Pilot Study Investigation of the Bongo Antelope Population and Forest Clearings of the Mombongo Region, Northern Congo

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SUMMRY

Due to an increasing interest in exploiting bongo antelope (*Tragelaphus eurycerus*) and a lack of information about the species and its ecosystem a pilot study of the bongo population in the region of Mombongo was undertaken from May to August 1995. This study was part of the Nouabale-Ndoki Project and funded primarily by the GEF Congo Project (PROGECAP). Preliminary investigation of bongo population demography, herd structure, ranging, and feeding ecology demonstrated that the area is used extensively by the region's bongo population(s). The methodologies for acquiring these data were field tested and refined. Based upon the results of the pilot study an in-depth study of the bongo population and Mombongo forest clearings will be conducted.

Historic and current indigenous use of the Mombongo area and knowledge and exploitation of bongo were assessed through interviewing indigenous hunters. Feeding ecology investigation by direct observation and tracking of individuals resulted in identification of seventy plant species eaten by bongo. Direct observations conducted from platforms in the forest clearing complex of Mombongo resulted in information on bongo population structure, social organization, group composition, group size, and activity patterns. Bongo were observed 73 times. One Trailmaster event recorder/remote camera unit was deployed June 3- August 7 at three different points in a forest clearing frequently used by bongo and forest elephant (*Loxodonta africana cyclotis*). 256 photographs of bongos were generated and 62 bongo were identified via stripe pattern, facial spots, and horn shape.

Observations of the dynamics of the Mombongo forest clearings and large mammal species led to insight into animal-bai interaction. The natural mineral licks, forest clearings ("bais"), and habitats of the study area were described and mapped.. Elephant and bongo activity (feeding on soil and vegetation) was observed to alter the structure of the clearings. Aerial videography of the area suggested that the bai complex may have been formed by an oxbow of the Sangha River and rests in a basin 10-30 m lower than the surrounding habitat.

Vegetation in the forest clearings was in various stages of succession and animal activity. General habitat types were described. By the end of the study period animal activity levels had altered the physical structure of many of the bais of the complex. The structure of the bai complex and high activity levels will permit the testing of hypotheses concerning the ecological relationships in large mammal-bai ecosystems. Direct observation and ground-based and aerial photographic monitoring methods were examined.

The pilot study provides a base from which methodological and conservation management recommendations are made.

BACKGROUND

The remote lowland rainforest ecosystem of northwestern Congo harbors some of the highest densities of lowland gorilla (*Gorilla gorilla gorilla)*, forest elephant (*Loxodonta africana cyclotis*), and bongo antelope (*Tragelaphus eurycerus*) in Africa (Fay and Agnagna 1990). Recognizing the ecological importance of the region, the Government of Congo established Nouabale Ndoki National Park (NNNP) in 1993 to preserve portions of a nearly undisturbed forest ecosystem while promoting integrated conservation. The Nouabale-Ndoki/ Congo Forest Conservation Project (NNP) is responsible for the management of the park and surrounding buffer zone region. The project is operated and funded by Wildlife Conservation Society (WCS) and GTZ in collaboration with the Government of Congo. The United States Agency for International Development (USAID) and the Global Environmental Facility Congo provide primary funding.

The area south of the NNNP, the Kabo UFA (Unite Forestier d'Amenagement) has been the site of large scale commercial timber exploitation since the 1970's. The economy of the region developed around this industry which experienced its economic peak during the late 1970's and early 1980's (Fay 1994). Many of the large timber companies went bankrupt in the mid-1980's and the industry has been declining since. The Kabo UFA is currently under license to the Societe Nouvelle des Bois de la Sangha (SNBS). As a means of diversifying the economy and contributing to regional management in northern Congo, the Government of Congo has expressed an interest in developing a tourist safari hunting program with a focus on bongo.

Safari hunting is an important component of management in eastern and southern Africa (Bond 1983; Child and Nduku 1986). Areas south of Mombongo in the Kabo UFA have been identified as having considerable potential for safari hunting and tourist safari hunting is planned as one of four components of the proposed Projet Integre de Conservation Kabo (PICK). The plan is to diversify the economy of the Kabo UFA away from logging with the goal of conserving the forest and integrating sustainable multiple-use revenue generating activities.

While the economic importance and exploitation of bongo as the base of safari hunting in the tri-national region (Cameroon, Congo, and Central African Republic) have escalated over recent years, there remains a paucity of scientific information about the species(Elkan 1995). The bongo, a member of the tribe *Tragelphini,* is the largest species of antelope in the African equatorial forest. Recent surveys in southeastern Cameroon and northern Congo (Elkan 1995, this study) and observations in Dzangha-Sangha, Central African Republic (Turkalo, pers. comm.) have yielded preliminary information on feeding ecology, social organization, and demographics.

Hillman's (1986, 1987) studies of bongo in the savanna/forest mosaic of southern Sudan have been the only documented attempts to investigate the ecology of the species in the wild. Data support an advanced bongo social organization: a range of group sizes regardless of habitat, large groups of females and juveniles, dominance behavior displayed in multi-male interactions, and adult males tending to be partially solitary) (Hillman 1986). Despite Hillman's pioneering study, little information exists on bongo ecology, population demographics, breeding strategies, ranging behavior, or habitat utilization.

Factors affecting the distribution and density of bongo are not well understood. The group sizes observed in Sudan, Congo, Cameroon, and C.A.R. are much larger than predicted for animals of large body size living in dense forest habitat (Estes 1974; Jarman 1974, 1983). Hillman (1986) proposed the large-scale patchy distribution of forest habitat in the savanna transition area of southern Sudan as an explanation for large group size.

Ingestion of soil (geophagia) by large mammals (and humans) has been widely documented in Africa and Asia (Weir 1972; Kreulen 1985; Stark 1986; Ruggiero and Fay 1994). Such studies suggest that sodium is the principal element sought although other elements are present (Stark 1986). The relative requirement levels of sodium and other elements and minerals as well as seasonal variation and availability may have a strong influence on feeding ecology, range and distribution. In addition, changes in physical structure of the habitat as a result of geophagia activity may be important in maintaining ecosystem heterogeneity (Ruggiero and Fay 1994).

