa *et al.* 2000; Fa *et al.* 2002).

9 Waitkuwait, W.E. Chef de projet PSVAP : Délégation de la commission Européenne (DCE), Quartier Bas de Gue Gue Loitissement des Cocotiers, Libreville, Gabon. Personal communication, 14 November 2006

10 Pauwels, O.S.G. Gabon Country Manager Smithsonian Institution, Monitoring and assessment of biodiversity program. B.P. 48 Gamba, Gabon. Personal communication, 29 November 2006

11 Eaton, M.J. PhD student: Department of Ecology and Evolutionary Biology, University of Colorado, N122 Ramaley Hall, Boulder, CO 80309-0334, USA. Personal communication, 15 August 2006

12 Foguekem, D. Bio-monitoring officer , WWF Campo Ma'an Project, WWF Cameroon Regional Programme Office. Laboratory of Zoology, University of Yaoundé 1, Po. Box 812 Yaoundé, Cameroon, Personal communication, 21 December 2006

13 LeBreton, M. Country director : Cameroon Herpetology. Project CAMHERP, BP 1616, Yaoundé, Cameroon. Personal communication, 29 December 2006

METHODS

Data on bush meat and wild populations of dwarf crocodiles were collected by the expedition during six months in late 2006 and early 2007 in the central African countries of Gabon, the Congo and Cameroon. Main objectives were to collect data on the distribution of *Osteolaemus*, determine population status of *Osteolaemus* in the Congo, Gabon and Cameroon, and to assess the effect of bush meat markets on wild populations.

Vendors at markets offering *Osteolaemus* as consumption meat often provided information as to where their specimens had originated. This kind of information, although not always very precise, gave an indication as to where populations of *Osteolaemus* are likely to be situated. For this study, no money was paid while collecting data on bush meat markets, so as not to encourage the bush meat trade. Due to the fact that dwarf crocodiles are crepuscular and nocturnal animals, capture of these animals in the forest was done at dusk and night. Wild dwarf crocodiles were located by headlamp spotlighting in the dark in appropriate swamps and rainforest habitat. Crocodilian eyes reflect red and thus can be identified and pursued. The stationary animal, which relies on its camouflage, can slowly be approached and then captured by hand. No snares were used. Dwarf crocodiles were generally grabbed right behind the head in order to prevent bites and struggle. They were subsequently muzzled with elastic bands and their legs were bound behind their back with parachute cord.

No immobilising agents were used. The animals were put in a dark carrying bag, after which they were safely transported out of the forest to the base camp, which was either set up in the nearest village, or at an alternative open spot in the forest. The animals were then left to calm down for the rest of the night to avoid the build-up of lethal lactic acids in their blood. The following day at first daylight, the crocodile was brought out of the bag to be examined and marked. Animals were clipped for scute markings in potential population studies (mark-recapture), and to obtain tissue for taxonomic DNA studies. However, neither of these latter two kinds of studies are included in this thesis. After processing, each animal was released back at its exact location of capture. *Osteolaemus* encounters were plotted using a Global Positioning System whenever possible. Surveys were usually carried out on foot, and also sometimes by boat in Gabon, where the deep lagoons made it impossible to walk

through the forested swamps. Data collection took place with the necessary research permits in hand, issued by several national Ministries.

The amount of infrastructure was calculated from Google Maps (2010) by creating a square extending 50km from the border of the park or appropriate urban area. Within this square, all visible forms of transport, including roads, rivers, and sometimes even railways, were then totalled in kilometres.

Analysis

Chi Square tests (VassarStats 2009) were run to compare the significance of wild animals in relation to their local bush meat circuit, compare bush meat circuits in various nations, and ultimately to determine the general relationship between *Osteolaemus* bush meat and its associated infrastructure and national parks.

Pearson correlations were run in SPSS 16.0 (2008) to compare the relationship between national park infrastructure and wild count of dwarf crocodiles, and also urban area infrastructure in relation to numbers of bush meat individuals, analysed for each nation studied.

RESULTS

A total of 88 African dwarf crocodiles were counted, of which 57 were encountered in the bush meat circuit, and 31 in the wild (Figure 3.2).

