SODEPAL

RAPPORT DE MISSION AU PARC DE LA LEKEDI BAKOUMBA, GABON

par

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RESUME :

En septembre 2000, le CIRAD-EMVT signait un accord-cadre de collaboration avec la SODEPAL. L'EMVT a ainsi accès au parc de 14000 ha de la Lékédi près de Bakoumba, Gabon. Les objectifs de cette première mission était de cartographier le ranch et de recenser la faune en forêt et en savane dans l'enceinte du ranch. Un article est en cours de rédaction sur « *Biomass of duikers in the Lékédi ranch* ». Un des objectifs initiaux de faire une étude analytique et prospective de l'élevage de potamochères a été restreint à la rédaction d'un article (en cours) « *Bushpig and red river hog as potential animal productions* ».
Le potentiel de recherche pour l'EMVT est énorme. Un thème est prépondérant pour la SODEPAL : l'élevage de potamochères. Ils ont de bons résultats de reproduction, mais un problème majeur de mortalité juvénile. L'EMVT pourrait développer ce thème de recherche sur l'élevage, peu abordé par la communauté scientifique, et en particulier la biologie reproductive.

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-Philippe Chardonnet pour sa mission et ses nombreux conseils,
-Lee White pour son accueil à la station de recherche de la Lopé, ses conseils avisés et la documentation qu'il m'a fournie.

SIGLES UTILISES

CIRAD : Centre International de Recherche en Agronomie pour le Développement
COMILOG : Compagnie Minière de l'Ogooué
EMVT : Département d'Elevage et de Médecine Vétérinaire (du CIRAD)
GPS : Global Positioning System
SODEPAL : Société d'Exploitation du Parc de la Lékédi
WCS : Wildlife Conservation Society

SOMMAIRE

I. JUSTIFICATION DE LA THEMATIQUE « FAUNE FORESTIERE »

Le département de l'EMVT, et le programme ECONAP en particulier, ne sont jamais intervenus dans les écosystèmes forestiers. Aucun projet n'a été développé sur les productions animales en zones forestières. Les méthodes classiques de développement de l'élevage tropical sont peu adaptées aux écosystèmes forestiers (contraintes sanitaires, zootechniques ou culturelles). De nouvelles voies doivent donc être explorées, et notamment l'élevage des espèces animales sauvages indigènes, donc bien adaptées aux problèmes sanitaires et écologiques qui se posent dans ces contextes.

La forêt tropicale humide, gravement menacée dans son existence, doit trouver tous les moyens pour perdurer face aux modes de valorisation à court terme comme la surexploitation forestière, voire la déforestation, mais aussi face aux modes d'utilisation alternatifs et concurrentiels comme l'agriculture. Tous les modes de valorisation de la forêt vivante sur pied peuvent contribuer à lui donner une valeur socio-économique suffisante pour concurrencer les usages destructeurs. La production de viande de gibier constitue l'une de ces alternatives.
Enfin la totalité des ranchs en Afrique se situe en zone de savane et élève donc des mammifères de savane.

Travailler sur l'élevage de gibier forestier est donc tout à fait innovant. Le ranch de la Lékédi, unique en son genre, constituerait un véritable laboratoire expérimental pour le CIRAD, avec une perspective importante de publications scientifiques.

II. CADRE ET OBJECTIFS DE LA MISSION

Début septembre 2000, le CIRAD-EMVT et la SODEPAL ont signé un accord-cadre (annexe 1) pour une période de 2 ans.
Cette première mission, phase de démarrage du partenariat, s'est déroulée du 16 septembre au 31 décembre 2000.

La SODEPAL a mis à ma disposition un logement équipé, un bureau et un pick up 4 x 4, a pris en charge l'eau et l'électricité du logement, le coût du téléphone professionnel, le carburant et la maintenance du véhicule, m'a laissé libre accès au matériel informatique et à la photocopieuse. Elle m'a aussi affecté du personnel pour le travail de terrain.

Les objectifs initiaux étaient:

- mettre au point un fond de carte géoréférencé du parc ;
- réaliser un inventaire de la faune dans l'ensemble du parc, inventaire qualitatif des grands mammifères et quantitatif , dans la mesure du possible, pour les ongulés ;
- réaliser une étude descriptive, analytique et prospective des systèmes de production actuels et potentiels du potamochère sur le ranch de la Lékédi, avec

mise en perspective par rapport aux travaux et connaissances acquises par ailleurs sur cette espèce.

III. PRESENTATION DU MILIEU

Le climat

La province du Haut-Ogooué est soumise à un climat de type équatorial caractérisé par une importante saison des pluies et une petite saison sèche peu marquée (de juin à août). La zone de Bakoumba présente des précipitations annuelles comprises entre 2000 et 2400 mm.
La température moyenne est de 26°C, avec peu d'écarts au long de l'année. L'humidité de l'air varie de 60 à 90%.

Le milieu physique

Le parc de la Lékédi est situé à 5 km du village de Bakoumba, dans le département de Lékoko, dans la Province du Haut-Ogooué, au sud-est du Gabon. Cette ville est situé à 45 km de Moanda, à environ 100 km au sud-ouest de Franceville et à 50 km au nord de la frontière congolaise.

Située sur la bordure orientale du massif du Chaillu, à une altitude de 600-700m, la zone de Bakoumba est caractérisée par une forêt sempervirente ombrophile à okoumé, béli, sorro, ilomba et engona et une mosaïque forêt-savane. Des forêts galeries bordent le principal cours d'eau du département, la Lékédi, et ses affluents. Les sols sont caractérisés par une texture argilo-sableuse à argileuse, assurant un bon bilan hydrique.

Le milieu humain

Le Haut-Ogooué est une des régions les moins densément peuplées (2,5 hab/km²) avec une population de 104 000 habitants sur 36 547 km². 73% de celles-ci sont concentrées dans les 4 principaux centres : Franceville, Moanda, Mounana et Okondja. Ensuite la ville la plus importante est Bakoumba avec 3000 habitants. Les ethnies majoritaires sont les Bandjabis et les Batsangis (Raponda-Walker et Sillans, 1995).

IV. PRESENTATION DU PARTENAIRE ET DU SITE

Création et activités de la SODEPAL

La COMILOG (Compagnie Minière de L'Ogooué) a pour actionnaire majoritaire ERAMET, une société d'Etat français, dite société des nickels de Nouvelle-Calédonie. Elle exploite le manganèse des mines de Moanda. Le minerai était acheminé jusqu'à M'Binda, au Congo, par un téléphérique de 76 km de long, puis de là par rail jusqu'à Pointe-Noire. Depuis la création du chemin de fer transgabonnais, le minerai est transporté à Libreville par cette voie.

La SODEPAL, (Société d'Exploitation du Parc de la Lékédi), filiale de la COMILOG, a alors été initiée, en 1990, dans le but de maintenir les 110 emplois du personnel qui travaillait à l'entretien du téléphérique.