The Mombongo area, located in the buffer zone southwest of the Nouabale-Ndoki National Park, contains a unique complex of forest clearings (bais) of significant ecological importance to the region's bongo and forest elephant populations (Blake 1994). The Mombongo bai complex is made up of a network of game trails and bais containing natural soil licks. Scientific understanding of bai ecosystems is minimal. Bais are thought to be important for nutritional supplement (in the form of geophagy and ingestion of water) and as centers for social interaction and breeding. Ruggiero and Fay (pers. comm.) have hypothesized that nutrient return and excavation by large mammals are important to the perpetuation of the bai clearings and mineral levels. The origin of the bais is uncertain.

INT ODUCTION RND OBJECTIVES

A pilot study of the bongo antelope (*Tragelaphus eurycerus*) population was undertaken in the area of Mombongo, northern Congo during May-August 1995. The study was conducted by the author in collaboration with the Nouabale-Ndoki Project and funded primarily by GEF Congo (PROGECAP). The main goals of the study were to determine appropriate methodologies to examine bongo antelope density, distribution, feeding ecology, and habitat utilization and to formulate the research design of an extensive study of the bongo population of the Mombongo region.

Objectives:
1) Investigate and map the complex of natural licks and game trails in the Mombongo area.
2) Describe general habitat types occurring in the area and bongo habitat utilization.
3) Assess indigenous persons' knowledge and exploitation of bongo.
4) Investigate bongo population structure, numbers, and distribution in the area.
5) Develop methods for a study of bongo diet, and feeding habits.
6) Preliminary investigation of bongo use of forest clearings.
7) Assess feasibility of bongo capture for telemetric study and develop its proposal.
8) Make recommendations for development of a monitoring system and information to be collected by sport hunters in the area to the South.

STUDY R/ER

Mombongo Study Rrea, Upper Sangha , Northern Congo
The region of Mombongo, (2⊕09.33 N, 16⊕08.12 E) located near the Sangha River approximately 30 km southwest of the Nouabale-Ndoki National Park (Figures 1a. and 1b.). This region is currently designated as part of a proposed multiple-use buffer zone in the Kabo UFA. The region is classified as dry tropical forest with a mean annual temperature of ca. 25.4⊕ C and a mean total annual precipitation of 1600 mm (Fay 1991).

Topography

The Mombongo bai complex (360 m elevation) covers an area of 6-7 sq. km. in a basin 15-30 m lower than the surrounding area (Figure 2.). It contains habitat types not known to occur elsewhere in the region. The forest of the complex is in various stages of succession indicating that there may have been extensive past flooding (Moutsambote, pers. comm.). This hypothesis has been supported by aerial videography of the area from which Fay (pers. comm.). infers that the complex was formed by the recession of a past oxbow of the Sangha River.

Vegetation

Vegetation of the bai complex can be categorized into three general habitat types. The dominant habitat type was "*Berlinia grandifolia* gallery" forest. This forest type is characterized by a low canopy, Berlinia dominated, seasonally inundated with water, and has an open understory. Within the Berlinia gallery type habitat occur open areas of Cyperaceae dominated "sedge plains" (Fay description) which constitute some of the bai areas. "Mixed forest" with *Lophira alata, Terminalia superba,* and *Pericopsis elata* trees and a Marantaceae

dominated understory occur in defined stands in better drained areas of the complex. A clay substrate was observed to underlie much of the Berlinia gallery and sedge plain habitat.

Monospecific *Gilbertiodendron dewevrai* (locally called "Bemba") type forest surrounds the bai complex. The border of the Bemba forest and bai complex is marked by a distinct change in elevation. Areas South and West of the bai complex experienced selective timber exploitation in the 1980's by Bois Sangha (predecessor of SNBS) creating secondary forest type. No sign of past logging in the bai complex was observed.

Bai Clearings

Sixty two bais and large mammal digging areas were identified over an area of approximately 9 sq. km. (Figure 2.). The bai clearings are linked by a network of well established animal trails. There are similar trails leading to the complex from the surrounding area. Clearings ranged in size from 10-5000 sq. m. The largest bai (reference #13) contained 5 digging areas with standing water. Bai 13 and other larger bais were characterized by "sedge plain" Cyperaceae vegetation. In several of the smaller bais animal activity had removed all surface vegetation. Bais occur in both the mixed and *Berlinia* forest. The majority of the bais were associated with either a standing pool of water or a small stream.

Historic and Current Human Issues in the Mombongo Region

The Mombongo village site (2° 10.5 N, 16° 08.7 E) is situated along the Sangha River about 7 km South of Bomassa (NNNP Headquarters) (Figure 2). Mr. Mosekela Bernard (tribe Bongili) and his wife and daughter have been the only "permanent" residents in the past few years. The site was originally settled by Mr. Mosekela's grandfather in 1975 (Mosekela, pers. comm.). The village was never more than a few houses with temporary pygmy settlements nearby.

For various reasons the different members of the family left the site, with Mr. Mosekela residing there intermittently during the 1980's. He returned to Mombongo in 1991 with his wife and daughter and has remained there since. Mr. Mosekela makes a living as a fisherman selling his fish in Kabo and Bomassa. During the study he was employed as a research assistant.

Interviews of the residents of Mombongo and Bomassa generated information on the extensive history of elephant hunting in the area. Two .375 caliber elephant rifles were operated in the Mombongo area for twelve years 1976-1988. During this time elephants were often killed in the bai complex. The proximity to the river facilitated the transport of the meat and ivory to Ouesso and Libongo. An elephant was killed in the bai as recently as 1994. Seven elephant skeletons (all >1 year old) were found during the course of field work. Elephants became agitated and fled immediately on all occasions when humans were sensed. They were rarely observed in the clearings during daylight hours.