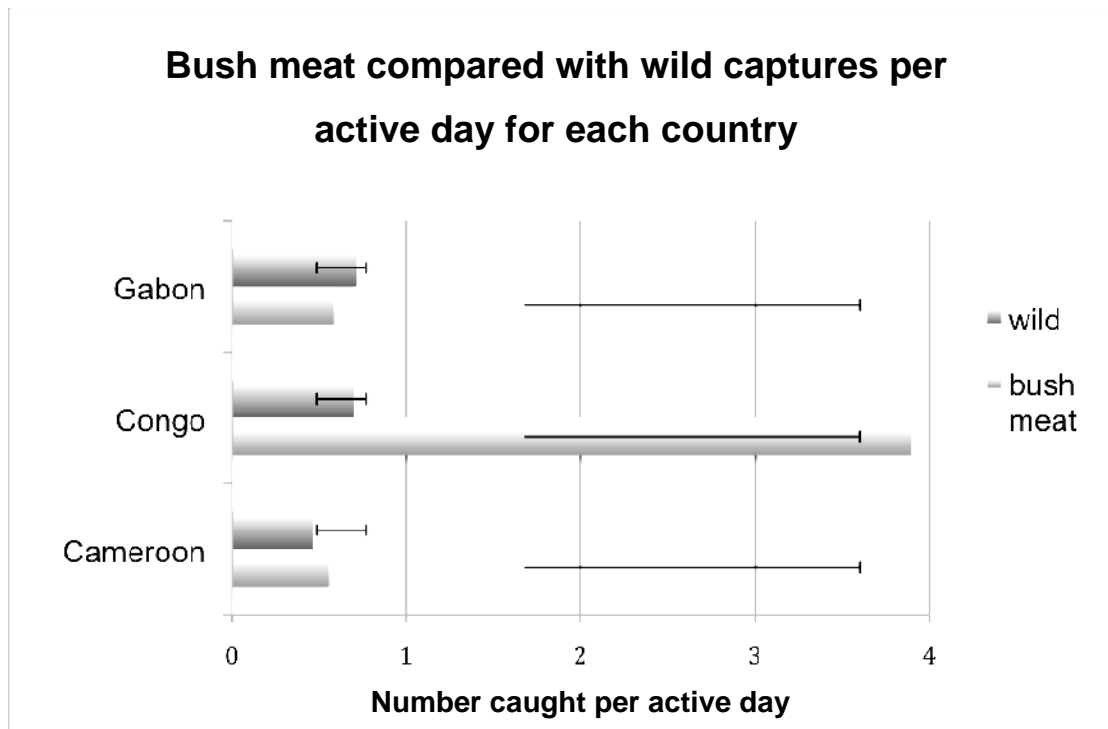


Figure 3.2: Bar chart showing the number of dwarf crocodiles encountered within active survey days in each country. Bush meat markets and wild captures are compared. Standard deviations are displayed as horizontal thin lines.

There was a significant difference between overall counts of bush meat compared to wild caught *O. tetraspis* ($X^2=14.62$; $p=0.0007$; $df=1$). This general difference can be accounted for by its component significant differences contributed by each individual country (Gabon: $X^2=11.66$; $p=0.0006$; $df=1$; Cameroon: $X^2=11.66$; $p=0.0006$; $df=1$ and Congo: $X^2=22.26$; $p < 0.0001$; $df=1$).

There was no significant difference within countries when comparing days spent actively searching for bush meat versus wild. (Gabon: $X^2=1.32$; $p=0.25$; Cameroon: $X^2=1.2$; $p=0.27$ and Congo $X^2=0$; $p=1$; $df=2$). Success rate of encountering animals to number of days still proved more efficient in the bush meat markets (Table 3.1).

Table 3.1: Success rate by country for bush meat and wild encounters

Country	Success Rate Bush meat	Success Rate Wild
Cameroon	0.56	0.47
Congo	3.90	0.70
Gabon	0.42	1.00

The proximity of habitat was examined for each bush meat market. This proximity was arbitrarily divided into localities that are over 15km away, as compared with those under 15km from the market. A significant proximity difference ($X^2=9.28$; $p=0.002$; $df=1$) was found (Figure 3.3). In order to better assess the significance of these proximity results, transport type from the wild to the markets by alternatively water, road, or by foot was analysed. A significant difference can be accounted for by the data about various transportation alternatives ($X^2=18.09$; $p=0.0001$; $df=2$) (Figure 3.4).