Les activités de la SODEPAL sont multiples :

- Pisciculture (élevage de tilapias)
- Gestion et protection de la faune (parc à mandrills et chimpanzés)
- Production de gibier :
  - espèces importées de Namibie (Impalas)
  - espèces locales (Potamochères, Buffles, Aulacodes)
- Production de pleurotes
- Tourisme de vision
- Sensibilisation à l'environnement

Un parc clôturé

Le parc de la Lékédi couvre une superficie de 14000 ha de mosaïque forêt-savane, entièrement clôturée de 86km de grillage (type Cyclone) de 1,9m de haut, surmonté de rangées de barbelés. Il est divisé en 3 modules de 650, 1 750 et 11 600 ha.

Changement de la direction du parc

La COMILOG cherche un nouveau chef d'exploitation, puisque l'ancien directeur Mr Jean Bourgeais a quitté son poste en septembre 2000.

V. ACTIONS MENEES

1. Fond de carte géoréférencé du parc

La première semaine a été pleinement consacrée à la prise de connaissance du milieu. Il n'existait qu'une carte très sommaire du parc, avec les pistes et les 3 stations piscicoles. Il a fallu parcourir toutes les pistes pour repérer les zones de

savanes et de forêts, et les endroits potentiels où tracer les transects. En même temps, je référençais les pistes parcourues par GPS.

Par la suite, toutes les infrastructures (parcs piscicoles, parcs à potamochères, à volailles, à primates), les 2 principaux lacs et tous les transects ont été cartographiés sur MapInfo.
Une photo satellite très récente (mars 2000) couvrant le parc a été achetée par le CIRAD-Forêt. Valéry Gond et Nicolas Fauvet doivent, dans les semaines à venir, caler la carte du parc (annexe 2) sur la photo Landsat.
Les zones de savanes et de forêt seront ainsi représentées sur la carte.

2. Mission à la station de recherche de la Lopé

J'ai rapidement effectué une mission au parc national de la Lopé (du 28/09 au 05/10). Le but était d'échanger avec Lee White, chercheur pour le WCS, depuis 11 ans à la Lopé, sur les méthodes et les aspects pratiques de recensement de faune. Il m'a fourni beaucoup de documentation, de nombreux conseils, du matériel (topofil) pour le tracé des transects et un logiciel d'analyse des données (« Lopes »).

3. Inventaire de la faune

L'effort principal de cette mission a porté sur l'inventaire.
Avant mon départ, P. Chardonnet et moi-même, nous étions mis d'accord pour appliquer la méthode des transects et observations directes des animaux en forêt. Pour le recensement des animaux en savane, les transects en voiture étaient préconisés, éventuellement à adapter selon les conditions du milieu.

A . Inventaire des grands mammifères du ranch

Le ranch a la spécificité d'abriter des espèces indigènes (tableau I), mais aussi importées de Namibie (tableau II).

Tableau I : Liste des espèces de grands mammifères indigènes

Nom commun	**Nom scientifique**
Céphalophe bleu	*Cephalophus monticola*
Céphalohe bai	*C. dorsalis*
Céphalophe d'Ogilby	*C. ogilbyi*
Céphalophe de Peters	*C. callipygus*
Céphalophe à ventre blanc	*C. leucogaster*
Céphalophe à front noir	*C. nigrifrons*
Céphalophe à dos jaune	*C. sylvicultor*
Chevrotain aquatique	*Hyemochus aquaticus*
Guib harnaché	*Tragelaphus sriptus*
Sitatunga	*T. spekei*

Buffle	*Syncerus caffer nanus*
Potamochère	*Potamochoerus porcus*
Hocheur	*Cercopithecus nictitans*
Moustac	*C. cephus*
Cercopithèque pogonias	*C. pogonias*
Colobe noir	*Colobus satanus*
Mangabé à joues grises	*Lophocebus albigena*
Gorille	*Gorilla g. gorilla*
Chimpanzé	*Pan t. troglodytes*
Mandrill	*Mandrillus sphinx*
Pangolin géant	*Smutsia gigantea*
Pangolin commun	*Phataginus tricuspis*
Panthère	*Panthera pardus*

231 potamochères ont été introduits après capture dans la réserve présidentielle de Wonga-Wongué. Des céphalophes fournis par les villageois ont aussi été introduits . Les introductions n'ont eu lieu que dans les modules 1 et 2.

Tableau II : Liste des espèces importées de Namibie

Nom commun	**Nom scientifique**	Date d'importation	Nombre d'animaux importés	Nombre d'animaux vivants fin 2000
Impala	*Aepyceros melampus*	15/06/93 17/08/96 20/08/96 27/08/96	6 74 81 66	192
Damalisque à front blanc	*Damaliscus dorcas*	15/06/93	22	8
Elan du Cap	*Taurotragus oryx*	20/08/96	6	0
Bubale caama	*Alcelaphus buselaphus*	17/08/96	9	1
Gnou bleu	*Connochaetes taurinus*	5/06/93	10	4
Autruche	*Struthio camelus*	27/08/96	30	4

Ces importations auraient pu perturber le peuplement animal indigène. Mais, à cause de leur inadaptation aux conditions locales, la quasi-totalité des taxons exotiques est en voie de disparition. Seul le cheptel d'impalas est encore conséquent, malgré une grave épidémie de piétain, traitée par la construction de pédiluves autour de pierres à sel. Cette espèce se cantonnant aux savanes, interfère peu avec l'habitat et la faune locale.

Au total, 227 impalas ont été importés. Fin août 2000, le cheptel d'impalas s'élevait à 192 têtes (tableau III) malgré de nombreuses naissances.

Tableau III : cheptel d'impalas fin août 2000

	Mâle	Femelle	Jeune mâle	Jeune femelle	Nouveaux nés	**Total**
Module 1	11	64	18	3	7	**103**
Module 2	14	53	14	3	5	**89**

B. Recensement en savane

Les animaux en savane ont été recensés sur des itinéraires parcourus en voiture, dans les 3 modules. Les principaux animaux observés en savane sont les guibs harnachés, les sitatungas et les buffles. Signalons ici le caractère exceptionnel d'une observation aussi aisée des sitatungas.

Les nombreuses données récoltées ne sont pas encore analysées. Il était prévu d'écrire un article sur les indices d'abondance des animaux dans les savanes du ranch de la Lékédi. Mais cela n'a malheureusement pas été fait par manque de temps, puisque la priorité a été donnée au recensement en forêt.

C. Recensement en forêt

Echantillonnage et tracé des transects :

La première étape a été d'échantillonner les transects. En l'absence d'une carte de végétation et de relief du parc, le parc a été divisé en 8 blocs géographiques, dans chacun desquels un transect a été tracé. 8 transects d'une longueur moyenne de 1,6 km ont été tracés. Un travail long et pénible, qui a découragé plus d'un agent de la SODEPAL. Il a fallu en moyenne 20 homme-jours pour tracer un transect, le nettoyer et le marquer. Les longues distances à parcourir quotidiennement pour se rendre dans le module 3 ont fait perdre beaucoup de temps (en moyenne 2h30 de trajet par jour).