Traditionally, the Mombongo area has not been regularly exploited by subsistence hunters. Subsistence hunters from Bounda, Bomassa, and Babali tend not to use the area because of its relative distance from their locations and the abundance of game near their own villages (Blake 1994). Sign of night hunting activity ("jack-lighting" with 12 gauge shotguns and flashlights)

was observed in the region five times during the study period. No snares were observed. The hunting activity was reported to be commercial hunters coming from the village of Kabo, staying the night and leaving the next day. Observations of sign supported this explanation. A temporary hunting camp was discovered 3.5 km west of the complex and hunting trails 3 km east of the complex showed sign of frequent activity.

A trail on the western edge of the bai complex, leading to Babali, Bonga (13 km south) and eventually to Kabo (18 km), was used occasionally for gathering of mushrooms (unidentified species) and "Coco"(*Gnetum africanum*) by persons in transit and the families of the Mombongo Camp employees. No sign of further human activity in the bai complex area was observed during the course of the pilot investigation.

METHODS

Mapping of the Mombongo Bai Complex

The bai complex and surrounding region was mapped during the course of the study (Figure 2). Latitude/longitude coordinates were obtained for the bai areas using a Trimble Flightmate geographical positioning system (GPS) (Appendix III). A field assistant who had hunted elephant in the area 1985-90 acted as guide for the mapping investigations. General vegetation types and their distribution were assessed during the course of the study by ground survey.

Human Knowledge and Exploitation of Bongo

Indigenous knowledge and exploitation of bongo was investigated through interviews of local hunters. Half of the interviews were structured by, but not limited to, a questionnaire completed by the investigator during the course of the interview (Appendix IV). The remaining interviews were less structured: a conversational technique was employed with responses recorded post-interview.

Bongo Population Demographics and Social Organization

The potential for data collection on bongo demographic and social organization was investigated through direct observations obtained from platforms in the bai complex, miscellaneous sightings while walking in all habitat types of the area, and by tracking (Hillman 1986, 1987). Three temporary wooden platforms (9, 11, and 13 meters in height) were constructed at bais numbers 13, 7, and 11 to permit the undertaking of night and day observations (Figure 2). Access trails to the platforms were adapted from existing game trails.

Bongo were generally found to visit the bai clearings during the night. Therefore, night observation sessions were undertaken as the lunar cycle permitted. Binoculars and image intensification equipment were employed. Data on group size, age/sex structure of groups, behavior, and habitat utilization were collected. During 20% of these sessions there was one observer (the investigator) while there were two during the remainder (the investigator and a Bambendzele research assistant). Data collected represents a consensus between observers. Analyses were performed using Microsoft Excel software.

Bongo were classified into four age classes (adult, subadult, juvenile, and calf). Adult and subadult males and females were differentiated as conditions permitted. When possible data (photographs, notes, and sketch drawings of stripe patterns, horns, and scars) were taken for potential identification analysis and information on herd dynamics.

emote Camera Photographic Identification of Individuals

The potential for photographic identification of individuals through the use of Trailmaster (TM 1500) Infrared Trail Monitor with automatic weatherproof Minolta 35 mm camera was investigated. The remote camera/monitor apparatus includes a computerized monitor which records the date and time of passage of an animal and triggers the remote camera to take an accompanying photograph. An infrared beam emanating from a source unit to the trailmonitor acts as a trigger mechanism. When the beam is broken for a preprogrammed length of time (i.e. a subject passes between the units) a message is sent from the trailmonitor to the camera and a picture is taken. The unit can be programmed to take pictures at different levels of sensitivity (length of time beam broken) in order to focus on a particular body size. There is also a capacity (programmed delay) to avoid taking repeated photographs of the same animal if it remains in front of the camera. These features enable the unit to be set up according to the objectives and conditions of the study. Such technology has generated mark-recapture data at Wali bai near Nouabale-Ndoki Project base in Bomassa (Ruggiero, pers. comm.)

The Trailmaster event recorder and accompanying remote camera were deployed June 3-August 7 at three different points in a bai frequently used by bongo and elephant. Photographs showing the stripe pattern, horns, and facial spots of individual bongo were analyzed according to which lateral side of the animal was photographed (left or right, due to the asymmetry of the stripe patterns of an individual.) By systematically assessing the photographs individual bongo were differentiated and recapture histories produced.

Ektachrome Elite 100, KodakGold 200, Ektachrome Elite 400, Ektachrome 400x , Kodachrome 200 PKL, Fujichrome ISO50/18, Ektachrome Lumiere 100LPP, Kodachrome PKM25, and Tudor XLG100 135 films were tested.

Feeding Ecology

Information on bongo diet was obtained through direct observation of feeding bongo, fresh feeding sign observed opportunistically in the region, and systematic tracking of bongo with assistance of skilled trackers. Tracking distance was estimated using a hipchain and topofil. Canopy permitting, latitude/longitude coordinates were obtained with a GPS. Specimens of bongo food plants were collected for identification and the local name was recorded. Letouzey's Manuel de Botanique Forestiere (1982) was employed as a reference. Count of approximate number of plants and plant parts eaten was recorded. Data on general behavior and habitat use (i.e. points of rest, attack by leopard, rubbing in soil, soil ingestion) were also gathered.

Large Mammal-Bai Ecosystem Dynamics

Preliminary investigation of the ecosystem dynamics of the Mombongo bai complex and large mammal species generated information on animal-bai interaction. The natural soil licks, bais, and habitat types of the complex were described and mapped (Figure 2). The bais were

photographed and monitored monthly (some more frequently as research permitted) for animal activity through direct observation of sign. The NNP conducted aerial videography of the bai complex in August 1995 as a preliminary test for monitoring applications.