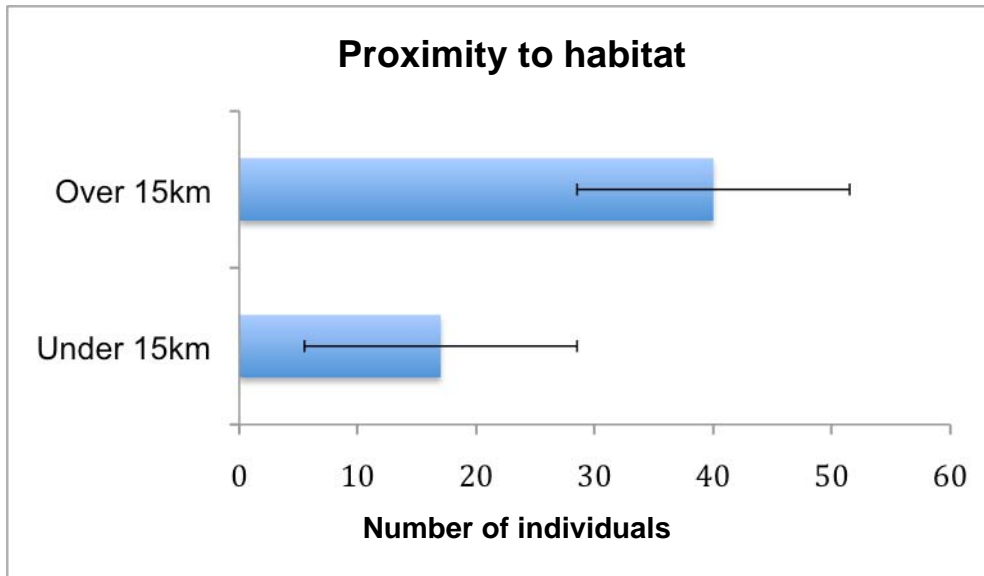


Figure 3.3: Bar chart displaying the number of bush meat crocodiles encountered and their proximity to the habitat. Standard deviations are shown.

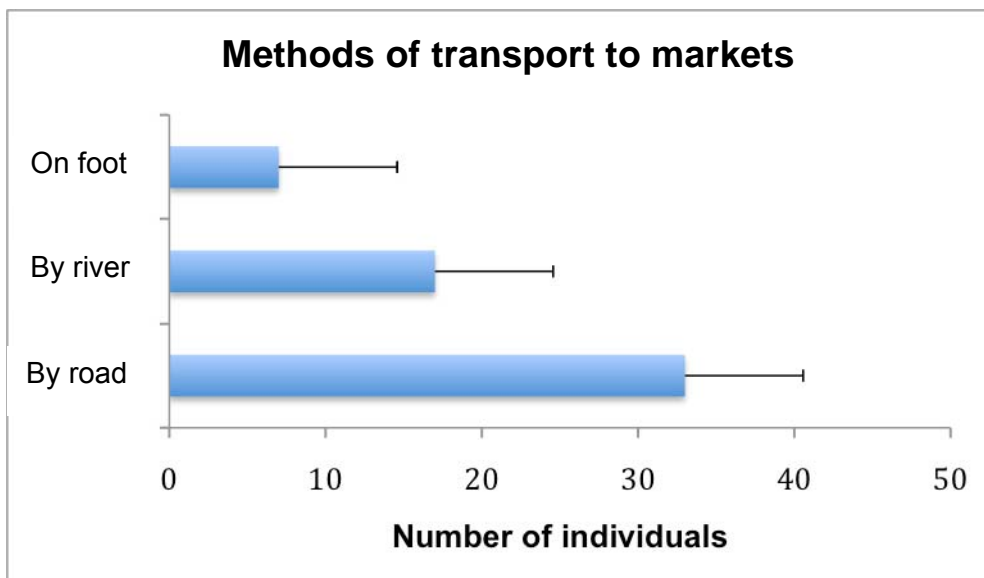


Figure 3.4: Bar chart displaying the form of transport used to remove them from their original habitat. Standard deviations are shown.

While not significantly correlated, infrastructure surrounding national parks negatively correlates with the number of wild-caught dwarf crocodiles (corr.= -0.962, p= 0.176) (Table 3.2). When urban area infrastructure is compared to bush meat found in markets, there is no significant correlation (corr.= -0.776, p= 0.434).

Table 3.2: Pearson correlation and significance between infrastructure around national parks and urban areas compared to the number of bush meat and wild-caught individuals.