La société a initialement mis à ma disposition des membres de son équipe faune pour tracer les transects. Mais ce travail s'est révélé beaucoup plus long que prévu, au total environ 2 mois. Et la SODEPAL ne pouvait mobiliser la majorité de cette équipe trop longtemps, puisque celle-ci devait parallèlement assurer son travail habituel. La SODEPAL a accepté de renforcer mon équipe en embauchant des temporaires pour accélérer le travail de préparation des transects.

Vu le peu de temps restant à consacrer à la récolte de données, il a été proposé de créer une deuxième équipe d'observateurs. Encore une fois, la SODEPAL a accepté de m'affecter 3, et non 1, de leurs agents de manière permanente.

Comptage et résultats :

Un article est en cours de rédaction (annexe 3). On peut s'y référer pour la méthode et les résultats du recensement en forêt. Nicolas Gaidet a largement participé à l'analyse des données.
Les résultats bruts sont présentés dans le tableau IV.

Tableau IV: Taux moyen de rencontre (TMR) de groupes pour chaque espèce

Espèce	**TMR**	**n**	**SE**
Cephalophus monticola	0.3305	29	0.0555
Céphalophes rouges*	0.2815	25	0.0515
Potamochoerus porcus	0.0129	1	0.0129
Tragelaphus scriptus	0.0109	1	0.0109
Cercopithecus cephus	0.2134	16	0.0517
C. nictitans	0.0758	7	0.0278
C. pogonias	0.0501	4	0.0244
Colobus satanus	0.0971	7	0.0420
Mandrillus sphinx	0.0254	3	0.0178
Gorilla gorilla	0.0128	1	0.0128

*: ***Cephalophus ogilbyi, C.callipygus, C.nigrifrons, C. leucogaster, C. dorsalis***

TMR: taux moyen de rencontre des groupes/km
n: nombre total d'observations de groupes
SE: écart-type

Les taux de rencontre des espèces observées avec une faible fréquence ne signifient évidemment pas grand chose. Ils sont donnés comme base indicative, tout comme les taux de rencontre par espèce et par transect (tableau V), dans l'éventualité d'une future étude sur les abondances.

Tableau V: Taux moyens de rencontre de groupes par espèce et par transect

Espèce	Transect 1 shaba		Transect 2 les gazelles		Transect 3 buffle		Transect 4 moustac		Transect 5 potamochères		Transect 6 panthère		Transect 7 mandrill	
	TMR	n	TMR	n	TMR	n	TMR	n	TMR	n	TMR	n	TMR	n
C.monticola	0,29	4	0,30	5	0,36	7	0,48	7	0,23	2	0,10	1	0,45	3
Céphalophes rouges*	0,51	7	0,18	3	0,21	4	0,07	1	0,46	4	0,38	4	0,30	2
Potamochoerus porcus											0,09	1		
Tragelaphus scriptus	0,07	1												
Cercopithecus nictitans			0,12	2	0,16	3			0,11	1			0,15	1
C. pogonias			0,12	2							0,09	1	0,15	1
C. cephus		3	0,06	1	0,10	2	0,07	1	0,23	2	0,19	2	0,76	5
Colobus satanus		2	0,12	2							0,09	1	0,30	2
Gorilla gorilla							0,07	1						
Mandrillus sphinx			0,06	1					0,11	1			0,15	1

*: ***Cephalophus ogilbyi, C.callipygus, C.nigrifrons, C. leucogaster, C. dorsalis***

Les taux de rencontre les plus élevés pour *C. monticola* sont sur les transects 4 et 7, respectivement 0,48 et 0,45, et pour les céphalophes rouges sur les transects 1 et 5, respectivement 0,51 et 0,46. *Cercopithecus cephus* a été le singe le plus rencontré, puis vient *C. nictitans* et *Colobus satanus. C. cephus* présente le taux de rencontre le plus élevé sur le transect 7 (0,76).
Les taux de rencontre des singes sont beaucoup plus élevés sur le transect 7. Ceci s'explique probablement par la présence de nombreux arbres fruitiers sur ce transect, dûe à l'existence passée d'un village.

Les observations étaient suffisantes uniquement pour les céphalophes bleus et rouges pour lesquels nous avons calculé des densités. Celles-ci sont respectivement de 11,4 et 9,9 individus au km². Elles sont plus élevées que celles calculées pour les autres zones du Gabon. Dans la réserve de la Lopé, White (1994), a estimé les densités individuelles à 0,3 à 1,5 et 2,5 à 5,5 respectivement pour les céphalophes bleus et rouges. Prins & Reitsma, 1989, ont estimé la densité des céphalophes bleus et rouges, du chevrotain et de l'antilope de Bates, confondus, à 0,53 individus par km², dans la Province de l'Ogooué-Maritime, sud-ouest du pays.

Stratification de la végétation :

Avant mon départ au Gabon, j'avais contacté le CIRAD-Forêt, afin qu'il envoie un de ses agents à la Lékédi pour faire une stratification de la végétation de la zone et en particulier des transects. Je suis partie sans aucune certitude. Finalement P. Chardonnet et Gilles Mille avaient demandé à Charles Doumenge, partant en poste à Libreville en novembre, de venir faire ce travail. Malheureusement, cela n'a pu se faire et jusqu'à présent cette stratification fait défaut, en particulier pour discuter les résultats selon les habitats.

4. Etude critique et prospective sur les systèmes de production du potamochère au ranch de la Lékédi

Cet objectif a été annulé lors de la mission de P. Chardonnet. La durée de la mission était trop courte pour mener à bien cette étude.

En revanche, un article est en cours de rédaction (annexe 4) pour le présenter au congrès de Pretoria « International wildlife ranching symposium » en mars 2001. Cet article intitulé « Bushpig and red river hog as potential production animals » présente entre autres les résultats de l'élevage de potamochères de la Lékédi.

Leurs résultats de reproduction sont très intéressants : 2 mises bas par an et reproduction concommittante de plusieurs femelles d'un même groupe. Le problème majeur est une très forte mortalité juvénile (causes suspectées : cannibalisme et stress thermique).
Malheureusement, il n'y a aucun suivi rigoureux de cet élevage.

5. Atelier de restitution sur la gestion de la faune dans les exploitations forestières

Un atelier s'est tenu à la Lopé sur la gestion de la faune dans les exploitations forestières. Je n'ai malheureusement pas eu le temps d'y participer, mais j'ai assisté à l'atelier de restitution à Libreville. Les recommandations issues de cet atelier sont présentées en annexe 5.

Durant ce séjour, je suis également allée sur les marchés de gibier, prendre des données sur les espèces présentes et les prix de la viande de brousse.

Tableau IV : Prix de la viande de brousse en F CFA

Marchés	LBV Oloumi	FCV	BKA-Brousse
Thryonomys swinderianus	9000	6000	M: 6000 F: 4000
Atherurus africanus	7000	8000	5000
Cercopithecus cephus	M:7000 F:8-10000	6500	M: 8-9000 F:7000
Cercopithecus nictitans		9000	M: 12000 F:9000
Cephalophus monticola	7000	7000	5000
Cephalophus dorsalis			
Entier	15-18000	15000	
Pattes	7000	3000	
Cephalophes rouges			
Entier			14-15000
Leg			
Quartier de l'animal			3500
Cephalophus silvicultor		25000	
Smutsia gigantea		50000	40000
Potamochoerus porcus			
Entier		50000	50000
Patte	Av.: 12000 Arr.: 16000	8000 10000	10000
Poitrine	7500		
Côtelettes	6000	7000	5000
Quartier			15000
Tête		7000	
Intestin		3000	
Tragelaphus spekei		60000	
Syncerus caffer (kg)			4000-4500
Chèvre		30-50000	20000-50000
Poule		M: 2500 F: 3000	M: 2000 F: 2500

LBV : Libreville
FCV : Franceville
BKA : Bakoumba
Les prix des chèvres et des poules sont donnés à titre comparatif.