ESULTS/DISCUSSION

Human Knowledge and Exploitation of Bongo

Twelve Bomassa, Bakwele, Bambendzele, and Bangombe subsistence and commercial hunters from the Bomassa, Bonga, Bounda, and Kabo areas were interviewed. Responses indicated that bongo are not a preferred game species due to the belief that eating the meat causes epilepsy in children. The majority of the hunters interviewed felt that the status of the bongo populations were good. When bongo are taken it was reported that there is a limited market for the meat in the Kabo area, thus inferring that the meat might not be worth the effort to transport it to the buyer. The bongo was felt to be of "little importance to (them) because there is no market for the meat" and it isn't a preferred part of their own diet. A commercial bushmeat hunter from Kabo suggested that "if not for the taboo the bongo population would have been depleted a long time ago as they are easy to kill with a 12 gauge shotgun."

The Mombongo bai complex area was cited as having one of the highest densities of bongo along with Dja-Dja Bai (Southeastern Kabo UFA) and Wali Bai (3 km N of Bomassa). Bongo were reported to frequent the bais to eat young herbaceous type plants and drink water. Most feeding, traveling, social activity, and use of the bais is believed to occur at night. The bongo was thought to be wide ranging, moving easily from Mombongo to Wali Bai (est. 12 km) according to two hunters. The hunters generally indicated the bongo activity pattern as one of nocturnal activity, feeding and traveling into the early morning. A rest period starts in the mid-morning and lasts until late afternoon with the bongo resting in dense vegetation.

Reports on male association with groups were conflicting. Some maintained that there were permanent herd males while others felt that the males did not have fixed groups and that they moved about looking for any females. Some interviewees felt that old males were driven from their groups by the younger males and remained somewhat solitary. However, others reported that young dominant males also leave the groups and come back to "their" group periodically. Two Bambendzele hunters interviewed felt that multi-male groups were common and that, although there was intrasexual aggression, several males could remain in the same group mixed with females. Despite these differing beliefs about male associations with herds, the bongo was unanimously reported to gather in large groups (20+) which then break up into smaller more permanent groups (3-5).

-Reports on bongo calving season were varied. Several responses indicated year-round calving while others maintained that the end of the rainy season (December) was the period when bongos calved.

-The only predator reported to take bongo was the leopard. The leopard was generally thought to be capable of taking adult bongo.

-Two complaints of bongo eating cassava leaves (*Manihot escultenta*) were later confirmed.

Bongo Demography and Social Organization

A total of 150.5 hours (defined as when clear observation was feasible) of night and day observations were conducted over the course of 20 sessions (2 to 14.5 hours) from platforms at three different bai clearings in Mombongo. Bai clearing sessions yielded observations of bongo during the hours of 1600 - 0600 with activity throughout the night. Bongo were observed during 15 out of the 20 sessions. Miscellaneous observations of bongo were obtained while walking in the Mombongo area on 12 occasions. Bongo were successfully tracked to observation five times. The data includes only those observations which were unobscured by darkness or vegetation. Nevertheless, group size may be bias toward low estimates because some animals in a group were not observed.

Seventy three observations were obtained on 42 different occasions resulting in information on group size (Figure 3.) and population demographics. Thirty nine groups ranging in size from 2 to 21 individuals were observed. The most common group type observed included both male and female adults, subadults, juveniles, and calves, however, all adult groups containing both males and females were also common (25.8%)(Table 1.).

Figure 3. The frequency with which bongo group sizes were observed. Observations of solitaries are included. These observations probably include repeated observations of the same individuals and or groups.

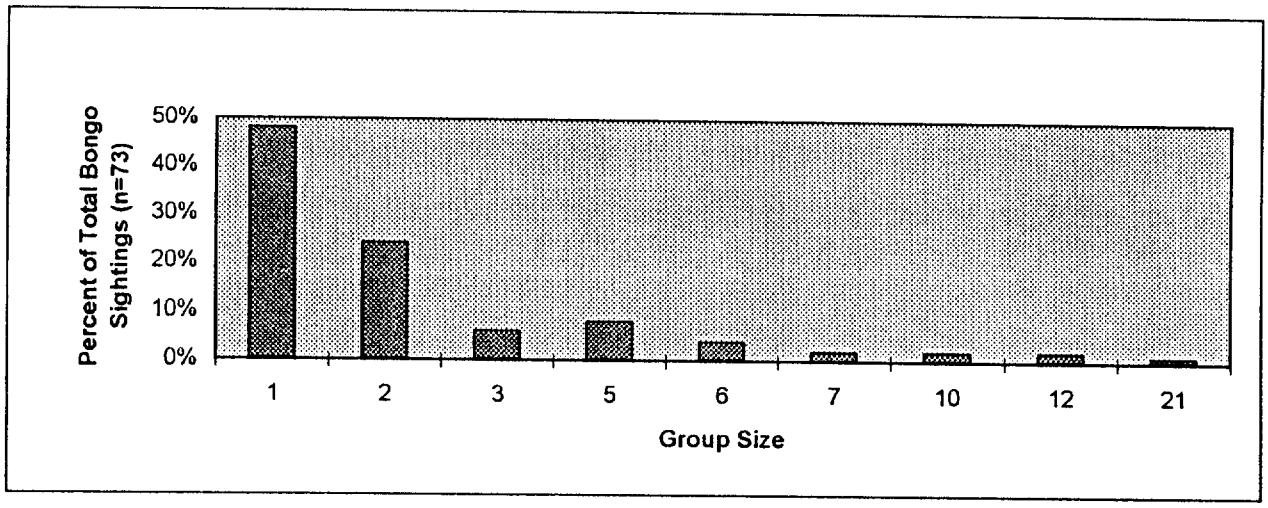

Table 1. Composition of bongo groups (2 or more individuals) and frequency of observation.

Type	n	% total observations (N=31)
Adult males only	3	9.7
Adult females only	3	9.7
Adult males and females	8	25.8
Adult fem, sbad, juv, calf	5	16.1
Adult male, fem, sbad, juv, calf	12	38.7

3 of 12 mixed age class groups containing adults of both sexes had two or more adult males present. Three adult male groups of two animals each were seen.