Infrastructure		Wild caught	Bush meat
National Park	Pearson Correlation	-.962	-.382
	Significance	.176	.751
Urban area	Pearson Correlation	.537	-.776
	Significance	.639	.434

Finally location of both bush meat and wild caught individuals were compared within and outside of a national park (bush meat within versus outside $X^2=2.2$; p=0.14; wild within versus outside $X^2=1.64$; p=0.20). There was a significant difference between being inside or outside of a national park boundary ($X^2=3.76$; p=0.05; df=1) (Figure 3.5).

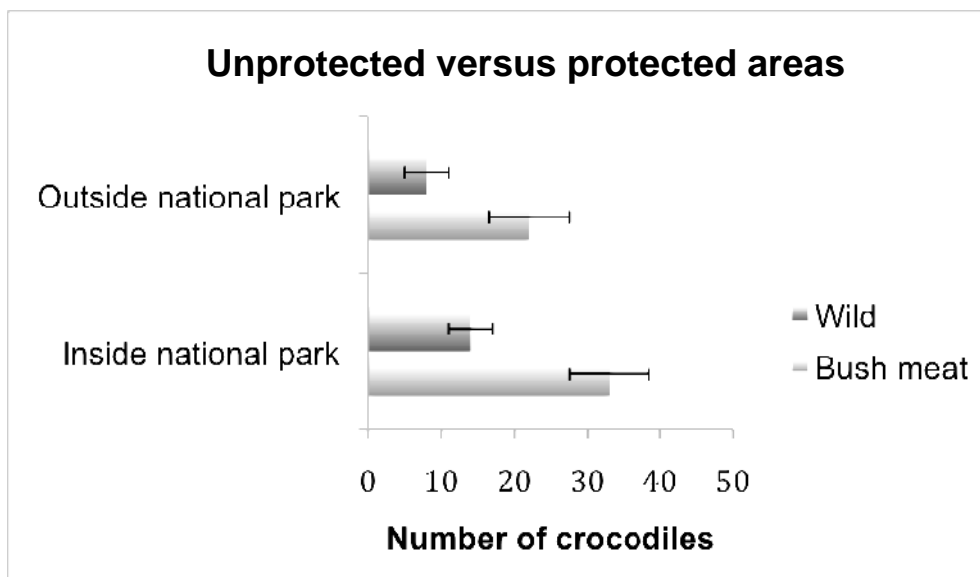


Figure 3.5: Bar chart showing number of bush meat versus wild individuals within and outside of the national parks. Standard deviations are presented.

DISCUSSION

More bush meat markets were visited than wild locations due to the politics of capturing wild animals. Several permits are necessary in order to be able to catch wild animals, whereas bush meat data is freely available. This partially accounts for the significant difference in overall counts when bush meat versus wild-caught is analysed. However, the significance between animals encountered in the bush meat circuit compared to the wild in each country can be seen. Any bias between number of locations is removed when active days are compared for the wild and the bush meat circuit in each country.

INFORMATION SUCCESS KINDS SEPARATED BY COUNTRIES

Congo

Bush meat versus wild

Mostly bush meat was encountered in the Congo, and no access was granted for catching inside national parks in this country. Therefore, *Osteolaemus* was searched for outside of the national parks, which possibly resulted in a lower frequency of wild encounters. While waiting for the appropriate permits to be issued, several visits were made to local bush meat markets, where a large amount of bush meat was seen, including many dwarf crocodiles. There is a flourishing trade in bush meat in the Congo, which probably explains the fact that the number of crocodiles encountered on markets was always higher than wild-caught animals. Even excluding the theoretical potential of denser populations inside national parks, the bush meat market trade definitely has a direct effect on the total wild population of dwarf crocodiles in the nation of Congo.

Congo success

Negative publicity concerning the bush meat trade has made local sellers wary of unfamiliar faces. Vendors are generally unwilling to assist foreign scientists in all of Central and western Africa, and this was often true in the Congo. Cooperation with the French organisation Renatura, who knew the bush meat sellers at the markets in Pointe Noire personally due to their work with marine turtles, resulted in the salesmen allowing access to their animals. In Brazzaville, one of the United Nations guardians personally introduced the researchers to a Brazzaville bush meat salesperson, which again was directly advantageous. Getting acquainted with

individual vendors can have a considerable influence on the number and frequency of bush meat observations in the Congo.