6. Mission de P. Chardonnet

P. Chardonnet a effectué une mission d'appui à la Lékédi du 28 octobre au 5 novembre (rapport en annexe 6).

Les décisions prises lors de cette mission ont été les suivantes :

- recentrage du travail sur le module 3 pour le recensement en forêt,
- limitation à 8 transects (au lieu de 10 initialement prévu),
- annulation de l'étude sur les potamochères,
- rédaction de l'article sur les potamochères pour présentation au symposium de Pretoria.

7. CONCLUSION ET PERSPECTIVES

Il est fondamental de valoriser la forêt tropicale sur pied afin d'éviter sa destruction. L'accord-cadre signé avec la SODEPAL met à la disposition de l'EMVT un laboratoire grandeur nature. Le parc de la Lékédi est un site unique au monde avec ses 14000 ha de mosaïque forêt-savane clôturés.

Un travail initial a permis de faire un état des lieux avec cartographie et recensement. Il faut maintenant valoriser ce travail.

De multiples recherches pourraient être entreprises. Les thèmes susceptibles d'être développés sont nombreux :

- l'écologie des mammifères de forêt, en particulier les céphalophes , le sitatunga et le potamochère pour lesquels peu de données existent,
- la production de viande de gibier, et en particulier l'élevage de potamochères,
- la biologie reproductrice du potamochère en captivité,
- l'élevage du buffle de forêt,
- les techniques de recensement de faune en forêt,
- introduction de l'hylochère, du bongo, voire de l'éléphant,
- etc., etc.

Le CIRAD-EMVT ne peut évidemment se lancer dans toutes ces recherches à la fois. Le souci de la SODEPAL est d'augmenter sa production de gibier.

Peu de travaux existent sur le potamochère. Seydack (1990) a fait une thèse sur l'écologie de ce suidé. Il a aussi publié sur la détermination de l'âge en fonction de la dentition. Ce sont parmi les seuls travaux importants entrepris sur cet animal.

Il semble que les résultats de reproduction de la SODEPAL n'aient jamais été décrits dans la littérature : 2 mises bas par an et reproduction de plusieurs femelles d'un même groupe (voir l'article en annexe 4). Le CIRAD pourrait développer un thème de recherche sur l'élevage de potamochère et en particulier sur sa biologie reproductrice.

ANNEXES

Annexe 1

Accord-cadre

ACCORD-CADRE DE PARTENARIAT ENTRE LE CIRAD-EMVT ET LA SODEPAL

Les partenaires ci-dessous désignés, désireux de collaborer et d'unir leur savoir-faire dans leurs domaines spécifiques de compétence, sont convenus des dispositions suivantes :

ARTICLE 1 : LES PARTENAIRES

- Le CIRAD-EMVT, Centre de coopération internationale en recherche agronomique pour le développement-département d'élevage et de médecine vétérinaire, EPIC français,
- La SODEPAL, Société d'exploitation du parc de la Lékédi, société anonyme dont le siège social est à Moanda au Gabon.

ARTICLE 2 : OBJET

Le présent accord-cadre vise à définir la nature et les modalités du partenariat établi entre le CIRAD-EMVT et la SODEPAL. Un avenant à l'accord-cadre établira les modalités d'application.

ARTICLE 3 : DUREE

Le présent accord-cadre entre en vigueur à la date de sa signature pour une période de deux ans. Il sera renouvelable chaque année pour une période d'un an.

ARTICLE 4 : ADMINISTRATION

Deux membres sont désignés par les partenaires, et représentant l'un le CIRAD-EMVT l'autre la SODEPAL, pour administrer le présent accord-cadre.

ARTICLE 5 : NATURE DU PARTENARIAT

Le partenariat concerne les actions conjointes du CIRAD-EMVT et de la SODEPAL avec la mise en commun des moyens et des compétences respectifs des partenaires dans le domaine exclusif de la faune sauvage et de ses habitats. Les objectifs poursuivis sont respectivement :

- pour le CIRAD-EMVT : l'acquisition de connaissances et la production technique et scientifique dans les domaines évoqués,
- pour la SODEPAL : le développement des activités d'élevage de faune et d'écotourisme.

ARTICLE 6 : RESPONSABILITES

- Du CIRAD-EMVT : le CIRAD-EMVT s'engage à :
  - rémunérer intégralement son personnel (salaire et couverture sociale, assurance voyage, etc.) durant son séjour à la SODEPAL,
  - apporter un maximum d'informations et de savoir-faire à la SODEPAL dans le domaine de la faune sauvage et de ses habitats,
  - respecter le règlement intérieur de l'entreprise.

- De la SODEPAL : la SODEPAL s'engage à fournir au personnel du CIRAD-EMVT durant son séjour à la SODEPAL :
  - un logement de fonction de type villa, au sein de la cité Cadres, meublé et équipé, avec électricité et eau gratuite,
  - un véhicule personnel de fonction de type 4x4, ainsi que la maintenance et le carburant,
  - un accès aux structures telles que économat et mess,
  - une mise à disposition des structures d'élevage du parc, de la logistique nécessaire, ainsi que du personnel de l'équipe faune selon les nécessités du travail.

ARTICLE 7 : RESILIATION

Cet accord-cadre peut être résilié d'accord parties après avis de l'un ou l'autre des partenaires par lettre recommandée avec AR au moins 30 jours avant effet.

ARTICLE 8 : LITIGES

En l'absence de règlement à l'amiable, le Tribunal de Commerce de Montpellier serait désigné aux fins d'arbitrage.

Fait en deux exemplaires originaux,

Pour le CIRAD-EMVT,	Pour la SODEPAL,
Monsieur Joseph Domenech Directeur du CIRAD-EMVT	Monsieur Directeur Général de la SODEPAL
Date :	Date :
« Lu et approuvé »	« Lu et approuvé »

AVENANT A L'ACCORD-CADRE DE PARTENARIAT ENTRE LE CIRAD-EMVT ET LA SODEPAL

Les partenaires ci-dessous désignés, souhaitant définir les modalités d'application de l'accord-cadre de partenariat, sont convenus des dispositions suivantes :

ARTICLE 1 : LES PARTENAIRES

- Le CIRAD-EMVT, Centre de coopération internationale en recherche agronomique pour le développement-département d'élevage et de médecine vétérinaire, EPIC français,
- La SODEPAL, Société d'exploitation du parc de la Lékédi, société anonyme dont le siège social est à Moanda au Gabon.