***Note:** For purposes of analysis an equal probability of multiple observations of the same animal(s) has been assumed. Interpretation of estimates calculating summary statistics, groups sizes, and population structure must take this assumption into consideration. The same bongos and groups of bongo were observed on more than one occasion (confirmed by identification of individuals). Population estimates should not be extrapolated from these data.

Mean group size (Table 2a). was estimated at 2.92 (SD=3.41) with observations of solitaries (n=34) included. Mean group size was 4.59 (SD=3.99) for observations of 2 or more individuals (Table 2b.). A two sample one-tailed t-test assuming unequal variance performed for estimates without solitaries showed no significant difference in group size observed at and away from bai clearings (t=.3929, p=.3491, df=21). Mean group size for groups (2+) containing juveniles (5.46) and calves (9.71) were significantly different from groups with adults only (2.3) (t=3.218, p=.0041, df=11; t=3.427, p=.0070, df=6). Mean group size was not found to be significantly different for groups containing juveniles without calves compared to those with calves but may be approaching significance (t=1.802, p=.0545, df=8).

Table 2a &b. Comparisons of mean group size estimates in relation to group composition and observations at and away from bai clearings. Results presented in 2a. include observations of solitary bongo. 2b. includes only those observations of two or more bongo. Data is derived from direct observations.

2a. Estimates Including Solitary Individuals				
Group	Mean Group Size	SD	n	Range
All (adults-calves)	2.92	3.42	73	1-21
At bai clearings	2.98	3.65	56	1-21
Not at bai clearings	2.71	2.57	17	1-10
Adults only	1.49	0.78	53	1-5
Adults w/juveniles	5.46	3.21	11	2-12
Adults w/calves	9.71	5.71	7	5-21
2b. Estimates Without Solitary Individuals				
Group	Mean Group Size	SD	n	Range
All (adults-calves)	4.59	3.99	39	2-21
At bai clearings	4.70	4.32	30	2-21
Not at bai clearings	4.22	2.77	9	2-10
Adults only	2.30	0.77	20	2-5
Adults w/juveniles	5.46	3.21	11	2-12
Adults w/calves	9.71	5.71	7	5-21

The sex ratio including observations of "solitaries" was 1:1 (Table 3). Within groups of 2 or more that ratio was decreased to 1:1.58. It is likely that multiple observations of the same individual "solitary" males may have biased the estimates. The 4.5 adult female to one calf ratio, in conjunction with data from observations and remote camera photographs of females which appeared gravid during this time suggests breeding seasonality.

Table 3. Bongo population structure resulting from direct observations. Data presented includes observations of "solitaries" and groups. Equal probability of multiple observations of same animals are assumed.

Sex and age composition		
Sex/age category	% Total Overall (n=148)	%Total in Groups (n=128)
Adult males	33.8	24.2
Adult females	33.8	38.3
Subadults	7.4	8.6
Juveniles	17.6	20.3
Calves	7.4	8.6
Unknowns uncategorised (n)	(51)	(31)
Sex and age ratios	Overall	Groups
Male:female adult	1:1	1:1.58
Adult/juvenile(including calves)	2.7	2.2
Adult female/juvenile (excluding calves)	1.92	1.9
Adult female/calf	4.5	4.5

Sketches of stripe patterns, horn shape, and other distinguishing characteristics of 12 animals were made to identify individuals. One particular individual female was observed on three different occasions in group sizes of 5, 2, and 13 animals. Three of the sketched animals were reidentified in the remote camera photographs.

It was determined that individual identification of bongo by stripe pattern is feasible and will permit application of mark-recapture techniques for population estimation. The predominantly nocturnal nature of bongo activity in the clearings limited the capacity to identify individuals during the pilot study. However, the methods and system to obtain these data using infrared lighting and night videography are being developed with NNP staff and a specialist consultant. Night video of the groups will permit the image "capture" of stripe patterns and other characteristics to be used to differentiate individuals. Data on adult male association with groups, and therefore information on social organization, breeding strategies, and breeding seasonality can be generated using these methods.

emote Camera Photographic Identification of Individuals

Seven hundred and ninety eight events and 393 photographs were registered by the Trailmaster event recorder and accompanying remote camera over 61 nights (6.4 frames/night) June 3- August 7 in bai #4. 92% of the events were recorded at night and in the early morning between 1800h. and 0600h..

Two hundred fifty three photographs of bongo resulted. One hundred eighty three of these were clear broadside photographs of the full stripe pattern, horns, and facial spots from which individuals could be recognized. The data were analyzed according to which lateral side of the animal was photographed (left or right) due to the asymmetry of the stripe patterns of an individual. By systematically assessing the photographs 49 different bongo were identified from the left side and 62 from the right (it is likely that some bongo were photographed from both sides).

Capture histories were generated for individuals over the 60 nights of Trailmaster sampling. One manner in which these data can be treated is to divide the period into 5 sampling periods of 12-14 days each, obtaining the capture-recapture statistics presented in Table 4.. The data indicate a recapture rate of 6-13% for the 4th and 5th sampling periods. Determination of an appropriate model to analyze such recapture data requires extensive modeling investigation (Karanth 1995). Investigation of model applications is in progress by the author.

Table 4. Summary photographic capture-recapture statistics for bongo at a single bai in Mombongo 1995. These data resulted from capture-recapture histories generated for 62 and 49 individual bongo.

Right-side	June 3-14	June 16-29	June 30-July 11	July 12-23	July 24-August 6
Animals caught	1	31	17	20	3
Total caught*	0	1	32	46	60
Newly caught	1	31	14	14	2
Left side					
Animals caught	4	14	13	18	7
Total caught	0	4	18	29	45
Newly caught	4	14	11	16	4

*Total caught indicates the number of potential recaptures for that sampling period.