Dwarf crocodile habitat visited in the Congo was in all instances close to human settlements. It is possible that local people have a negative influence on the wild crocodile population due to family and village level hunting pressure. The success rate of wild-caught animals was therefore likely lower than would have been the case in protected areas. Local *in situ* projects creating awareness about the role of dwarf crocodiles in the ecology of the natural environment, if the local people get involved with sustainable use practices, will surely have a positive effect on many dwarf crocodile populations. Due to the cohabitation of humans and dwarf crocodiles, the need for *in situ* projects is probably equally pressing in areas of crocodile habitat both inside and outside of national parks.

Gabon

Bush meat versus wild

All wild-caught *Osteolaemus* in Gabon were encountered in Petit Loango National Park, where dwarf crocodiles are to be found in relative abundance. The total number of bush meat *Osteolaemus* found was nevertheless higher than expected, because the market at Lambarene acted as a magnet for bush meat. Animals had been prepared for sale (chopped into small pieces), making species identification often difficult or impossible. The researchers had to act as tourists, and were not given a chance to count the exact number of dwarf crocodiles represented. It is probable that these vendors had suffered bad experiences with law enforcement, and were wary of 'strangers' asking questions about crocodilians and other kinds of bush meat. Compared to the Congo, more bush meat animals in Gabon were encountered while travelling, and these were being offered for sale by the side of the road (Figures 2.0 and 2.1). This might be due to the fact that the infrastructure of Gabon is better than in the Congo. More tarred roads leads to an increase in traffic by road, both commercial and recreational, and thus a better chance of selling the animal to passers-by (or transport to markets in bigger cities).

Gabon success

Success rate at bush meat markets was considerably lower than in the Congo, due to the fact that vendors were reluctant to let the researchers collect data. Success rate in wild-caught animals was considerably higher due to the Petit Loango National Park visit. This national park is made up of lagoons, making it a difficult terrain to

access for potential poachers, and human settlements are scarce, probably resulting in a higher abundance of dwarf crocodiles. Nevertheless, it must be noted that the open waters of the lagoons are also the home of dwarf crocodile predators such as the larger Nile crocodile, and the voracious barracuda *Sphyræna barracuda* and red snapper *Lutjanus campechanus* fishes, all of which probably contribute to a lower local abundance of dwarf crocodiles (Pauwels *et al.* 2004).

Cameroon

Bush meat versus wild

Trade in bush meat seems minor (Koppert *et al.* 1996) in Cameroon compared to other central African countries, due to stricter enforcement of law. Animals are actively confiscated by police at bush meat markets in Yaoundé and Douala (Auzel 2001). The trade is more of an 'underground' activity in this country. Bush meat animals encountered by the expedition were primarily at remote locations and the markets were small in scale. There are reports of Cameroon animals being transported by boat to Equatorial Guinean Bioko Island (Malabo) just off the coast and facing Douala (Fa *et al.* 2000; Fa *et al.* 2002). The laws on Bioko are less stringent than in Cameroon. Animals originate mainly from the coastal forest areas located between Mount Cameroon in the north, and Campo Ma'an National Park in the south. Dwarf crocodiles in Yaoundé are probably transported from remote areas via tarred roads that lead to the capital.

Two national parks were visited in Cameroon (Campo Ma'an and Korup), with many dwarf crocodile encounters in the first park (in the south of Cameroon, and bordering Equatorial Guinea) but none at all in the latter (bordering Nigeria in the north) in spite of many nights of active searching. Apparently, hunting for bush meat is more of a problem in Korup National Park, where Nigerian nationals cross the border into Cameroon with ease, and then bring hunted animals back to Nigeria. The Nigerian human population density is many times higher than in Cameroon, and natural resources have been exploited more intensively in the past, driving Nigerian nationals across the border in search of bush meat. The more remotely situated Campo Ma'an National Park has less infrastructure, which could explain the relatively low number of animals hunted for bush meat. The bordering nation of Equatorial Guinea presumably has a similar amount of appropriate forest, and thus *Osteolaemus* inhabiting it. Therefore, cross border visits by Equatorial Guinea citizens are probably relatively unnecessary for bush meat collection.