ARTICLE 2 : OBJET

Le présent avenant fait partie intégrante de l'accord-cadre de partenariat entre les deux partenaires. Il a pour but de définir les modalités d'application de cet accord-cadre.

ARTICLE 3 : DUREE

Le présent avenant entre en vigueur au 15 septembre 2000 et se termine le 31 décembre 2000. Il correspond à la phase de démarrage du partenariat à l'issue de laquelle les modalités seront précisées en fonction des premiers résultats obtenus et des attentes des deux partenaires.

ARTICLE 4 : ADMINISTRATION

Les deux membres désignés par les partenaires pour administrer le présent avenant sont Philippe Chardonnet pour le CIRAD-EMVT et le Directeur d'exploitation du parc de la Lékédi pour la SODEPAL.

ARTICLE 5 : NATURE DU PARTENARIAT

Pendant cette première phase de démarrage du partenariat :

- les activités porteront sur :
  - un inventaire de la faune dans l'ensemble du parc de la Lékédi : inventaire qualitatif des grands mammifère (depuis le chevrotain aquatique jusqu'au buffle) et un inventaire quantitatif, dans la mesure du possible, des espèces d'ongulés,
  - une étude descriptive, analytique et prospective des systèmes de production actuels et potentiels du potamochère sur le parc de la Lékédi, avec mise en perspective par rapport aux travaux et connaissances acquises par ailleurs sur cette espèce,
  - la mise au point d'un fonds de carte géoréférencé du parc de la Lékédi.
- les activités ne porteront pas sur :
  - la gestion des parcs de la Lékédi et des plateaux Batéké,
  - l'élevage des espèces exotiques,
  - l'élevage d'aulacode,
  - la pisciculture,
  - les primates en dehors de l'inventaire qualitatif,
  - l'écotourisme.

ARTICLE 6 : RESPONSABILITES

- Du CIRAD-EMVT : le CIRAD-EMVT s'engage à :
  - affecter son agent, Mlle Laurence LANNOY, en poste à la SODEPAL, en durée déterminée pendant la durée du présent accord particulier,
  - rémunérer intégralement son agent (salaire et couverture sociale, assurance voyage, etc.) durant son séjour à la SODEPAL,
  - transmettre à la SODEPAL tous les résultats des travaux qui seront menés par son agent dans le cadre de son affectation à la SODEPAL,
  - ne pas diffuser les résultats des dits travaux sans l'accord préalable exprès de la SODEPAL,
  - si besoin est, prendre en charge le salaire à durée déterminée, pendant la période du présent accord de partenariat, d'un pisteur local hors SODEPAL qui soit expérimenté dans l'approche des animaux sauvages, pour appuyer les travaux d'inventaire de faune sur le terrain,
  - respecter le règlement intérieur de l'entreprise.

- De la SODEPAL : la SODEPAL s'engage à fournir à l'agent du CIRAD-EMVT, Mlle Laurence LANNOY, durant son séjour à la SODEPAL :
  - un logement de fonction de type villa, au sein de la cité Cadres, meublé et équipé, avec électricité et eau gratuite,
  - un véhicule personnel de fonction de type 4x4, ainsi que la maintenance et le carburant, pour tous les déplacements, y compris un déplacement au parc national de la Lopé et les déplacements nécessaires à Franceville,
  - un accès aux structures telles que économat et mess,
  - toutes les données techniques existantes, y compris les cartes, sur le parc de la Lékédi et sur sa faune,
  - une mise à disposition des structures du parc, de la logistique nécessaire à l'exécution , ainsi que du personnel de l'équipe faune selon les nécessités du travail,
  - la mise à disposition de manière permanente d'au moins un agent affecté à l'agent CIRAD, après sélection de l'agent d'accord parties.

ARTICLE 7 : RESILIATION

Cet avenant peut être résilié d'accord parties après avis de l'un ou l'autre des partenaires par lettre recommandée avec AR au moins 30 jours avant effet.

ARTICLE 8 : LITIGES

En l'absence de règlement à l'amiable, le Tribunal de Commerce de Montpellier serait désigné aux fins d'arbitrage.