Feeding Ecology and Habitat Utilization

Direct feeding observations were obtained on six occasions (3 in the bais, 2 roadside, and 1 in a Mombongo field). Seventeen systematic tracking sessions were carried out. A total of 50.75 hours were spent tracking bongo over 29.3 km. Tracking sessions ranged from 0.5 to 5.5 hours and from 0.2 to 4.9 km. Bongo were tracked to observation five times with the majority of sessions resulting in the bongo hearing our approach and fleeing without being observed.

Information on vegetation type, plant species and parts eaten, and approximate number of bites was gathered. Bongo food plant specimens were collected and will be submitted to the Centre D'Etudes sur les Ressources Vegetales, Brazzaville, Congo and the Missouri Botanical Garden, St. Louis, MO, USA. Plants were identified with the assistance of Mr. Jean-Pierre Makanya, Mr. Gabriel Yoka, Dr. Jean-Marie Moutsambote, and Mr. Michael Fay.

Seventy plant species eaten by bongo were identified (Table 2). Bongo were observed to feed along timber roads and in all habitat types occurring in the region (Bemba forest, bai clearings, Berlinia Gallery, mixed exploited secondary growth areas, and primary forest). Tracking and direct observations suggested that bongo prefer the young leaves of small trees, lianas, bushes, herbs, creepers, climbing shrubs, and grasses. Bongo occasionally stood on elevated points in order to access choice plants normally above their reach. It was common for bongo to feed heavily on small stems/leaves which occurred in dense patches (i.e. Rubiaceae sp., *Malvestrum coromandelianum*, *Ludwigia sp.)*. Grasses (*Paspalum sp.* and *Acroceras sp.*) made up a small but noticeable part of the bongo diet. No sign of fruit consumption was observed. In late July bongo were observed to feed on the seeds of the *Gilbertiodendron dewevrai* in the Bemba forest.

In the unexploited mixed forest habitats plants from the Acanthaceae family (*Thomandersia* and "Indolou"), *Palisota sps.*, and *Rinorea sp.* seemed to be among principal foods. *Rinorea* ("Esanja") trees were found broken over at 1.5 meters with evidence of bongo feeding on the leaves. A variety of secondary growth species (i.e. *Ipomoea involucrata*, *Chromoleana*

odorata and *Triumfetta cordifloria*) found along old timber roads and natural tree gaps were fed upon. Feeding activity observed in the bais was on *Brillantasia sp., Triplotaxis stelluliflora,* and *Phyllanthus sp.*.

Table 5. Family and species of bongo food plants. Data collected from tracking and direct observation of feeding bongo. Key: * indicates principal food species observed +Bambendzele Name sp. ? unidentified species

MYRISTICACEAE
Pycanthus angolensis
MENISPERMACEAE
Dioscoreophyllum cumminsii
sp.?
VIOLACEAE
Rinorea sp. **
ONAGRACEAE
Ludwigia sp.
THYMELEACEAE
Dicranolepis laciniata
PASSIFLORACEAE
Adenia cissampeloides
Barteria fistulosa
MELASTOMATACEAE
Dissotis erecta
HYPERICACEAE
Harungana madagascariensis
TILIACEAE
Doboscia macrocarpa
*Truimfetta cordifloria***
ALVACEAE
Sida alba
*Malvestrum coromandelianum**
EUPHORBIACEAE
*Alchornea cordifloria***
Eleophorbia sp.
Maprounea africana
Macaranga saccifera
*Macaranga monandra**
Manniophyton fulvum
Phyllanthus sp.
Ricinodendron heudelotti
CAESALPINIACEAE
Afzelia bipendensis
Gilbertiodendron dewevrai
MIMOSACEAE
Acacia pentagona
Albizia zygia
Mimosa pudica
PAPILIONACEAE
Dalhousia africana
Leptoderris sp.
Milletia sp 1
Milletia sp 2
MORACEAE
Myrianthus arboreus
Musanga cecropioides
URTICACEAE
Urera sp.
LORANTHACEAE
sp?
VITACEAE
*Cissus dinklagni**
SAPINDACEAE
Chytranthus sp.
ANACARDIACEAE
Chytranthus macrobotrys
APOCYNACEAE
Pleiocarpa bicarpelleta (? scrape horns, eat bark)
Tabernaemontana penduliflora
RUBIACEAE
Bertierra sp.
Diodea sp.
Unicara sp.
sp.?
sp.?

ASTERACEAE
Chromolaena odorata **
Triplotaxisstellulifera

CONVOLVULACEAE
*Ipomoea involucrata**

ACANTHACEAE
Brillantaisia sp.
Pycnobotrya nitida
Thomandersia lauriflora. **
Indolou+ sp. ?**
Mobosu+ sp. ?*
sp.?
VERBENACEAE
Vitex sp.
COMMELINACEAE
Albizia zygia
Aneilema sp.
Mimosa pudica
Palisota barteri
*Palisota ambigua**
*Palisota schweinfurthii**
sp. ?
ZINGIBERACEAE
Costus sp.
Reneamia sp.
ARACEAE
Culcasia sp.
DIOSCOREACEAE
Dioscorea sp.1
Dioscorea sp.2
GRAMINACEAE
Acroceras amplectens

*Paspalum conjugatum**

Large Mammal-Bai Ecosystem Dynamics

The bais were found to be in various stages of succession and use at the beginning of the study period. By the end of the study period the landscape and animal activity levels in many of the bais had changed significantly. Bais which had been growing over with secondary vegetation were completely opened and vegetation removed, large trees were felled, holes up to one and a half meters deep and four meters wide were excavated. These changes in activity levels were readily observed in the ground level photographic documentation.

The qualitative ground photographic data can be correlated with the aerial videography. The aerial video taken of the region in August 1995 provided information about the general topography and vegetation type distribution, however, in this case, the resolution was not conducive to evaluation of the bai clearings specifically. The potential for application of videographic monitoring methods to the Mombongo area is good. The appropriate resolutions and flight paths can be developed and refined over the course of such trials.