Cameroon success

The success rate of encountering dwarf crocodiles at bush meat markets was not significantly different than in the wild. However, it must be said that access to *Osteolaemus* at these markets was considerably denied and often made impossible by vendors. Thus, because these days still counted as active days of searching, the result was a lower success rate. On the other hand, the low success rate in Korup National Park, where no crocodiles were encountered, had a comparable negative effect on the success rate of wild-caught animals in that country, with many nights of active yet futile searching. This was a big contrast to the relatively high success rate in Campo Ma'an National Park, where many dwarf crocodiles were caught and examined.

Although fewer *Osteolaemus* were encountered in the bush meat market, it is thought that the wildlife trade in Cameroon is more 'underground', which would explain the insignificant difference. Bush meat is still a problem in Cameroon, although not clearly visible, and snares encountered in both Campo Ma'an and Korup show that active hunting for crocodile and other kinds of bush meat is also taking place in national parks.

LOCATION AND INFRASTRUCTURE AS DRIVING FORCES BEHIND TRADE

Habitat proximity, and various kinds of transport

The proximity to habitat, and also the available infrastructure, which comes with logging, both play significant roles in predetermining the availability of bush meat. This conclusion might be influenced by the expedition's low success rate in finding wild animals. However, other studies have also concluded that increased human activity in a formerly remote area is highly correlated with an increased hunting pressure on wildlife (Auzel and Wilkie 2000).

In all three countries, the biggest bush meat markets were situated at places where paved roads or navigable rivers allow for intensive traffic (of both animals to be sold and number of sellers). Expanding transportation infrastructure has led to a proliferation of commercial bush meat hunting that has increased the pressure on natural resources (Wilkie *et al.* 1992). The dwarf crocodile is particularly well-suited for the commercial trade. The small size and slow metabolism of *Osteolaemus* allows

it to be captured and transported alive over long distances without the need for refrigeration. Vendors often store these live crocodiles and sell them only when other game becomes temporarily scarce, elevating the African dwarf crocodile to the biological equivalent of a savings account (Eaton 2009).

Bush meat *Osteolaemus* was usually encountered in relatively large cities. It is possible that law enforcement close to the protected areas is stricter, and therefore the hunters need to transport the animals to locations where the risk of confiscation is much lower. Naturally, when bush meat is offered at a location where there are more people with money to spend, sales will be higher, and this is also a very good reason to transport the live animals to large cities.

Most of the bush meat dwarf crocodiles were transported to their ultimate markets by road or by river. This expedition travelled by car, and was therefore not able to visit markets that were only accessible by boat (or by air), such as Port Gentil in Gabon. This might explain the higher amount of animals encountered that had been transported by road. Note that in places where markets are accessible by both road and river, such as Brazzaville, there is a preference for transport to take place by river. In contrast, transport of *Osteolaemus* by foot traffic must be over shorter distances, and these bush meat sales will therefore happen close to the natural habitat.

An increase in available infrastructure allows for better access to the national parks, and also to the relatively big cities where the demand for bush meat is higher than in rural villages. One would expect that the number of bush meat individuals offered for sale would go up with improved infrastructure. However, contradictory to previous work (Akani *et al.* 1998; Auzel and Wilkie 2000; Davies 2002; De Merode *et al.* 2004; Fa *et al.* 2002; Nasi *et al.* 2008 and Schenck *et al.* 2006), this study found a strong negative correlation between urban infrastructure and the number of bush meat individuals encountered. This information may indicate a breaking point, in favour of development, between urbanisation (percentage of the population living in urban areas) and the bush meat trade as habitat becomes less available. Urbanisation may occur more rapidly in developing countries than land protection programmes can counter (Table 3.3) (Earth trends 2003, and Nations encyclopedia 2003).

Table 3.3: Percentage urbanisation of the human population of each country along with that country's percentage of land allocated as protected areas

Country	% Urbanisation	% Protected area*
Congo	63	15,8
Cameroon	49	8.0
Gabon	81	3.4

*protected areas include any land set aside for reserves, sustainable use, or natural parks

THE STRENGTH OF NATIONAL PARK BOUNDARIES

An important note is that despite delineation of national park boundaries (Gabon's former president Omar Bongo Ondimba announced the creation of a network of 13 national parks comprising 10% of his country), bush meat can still be acquired. Conversations with bush meat salesmen resulted in information as to the origins of their animals, and many of these animals came from national parks. There is a significant difference between dwarf crocodiles caught within and outside of national parks (the result is significant when smaller or equal to 0.05, and in this case the result is 0.05). This basically means that a national park does not offer enough protection for the animals to be safe from the bush meat trade. Lee *et al.* (2006) also came to the conclusion that the African countries surveyed (including Cameroon, Congo and Gabon) still lack adequate protection of their national park boundaries. Snares were also encountered in several of the national parks visited by the Zoer expedition, adding to the evidence that wildlife hunting is still a problem in protected areas.