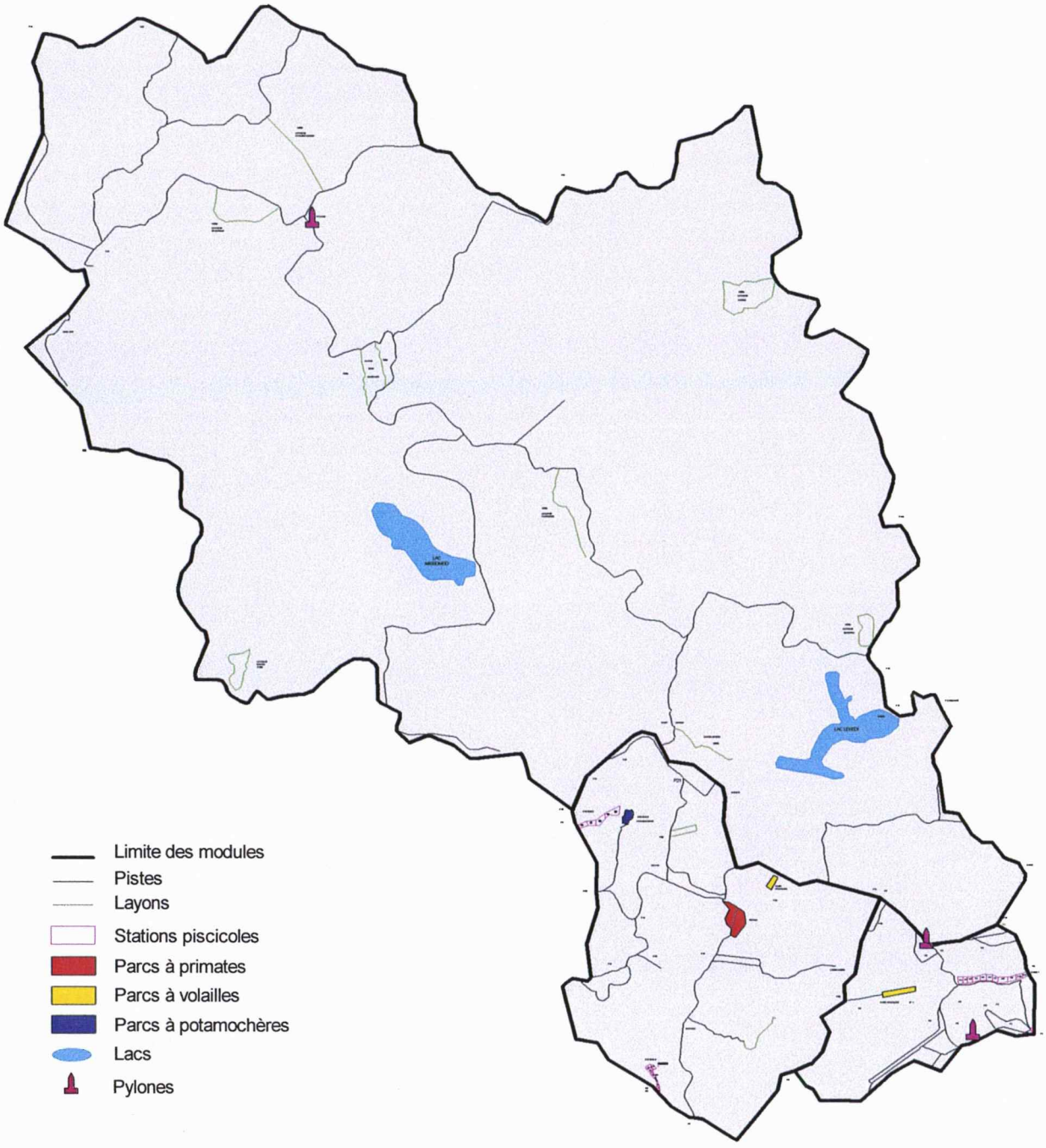
Fait en deux exemplaires originaux,

Pour le CIRAD-EMVT,	Pour la SODEPAL,
Monsieur DOMENECH Joseph Directeur du CIRAD-EMVT	Monsieur ABEKE Directeur Général de la SODEPAL
Date : « Lu et approuvé »	Date : « Lu et approuvé »

Annexe 2

Carte du ranch de la Lékédi

PARC DE LA LEKEDI



Annexe 3

Article en cours de rédaction

« Abundance of rain forest middle-sized mammals

in the Lékédi ranch (Gabon) »

Biomass of duikers in the Lékédi ranch (Gabon)

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Summary

This study was carried out in the Lékédi ranch, south-east Gabon. The aim is to determine the initial status of duikers to monitor the population. The vegetation in the area is characterised by a dense evergreen rain forest and forest-savanna mosaics. Abundance of duikers was estimated using line transect method with direct sightings. Densities and biomass were calculated using DISTANCE program. Densities are respectively 11.44 (CV=19.99) and 9.87 (CV=22.14) individuals per km² for blue and red duikers. Biomass are 46.9 kg/km² for blue duiker and 142.1 kg/km² for red duikers.

Key-words: biomass, duikers, rain forest, line transect, Lékédi, Gabon

Résumé

Introduction

Estimation of animal population size is notoriously difficult. Seber, 1992, provides a review of the general subject. There are few, if any, really satisfactory methods of assessing the abundance of wild animals, especially in rain forests (Koster & Hart, 1988). However the abundance estimates are necessary to the conservation and the monitoring of wildlife.
The use of distance sampling techniques to estimate animal population densities has become increasingly popular since the production of the computer package DISTANCE (Buckland *et al.*, 1993). Indirect estimation techniques are generally preferred for mammals in the tropical forests to direct observations (except for primates as for these latter many species are highly visible) because visibility is often poor and some species cannot be approached in safety.
It is the first study to estimate duikers abundance in the forest of the Lékédi ranch. The aim is to determine their initial status to monitor their population. The method of direct observations of animals was preferred. Indeed no study has been done yet in this ranch and there was no time to calculate the parameters of conversion of signs counts into densities in this area. Moreover as we will discuss in the chapter "monitoring", visual sightings are better than indirect methods to detect change in the populations (Plumptre, 2000).

Methods

Study area

The Lekedi park lies near the village of Bakoumba, in Lekoko Department, in the Province of Haut-Ogooué, in south-east of Gabon, between 1°39' and 1°49'S and 12°52' and 13°01'E.
This private park is ran by SODEPAL, (Société d'Exploitation du Parc de la Lékédi), under the cover of COMILOG, a mining company. It was created in 1992.
Located at an altitude of 600-700m, the area is characterised by a dense evergreen forest of *Aucoumea klaineana*, *Paraberlinia bifoliolata*, *Scyphocephalium ochocoa*, *Pycnanthus angolensis* and *Pentaclethra eetveldeana* trees and forest-savanna mosaics. Lékédi river and its numerous tributaries cross the zone.
Soils are characterised by a sandy-clayey to clayey texture, assuring a good hydrous outcome.
Mean annual rainfall is 2000-2400 mm.
The Lekedi ranch covers 14000 ha entirely enclosed with 86km of iron net (Cyclone type) of 1,9m high. It is divided in three modules of 650 ha, 1750 ha and 11600 ha for the third one.
The study took place in module 3, where no animals have been introduced.
Table 1 lists the indigenous middle-sized and large mammals present in the ranch (some game has also been imported from Namibia).

Census

Distance sampling theory (Buckland *et al.*, 1993) was applied.
Line transects and direct method with animal sightings were used to estimate duikers densities.
The module 3 was divided in seven geographical blocks. One transect was cut out in each of the seven blocks. The 7 transects were from 1.32 to 2.4 km long.
Surveys were conducted from the 20th of October 2000 until the 21st of December 2000. They were generally conducted between 7:00 and 11:30 or in the afternoon between 3:00 and 5:30. If rain fell continuously for more than 15 minutes the survey was abandoned, because the noise of water dripping on foliage and mammals' behavioural responses to rainfall might alter the probability of detecting them. Transects were covered in both directions. Intervals between successive counts on any one transect were at least three days, except when rain fell hard during several hours, then there could be only two days interval.
Survey was focused on duikers.
The perpendicular distance from the mid line of transect to the observed animal was measured with a rope marked every meter with knots.
When animals were clustered by two, only the perpendicular distance of the first individual detected was recorded.
The average speed of travel was 0.76 km/h.
There were two observers' teams of two persons led by a hunter. The two teams covered all the transects.

Density and biomass

Densities were estimated using the DISTANCE program (Laake *et al.*, 1993).
Encounter rates in rain forests are very low. Only blue and red duikers were regularly observed. Anderson *et al.*, 1979, indicate that at least 40 sightings are needed to conduct proper statistical analysis. The number of sightings for each group of duikers is lower.
Buckland *et al.*, 1993, indicate that in a multi-species study, it may be acceptable to estimate the detection function by pooling over similar species. The data of all duikers (56 sightings)

were pooled to estimate the detection function. Indeed blue and red duikers have similar size, habitat, feed... (Kingdon, 1997). The shape of the distribution of the perpendicular distances of detection of the two populations of blue and red duikers are similar and there is no significant differences between their medians (Test of Mann-Whitney: n=54; U=355; p=0,896). Two duikers were not precisely identified. Nevertheless they were used to fit the model of the detection function and calculate the global density for duikers as their distances of detection were within the range of the distances of the two other populations.
Duikers were often seen after being detected by alarm vocalisation or the sound of movement when they ran away. It was generally possible to determine the location from which they ran away, but not always possible to identify the species, so census data for duiker sightings and flushings (when location was identified) were amalgamated and an overall figure calculated.
Four models for the detection function were tested to fit data: Uniform-cosine, Uniform-simple polynomial, Half normal-hermite polynomial and Hazard rate-cosine. The Hazard rate function with cosine adjustments was selected because of its lower Akaike index and its χ^2 goodness of fit. The number of sightings is low, but there is a good fit between the model and the observations. Clusters were the unit of analysis. No truncation was made as we have few data and they are homogeneous.
The detection function calculated from the grouped data of all duikers give estimates of densities and cluster size for each group of duikers.
Since distances were considered not to have a normal distribution, statistic analysis were run with non parametric tests.