Table 6. presents estimates of the status of large mammal species in the region of Mombongo and how they use the bai complex. These data are based on direct observation of animals and sign during 70 days.

Table 6. Observed sign of large mammal species in the region of Mombongo and their use of bai clearings.

Species	Status in Region	Use of Bai Complex and Clearings
Loxodonta africana cyclotis	abundant	ingestion of soil and water, feeding, socialization
Tragelaphus eurycerus	abundant	ingestion of soil and water, feeding, *socialization*
Tragelaphus spekei	common	rare in bai complex
Syncerus caffer nanus	common	water, grazing in grassy clearings
Cephalophus monticola	abundant	water, forage?
Cephalophus sylvicultor	common	water, forage?
Cephalophus dorsalis	common	?
C. callipygus	abundant	?
C. leucogaster	not observed	
C. nigrifrons	uncommon	
Potamochoerus porcus	common	forage in Berlinia Gallery, not in clearings
Hylochoerus meinertzhageni	not observed	
Manis gigantea	not observed	
Orycteropus afer	not observed	
Hyemoschus aquaticus	not observed	
Panthera pardus	common	hunting?
Felis aurata	common	hunting?
Cercopithecus cephus	common	eat *Berlinia* fruit
Cercopithecus nictitans	abundant	eat *Berlinia* fruit
Cercopithecus. pogonias	abundant	eat *Berlinia* fruit
Cercopithecus neglectus	not observed	
Colobus guereza	uncommon	
Colobus badius	not observed	
Cercocebus albigena	uncommon	
Cercocebus galeritus	common	eat *Berlinia* fruit
Pan troglodytes	common	edge of bai complex, drink water (two obs).
Gorilla gorilla gorilla	common	uncommon in bai complex

CONCLUSIONS/ ECOMMENDRTIONS

This pilot investigation has accomplished the development of research methodologies and the description of a special area of high scientific and conservation priority. While much of the findings of the study are preliminary, vulnerable to potential seasonal bias and sample size limitations, general trends in the data and methodological applications can be evaluated.

egional Conservation

The remoteness of the tri-national region lends to the maintenance of healthy populations of large mammals. The local taboo against eating bongo meat may provide additional conservation relief to the bongo populations. The beliefs reported in this study concur with customs observed in southern Sudan, southwestern C.A.R., and southeastern Cameroon (Hillman 1986; Fay 1990; Elkan 1995). These customs have probably thus far aided in conserving bongo populations because snares are not set expressly to take them. However, snare hunting does take young bongo and wound adult bongo in northern Congo (Auzel, pers.comm.) and southeastern Cameroon (Elkan 1995). Snare hunting remains a serious problem to regional conservation efforts.

The low level of indigenous human exploitation of the forest of the Mombongo region makes it a good area for directed research. The high concentrations of bongo expedite the collection of data and permit the application of robust methods requiring large sample sizes. Located near the Sangha River, travel and logistics for the site are facilitated. The structure, diverse animal activity levels, and various stages of succession of the bai complex provide a unique opportunity for the testing of hypotheses on ecological relationships in large mammal-bai ecosystems.

The Mombongo bai complex is important to the region's large mammal populations as a center for socialization, breeding, and nutritional supplement. The mammal- bai complex relationship, preliminarily described, is not well understood and there were indications that it may be sensitive to disturbance. It is in the interest of regional conservation management to consider the area to be of special scientific and ecological status. No safari hunting should be conducted in the region of Mombongo. The area may be able to sustain a *light* level of ecotourism which could potentially be coordinated by the NNP in collaboration with tourism operators (Fay 1994). Any such activities would need to be closely monitored for negative effects.

Tourist safari operators in the tri-national region are in a position to collect ecological, hunt, and trophy data to contribute to conservation, monitoring, and management. Congo Safaris has expressed interest in participating in this manner. The draft protocol and data sheets (Appendix III) designed during the pilot study may be considered as an outline for collection of such information.

Methodologies

An in-depth study of the bongo antelope population and the Mombongo bai complex will undertaken based on the methodologies developed during the pilot study. A research presence in the area will deter poaching activities with a minimum disturbance of the ecosystem.

Direct observations at clearings

Observations from tree stands as conducted during the pilot study will generate information on population structure and dynamics, and social organization. In order for this method to be more effective in gathering information about male breeding strategies and bongo social organization night videotaping of the groups will be employed. The nature of the clearings permit the use of infrared lighting devices in conjunction with a night vision scope and video camera. This technology will enable the differentiation of individuals, monitoring of herd structure, and collection of mark-recapture data independent of the lunar cycle.

Trailmaster event recorder and photographic identification

The photographic identification of individuals using the methods of the pilot study proved reliable. In order to increase the rate of recapture and sample size, 5 -7 units will be deployed in the bai complex. Two hundred ASA color print film will be used to permit efficient analysis of the data. The sampling technique will be selected based on the conclusion of modeling investigation of appropriate mark-recapture model application (White et al. 1982; Karanth 1995). Remote camera/event recorders will also be deployed on large animal trails used to access the bai complex (Seydack 1984). Direct observation and videography data will assist in associating the left and right lateral stripe patterns of individuals for easier recognition and recapture estimation.

Feeding Ecology and Habitat Utilization

The tracking methodology of the pilot study is simple and effective. Tracking of random groups and individuals will be continued. These data will be collected throughout the year in order to detect potential seasonal changes in diet. No changes in technique are deemed necessary. The forest of the Mombongo region contains little primary type habitat. Tracking of bongo in large primary forest habitat areas will be undertaken. The Mokole area of the Nouabale-Ndoki National Park may be a potential site for such investigation. Nutritional analyses of principal food plant species will be carried out.

Pilot investigation in Mombongo indicated that bongo exploitation of natural mineral licks is an important aspect of their ecology. The relative and seasonal variation of sodium and other minerals in bongo diet may have a strong influence on bongo feeding ecology and distribution (Weir 1972; Kreulen 1985). Analyses of the mineral content of the soil licks exploited by bongo will be undertaken for a better understanding of the importance of geophagia.