The second analysis indicates that there is no significant difference between wild-caught versus bush meat animals inside of some national parks. This is influenced by the amount of bush meat animals that has already (as of 2006-2007) been removed from national parks, where you would otherwise expect to find significantly more wild animals living in the legally and theoretically 'protected' forest.

CONCLUSION

Employing *Osteolaemus tetraspis* as a conspicuous and identifiable species, this information is reported in hopes of heightening the world's concern about domestic trade regulation and habitat protection in Central Africa. Despite international efforts, bush meat is still a constant threat to populations of selected species of ecologically and economically (tourism) valuable wild animals in all central African countries (Figure 1.1).

This study suggests that national parks are often active areas for poaching, despite their legal allocation as protected areas. When infrastructure is increased, populations of dwarf crocodiles are expected to decline, and so will all of the other animals susceptible to the bush meat trade. The trend shown between increased infrastructure and decreased bush meat implies that a threshold between urbanisation and land protection may exist. In the three central African countries studied, if current comparative rates continue, the equilibrium between expanding human population needs and the necessities of the natural ecosystems will be breached. As habitat protection in the three central African countries is probably not strong enough to counter urbanisation, a study to determine this equilibrium would benefit both conservation and development work.

Law enforcement close to protected areas is not sufficient at many locations. This is made clear by the numerous animals offered at bush meat markets originating from these areas. Law enforcement should also be increased in the markets in the larger cities, and simultaneously the appropriate governmental agencies should also stimulate alternative protein resources. However, strict law enforcement turns the bush meat circuit into an 'underground' operation, which is more difficult to monitor. Therefore, local people, including salesmen, should become involved in coming up with solutions, for instance by provision of low-cost agricultural food products as alternatives. Rivers and roads are the main ways of transportation of bush meat. It is recommended that instead of just visits to bush meat markets, law enforcement officers should actually concentrate on checking boats and trucks, to stop the supply of *Osteolaemus tetraspis* to the markets. It is evident that the bush meat trade is a flourishing business within central African countries. This trade is having a negative effect on already reduced populations of *O. tetraspis*, the African dwarf crocodile (Figure 1.0).

Six general suggestions relating to the economics and politics of developing countries are:

- 1) Bring the bush meat trade into the open, and clearly identify the parameters of legal versus illegal trade. All forms of wild-meat harvest should be recognised in national statistics (Asibey and Child 1991). Although it might appear that the level of bush meat consumption was relatively low in Cameroon, the underground market might be as big, or even bigger than those in Gabon or the Congo.
- 2) Stimulate sufficient alternatives for bush meat at low cost, such as replacing bush meat with farmed animals or fish.
- 3) Educate the local people. Rural communities have an inherent and long term interest in protecting their local resources. Effective control of hunting can only be established when there is full support from the local communities. Awareness can be raised concerning general crocodile ecology, including their role in the food chain, their feeding and nesting habits during the year (dry versus rainy season), and their possible sustainable use. Education also entails the rejection of those folklore beliefs that promote the consumption of bush meat.
- 4) Approaches must be specific for individual nations, and also at various context levels. The difference in crocodile abundance within Cameroon, between Korup and Campo Ma'an National Parks, shows that even within individual countries there can be huge differences, some of which would favour decentralisation of governance to better deal with different situations.
- 5) Unsustainable use of wildlife is usually linked with poverty. For example, weak local governance, war, famine and unfavorable terms of trade can all increase both poverty and the killing of wildlife (Davies 2002). Alternatively, positive factors such as political stability and the local distribution of economic rewards (for instance with natural resources such as oil or timber with money/resources flowing back to the local community) and simultaneously the promotion of low-cost agricultural alternatives can all decrease the need for excessive levels of hunting.
- 6) The knowledge and values of local communities should be acknowledged as valuable for biodiversity conservation, blending the biological and social elements of conservation, for all natural resources (De Lopez 2005; Pretty and Smith 2004).