Biomass calculation

Fa & Purvis, 1997, calculated a mean adult body mass from the literature for several mammals. They give 4.9 kg for blue duiker and 17.3 kg as an average of *Cephalophus ogilbyi, C. callipygus, C. nigrifrons*, *C. leucogaster* and *C. dorsalis* (grouped as red duikers).
To calculate average « individual » weight in a population, age and sex ratio have to be considered (Coe, Cumming & Philipson, 1976). The ratio we used was one juvenile half the adult weight to two adults (White, 1994).
Average individual weights are shown in table 2.

Results

Effort

Transects were walked 5 to 10 times (see table 3), representing a total length of 88.7 km and 117 h 24 mn of observation.

Mean Encounter rates

The global mean encounter rates were calculated (table 4), as well as the mean encounter rates for each transect (table 5).
There is no significant difference (Kruskal-Wallis test) between the MER per transect, neither for blue duiker (H_6=4.84; n=7; p=0,56), nor for red duikers (H_6=9.82; n=7; p=0,13). They vary respectively from 0.10 to 0.48 and 0.07 to 0.51.

Density and biomass estimates

The effective strip width provided by DISTANCE analysis is 16.5m.
The mean cluster size of duikers are presented in table 6.
Densities were calculated (table 7). The component percentages of the variance of the densities are presented in table 8.
Biomass were calculated from individual densities estimates and average "individual" weight (table 9).

Discussion

Method validity and limitation

Most of the time, observers record both direct sightings (or sounds) and indirect signs. Most of the census of ungulates in tropical forest use the droppings count (Koster & Hart, 1988; White, 1994; Fimbel *et al*, 2000). Indirect counts require conversion factors to be calculated to convert the count of signs to animal density (Barnes and Jensen, 1987). These parameters vary by location, season and species and are difficult to obtain. Moreover the associated errors of these conversion factors increase the estimate of the standard errors of the density estimate (Plumptre, 2000). We had no time to calculate the parameters of conversion of signs counts into densities. We would have had to take them from the literature. But there could be under- or over-estimated and give wrong results.
Even after pooling the data, sightings were still lower than 60 to 80 recommended by Buckland *et al.*, 1993. But as distances of detection are very homogenous and the maximum value is low (21m), even with 56 sightings we could fit a good model.
Sample size in transect analysis is related to the intensity of observation (the product of effort and efficacity). Then Buckland *et al.*, 1993, recommend that at least ten transects are surveyed so that sample sizes are sufficiently large. There are only seven transects for the present study, but as the data were homogenous, it was enough to fit a model and to run analysis with DISTANCE program.
A great inconvenient of line transect method is the long time needed to cut out the transects. In average 20 man.day are needed to cut, clean and mark a 1.6 km long transect, including three hours transportation per day.
The study respects the four assumptions, essential for reliable estimation of density on a line transect (Anderson *et al.*, 1979):
-Objects directly on the line transect are always detected.
The observers were walking very slowly to avoid making noise and to be sure that all large mammals on the line transect could be detected. Moreover when too many branches or leaves had fallen on a transect, and consequently the walk could become noisy, this one was cleaned.
-Objects are detected at their initial location, prior to any movement in response to the observer.
As we already said, animals hidden in the vegetation were often detected by alarm vocalisation or the sound of movement when they ran away, but it was generally possible to determine the location from which they ran away.
-Distances were measured accurately (more or less 20cm).
-Sightings are independent events.
Same coloured duikers were sometimes seen at few distance and time intervals. Duikers are known to come back toward an object that frightened them if they could not identify it. To be sure the assumption was verified, when blue duikers had been observed at less than 200m from each other, only the data of the first sighting has been kept. We took 200m as the territory of *Cephalophus monticola* is comprised between 2.5 to 4 ha (Estes, 1995). The same

for red duikers when they were observed at less than 300m, even so their home range can be more extended. We consider that it could not be the same duiker if it was observed so far from the first seen.
Line transect analysis usually rely on stratification to improve precision of density estimates (Buckland *et al.,* 1993). The present analysis was carried out without distinction of any strata.

Reliability of density estimates

In the study, transects were quite short to be walked in 3 hours maximum to avoid reduction of observers' concentration at the end of the walk. The nature of the transect imposes some practical constraints: time and effort were spent avoiding obstacles such as roots, holes, slippery slopes... along the transect. These factors reducing observers' concentration will reduce the probability of animals being detected, and may also reduce the accuracy of subsequent measurements.
As the observers had to go out of the trail to measure the perpendicular distance, they were making some noise. An error could be introduced here as it could make animals run away and so be undetected or unrecorded because detected from out of the line transect and so modify the detection probability.
Coefficients of variation of mean encounter rates per transect for blue and red duikers are very high (from 25 to 100%) (table 5). This is explained by the low number of sightings on each transect.
The number of samples in this study was too low to allow comparison of densities between transects.
The two groups of duikers have similar global encounter rates. Despite the few data, the coefficients of variation of densities are good (less than 20%). So density estimates are precise.
The variance of density estimates depends mainly on the variability of the encounter rate, respectively 66.6% and 70.4% for blue and red duikers. Then it depends on the effects of probability of detection (respectively 25.9% and 21.1%) and at last of cluster size (respectively 7.5% and 8.5%). Indeed as distance of visibility is small, there is not a big variability, neither in the cluster size (range one to two), on the contrary observers did not encounter blue and red duikers on every survey.
When we run the analysis for *Cephalophus* spp., the global variance of density estimates depends still mainly on the variability of the encounter rate, but only for 57.2%. Then comes the effects of probability of detection (36.1%) and the cluster size (6.7%). Indeed as at least a duiker was generally encountered on each survey, the part of the encounter rate is lower. We could think that this variability of the encounter rates could be due to the heterogeneity of the transects. But there is no significant difference of the mean encounter rates of all duikers together between transects (Kruskal-Wallis test, $p=0.64$).
On the contrary the part of the probability of detection is higher because the distance of visibility of the two unidentified duikers is important (15m).

Comparisons with other areas

Data of density estimates for duikers are very different acording to the sites in Central Africa. The density of small duikers (blue and red), water chevrotain and bates'pigmy antelope all together in south-western Gabon, in the Province of Ogooué-Maritime, is 0.53 individuals per km² (Prins & Reitsma, 1989). In the Lopé reserve in central Gabon the individual densities are also very low with 0.3 to 1.5 and 2.5 to 5.5 respectively for blue and red duikers (White, 1994). White, 1994, suggests that low densities at Lopé may be due to competition