Large mammal-bai ecosystem dynamics

Changes in physical structure of the habitat which result from elephant and bongo activity may be important in maintaining spatial heterogeneity and perpetuating bai clearings. Information on which species use the bais, how, and when will be obtained through direct observation and remote camera generated photographs as demonstrated during this investigation. Monitoring of activity

at the bais will be continued by periodic direct observation and ground based photographs from a tripod placed always at the same position and visited monthly. Activity level will be categorized based on clearly defined descriptive criteria. Aerial videography of the bais, conducted monthly if possible, will attempt to focus on the larger clearings and generate images to be compared with the ground based data. This will assist in "ground-truthing" of the rapidly developing aerial monitoring video technology and expand the potential for extrapolation of the results of the bai ecology component of the study.

Investigation of the mineral content of the soil and water of the bai licks, seasonal changes, hydrology, and abiotic parameters of the bai complex will be undertaken. Information on these factors will be compared with trends in mammal activity. Proposed methods (NNP, in prep.) will follow a defined protocol for testing of soil and water pH and conductivity in *situ* using pH/conductivity meters and controls. Soil samples will be tested for mineral content by x-ray defraction techniques in suitably equipped laboratories. A protocol for soil sampling and storage will be strictly followed to avoid biases.

Potential application of radio-telemetry

The use of radio-telemetry techniques is not deemed necessary at the present time. The methods outlined above should provide the ecological information upon which a regional management plan for the species can be based. The implementation of these methods will not allow time for the additional labor intensive task of following and locating radio-collared animals on a regular basis. However, if field conditions or information needs change, causing radio telemetry to become a higher priority, the application of these techniques will have considerable potential.

Observations made during the pilot investigation suggest that it will be feasible to capture bongo for the purposes of fitting radio-collars. Bongo can be captured using drop-nets at bai clearings. Upon being netted they should be immobilized for fitting of the radio collars.

Following of tagged animals could be occasionally assisted by the NNP aircraft (which would need to be appropriately equipped). However, use of the aircraft for this purpose may not be consistent due to other aerial monitoring obligations. Indigenous research assistants could be specially trained to locate and follow tagged animals. Based on tracking observations, the distances necessary to cover in order to locate and monitor tagged animals may be rather large for foot travel (10 km). These concerns need to be accounted for in the design of a radio-telemetry component.

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Rppendix I.

esume of Pilot Study Timetable and Logistics

Investigations of the bongo population in the area northeast of the village of Bomassa were conducted April 14 -May 20 1995 while authorization was being obtained from Societe Nouvelle des Bois de la Sangha (SNBS) to conduct research in the Mombongo area. 29 days were spent in the field in the areas of Wali Bai, Djeke River, and the Ndoki Camp (Preliminary Report August 1995). Ecological information on bongo and other large mammal species was collected.

During this period discussions were held with the Congo Safaris operator and a protocol developed for the collection of ecological, hunt, and trophy animal data by sport hunters Appendix II. Interviews of indigenous hunters, recruiting of research assistants, and discussions with the residents of Mombongo village were conducted. A research plan was designed and distributed to NNP, SNBS, and safari operators (Appendix IV).

Research was conducted in the Mombongo region during the period May 22-August 11. 70 days and nights were spent in field investigation in the bai complex and surrounding area. A temporary tented camp was established at the Mombongo village site (Latitude 2 10.505 Longitude 16 08.698) on the Sangha River. TTTTThree temporary wooden platforms were constructed at mineral licks in the bai complex (9, 11, and 13 meters in height) to permit the conduction of night and day observations. Access trails to the platforms were adapted from existing game trails.
A camp assistant and night guard were employed from the Mombongo village population (population of 4). Two pygmy trackers (Bambendzele and Bangombe) were employed as field assistants. One of the assistants was an originaire of the village of Bounda. Bounda is the closest inhabited village (eleven houses) located approximately six km West of Mombongo. Discussions were held with the Bounda population on May 29, June 25, and August 2.

Rppendix III.

Latitude/Longitude Locations for the Mombongo Bai Complex Region

(Positions obtained using a Trimble Flight Mate GPS)

Reference	Latitude	Longitude	Altitude
Mombongo Village	2⊕10.505	16⊕08.698	
Poorly Drained Area	10.275	08.448	
Bai 2	09.064	09.144	
Bai 3	09.115	09.108	
Bai 4	09.156	08.981	
Bai 6	09.038	08.939	
Bai 7	09.202	08.540	
Bai 8	09.297	08.548	
Bai 11	09.154	08.125	360m
Bai 12	09.291	07.908	390m
Bai 13 NE	09.329	08.137	
Bai 13 NW	09.349	08.117	
Bai 13 SE	09.296	08.118	
Bai 13 SW	09.309	08.144	
Bai 13 SWW	09.333	08.122	
Sedge Plain	09.247	08.299	
Sedge Plain	09.251	08.275	
Sedge Plain	09.189	08.289	
Bai 13z	09.310	08.121	
Bai 15	09.867	07.853	
Bai 19	09.697	07.654	
Bai 20	09.531	07.545	
Bai 26	09.373	08.297	
Bai 27	09.201	09.109	
Bai 31	10.025	08.089	
Bai 34.5	10.177	06.863	
Bai 35	09.192	08.448	
Bai 36	09.255	08.876	
Pt 41	09.269	08.404	
Pt 42	09.286	08.270	
Pt 43	09.318	08.228	360m
Bai 44	09.202	07.722	
Bai 45	09.060	07.806	
Bai 47	08.984	07.806	
Bai 49	08.910	07.589	
Bai 50	08.827	07.705	
Bai 51	09.064	07.589	
Bai 52	09.122	07.583	
Bai 53	09.182	07.534	
Bai 57	09.868	07.916	
Pt 59	10.099	07.059	
Bai 62	08.984	07.672	