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CHAPTER 4: CONCLUSION



Figure 4.0: Dispatched by a heavy machete blow slicing through its neck to sever the spinal cord, the suffering of this individual has ended in a hotel-restaurant in Ekouk, Gabon, fairly close to the forest in which it was captured

The literature reviewed in this thesis, and the expedition's observations and data as well, all agree that bush meat markets in Central Africa are flourishing. Approximately one billion kilos of bush meat animals are shot, snared or captured on a yearly basis, although this might be only a fraction of the total that is actually harvested. There are many inefficiencies and much waste in the bush meat extraction system. Of the three species of African crocodiles, the dwarf crocodile is by far the most heavily hunted, because its small size and its non-aggressive nature facilitate capture and transport to markets. Further, many populations of other edible animal species have already been badly depleted.

This expedition collected data about African dwarf crocodiles, both in the wild and on bush meat markets. The results give an indication of general population status, and document the influence of local consumption on those populations. This study has shown that a large number of dwarf crocodiles from theoretically protected areas actually end up on bush meat markets in Central Africa. Additionally, animals are also being transported between different areas inside individual countries. As a consequence, relatively few animals were encountered in the wild. There is a direct negative influence exerted by the bush meat trade, and it is reducing wild populations of dwarf crocodiles. Most dwarf crocodiles are consumed in large cities far away from the natural habitat where they were caught, particularly when infrastructure allows for relatively easy transport. Improvement of infrastructure would therefore benefit the bush meat trade with the current high demand for this source of protein.

The location of bush meat markets is determined by human population density and infrastructure. In Congo and Gabon, dwarf crocodiles are hunted in rural areas and transported alive on river boats. Where there are no rivers leading to large cities, animals are transported by road. It seems that a lack of infrastructure, whether it be a river or a paved road, implies only subsistence hunting, whereas locations next to rivers or roads allow for easier sale and movement of animals. In the case of the African dwarf crocodile, regulation of international transports is not enough. The captured animals are predominantly destined for the domestic market and are consumed within their nation of origin.

Reducing the demand for bush meat includes promoting alternatives, such as low cost agricultural products. This could be even more effective when the supply of illegal bush meat is effectively targeted by frequent law enforcement checks along roads and rivers, looking for bush meat being transported. Ecological research into population dynamics, including the identification and protection of important populations of dwarf crocodiles and habitats, can often provide valuable information for potential sustainable-yield programs. Realistic quotas can be established for how many animals can be harvested, and the local people can then be legally forced to restrict their hunting and transport of these animals to within ecologically safe limits. Under an enforced quota system, trade can be monitored. For a quota system to work, the local people must ideally be involved in the management of their own wild populations, and in the process must make money and gain status in their community. A complete ban on bush meat would be unfeasible, but regulation of trade, together with promotion of other foods, should contribute to the lessening of the currently unsustainable harvesting rate.

Stricter law enforcement measures, and an increase in ecological research relevant to protected areas, should combine toward providing improved chances of survival for wild populations. This study has additionally found that it is especially important in the case of *Osteolaemus tetraspis* that the demand for dwarf crocodile meat be reduced. The conservation of the African dwarf crocodile is a continuous and complicated process involving human factors and also the crocodiles themselves. While present efforts are showing good effect in some countries, such as Cameroon, they generally still lack effectiveness at regulating the bush meat trade, due to the combined lack of relevant information, low funding levels, and poor local support both inside and outside of the meat market system. Community awareness and participation should be the key in crocodile conservation, with law enforcement and improvement of ecological knowledge as the framework.

APPENDIX 1

Locations of crocodile encounters throughout Cameroon, Congo, and Gabon

Location	# of crocodiles	Market Presence	*Market Ranked by Size
<i>Cameroon</i>			
Campo Ma'an National Park	9	No	
Douala	4	Yes	A
Korup National Park	0	No	
Mundemba	4	Yes	B
Yaoundé	1	Yes	B
<i>Congo</i>			
Bellelo	4	No	
Bivundi	3	No	
Brazzaville	16	Yes	C
Coutou	0	No	
Dombouenou	1	No	
Pointe Noire	23	Yes	C
Youbi	4	No	
<i>Gabon</i>			
Ekouk	3	Yes	A
Lambarene	1	Yes	C
Libreville	1	Yes	C
Lope National Park	2	Yes	A
Petit Loango National Park	10	No	

* Ranked size is as follows: A= single seller by side of road, B= village market, small numbers of general bush meat available, C = city market, large scale bush meat trade