with elephants, which eat large quantities of fallen fruit (White, Tutin & Fernandez, 1993) that might otherwise be consumed by duikers.
There were much higher in Makokou, north-east Gabon, 20 years ago. Dubost, 1979, calculated densities of 62-78, 25 and 19/km², respectively for *C. monticola, C. callipygus* and *C. dorsalis.* But Okouyi (personal communication) did a study in 2000 where he had lower encounter rates than in Lékédi.
In Dzanga-Sangha region in Central African Republic, the densities vary from 10.7 to 20.4 individuals/km² respectively at 5 and 15 km from the hunters' village for *Cephalophus monticola*, and 0.9 to 1.2 / km² for *C. callipygus* (Noss, 1999).
In the reserve of Lobéké region of southeastern Cameroon, Fimbel *et al.,* 1999, found densities of 3.82 and 15.12 animals/km² , respectively for blue and red duikers.
Higher densities were recorded by Hart, 2000, in unhunted areas in the Ituri forest (Congo-Zaire). He found a range of 10.2 to 20.6 individuals /km² for *C. monticola,* 1.3 to 2.0 for *C. nigrifrons*, 5.3 to 6.9 for *C. leucogaster*, 0.6 to 11.2 for *C.weynsi*, 2.7-1.9 for *C. dorsalis.*
It seems that most of the surveys to estimate abundance of mammals in rain forest include the indirect observations (tracks, nets and droppings) (Koster & Hart, 1988; Prins & Reitsma, 1989; White, 1994; Fimbel et al, 1999). With a direct method conducted in a short time, we found quite high densities, similar to those from some areas of the region. These densities are higher than those found recently elsewhere in Gabon.
Even if the distance of visibility is low, the line transect method with direct observations give a minimum density in tropical rain forest with a good precision (low coefficient of variations). Encounter rates are low, animals are flushing, there are some bias in the observations (detection by alarm vocalisation or sound of movements when running away) and there may be error in the detection function (as observers go out of the trail for measuring). But these species live solitary or in pairs and are territorial with small home range. So data are homogeneous and even with few data, DISTANCE can fit a good model and give precise estimates. So this method is a good tool for monitoring.

Monitoring

Precise density estimates could be use as a reliable management tool. However, Plumptre, 2000, showed that differences of less than 10-30% change in the population are unlikely to be detected between two surveys where visual sightings of animals are made. When indirect methods of estimating the populations are used, it is unlikely that less than a 30-50% change in the population could be detected. These results are obtained on the assumption that two independent surveys are made and that the two density estimates obtained are tested for differences. The resolution can be improved in two ways if this assumption is not made (Plumptre, 2000):

- carrying out regular surveys and fitting a trendline to the data obtained (Buckland *et al.,* 1993)
- using the same transects for the second survey.

Sample sizes in surveys should reach at least 100 groups if the objective of the study is to monitor the population changes in the future (Plumptre, 2000). So the survey effort would have to be higher, even if our study shows that density estimates of duikers are precise even with few data because of the above quoted particularity of these species. For rare species, obtaining 100 sightings would be difficult. One option is to concentrate transects in areas where densities are known to be high and to monitor these areas.

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References

ANDERSON, D.R., LAAKE, J.L., CRAIN, B.R. & BURNHAM, K.P. (1979) Guidelines for line transect sampling of biological populations. *J. Wildl. Manage.*, **43**, 1, 70-78.
BARNES, R.F.W and JENSEN, K.L. (1987) How to count elephants in forests. *IUCN African Elephant and Rhino Specialist Group Technical Bulletin*, **1** : 1-6.
BUCKLAND S.T., ANDERSON D.R., BURNHAM K.P. and LAAKE J.L. (1993) *DISTANCE Sampling: estimating abundance of biological populations*. Chapman & Hall, London.
COE, M.J., CUMMING, D.M. & PHILIPSON, J. (1976) Biomass and production of large African herbivores in relation to rainfall and primary production. *Oecologia*, **22**, 341-354.
DUBOST, G. (1979) The size of African forest Artiodactyls as determined by the vegetation structure. *Afr.J. Ecol.*, **17**, 1-17.
ESTES, R.D. (1995) *The behavior guide to African mammals*. Russel Friedman Books cc.
FA J.E. and PURVIS A., 1997. Body size, diet and population density in Afrotropical forest mammals: a comparison with neotropical species. *Journal of Animal ecology*, 66, 98-112
FIMBEL C., CURRAN B. & USONGO L. (2000) Enhancing the sustainability of duiker hunting through community participation and controlled access in the Lobéké region of southeastern Cameroon. In: *Hunting for sustainability in tropical forests* (Eds. J.G. Robinson & E.L. Bennett). Columbia University Press, New-York.
HART J.A. (2000) Impact and sustainability of indigenous hunting in the Ituri forest, Congo-Zaire: a comparison of unhunted and hunted duiker populations. In: *Hunting for sustainability in tropical forests* (Eds. J.G. Robinson & E.L. Bennett). Columbia University Press, New-York.
KINGDON J. (1997) *The Kingdon field guide to African mammals*. Academic press, London.
KOSTER S.H. & HART J.A. (1988) Methods of estimating ungulate populations in tropical forests. *Afr. J. Ecol.*, **26**, 117-126.
LAAKE, J.L., BUCKLAND, S.T., ANDERSON, D.R. & BURNHAM, K.P. (1993) *DISTANCE user's guide*. Colorado Cooperative Fish and Wildlife Research Unit. Colorado State University, Fort Collins, U.S.A.
MARSH, C.W. and WILSON, W.L. (1981) *A survey of primates in peninsular Malaysian forests*. University Kebangsaan, Malaysia.
NOSS A.J. (1999) Censusing rainforest game species with communal net hunts. *Afr. J. Ecol.*, **37**, 1-11.
PLUMPTRE, A.J. (2000) Monitoring mammal populations with line transect techniques in African forests. *Journal of Applied Ecology*, **37**, 356-368.
PRINS H.H.T. and REITSMA J.M. (1989) Mammalian biomass in an African equatorial rain forest. *Journal of Animal Ecology*, **58**, 851-861.
SEBER G.A.F. (1992) A review of estimating animal abundance II. *International Statistical Review*, **60**, 2, 129-166.

WALSH P.D. and WHITE L.J.T. (1999) What it will take to monitor forest elephant populations. *Conservation Biology*, **13**, 5, 1194-1202.
WHITE L.J.T. (1994) Biomass of rain forest mammals in the Lopé Reserve, Gabon. *Journal of Animal Ecology*, **63**, 499-512.
WHITE, L.J.T., TUTIN, C.E.G. & FERNANDEZ, M. (1993) Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lopé Reserve, Gabon. *Afr. J. Ecol.*„ **31**, 181-199.

Tables

Table 1: List of the indigenous middle-sized and large mammals of the Lékédi ranch

Cephalophus monticola
C. dorsalis
C. ogilbyi
C. callipygus
C. leucogaster
C. nigrifrons
C. sylvicultor
Hyemocchus aquaticus
Tragelaphus sriptus
T. spekei
Syncerus caffer nanus
Potamochoerus porcus
Cercopithecus nictitans
C. cephus
C. pogonias
Colobus satanus
Lophocebus albigena
Gorilla g. gorilla
Pan t. troglodytes
Mandrillus sphinx
Smutsia gigantea
Phataginus tricuspis
Panthera pardus

Table 2: Average adult and individual weight of duikers

Species	Average adult weight (kg)	Average "individual" weight (kg)
Blue duiker	4.9	4.1
Red duikers*	17.3	14.4

*: ***Cephalophus ogilbyi, C.callipygus, C.nigrifrons, C. leucogaster, C. dorsalis***

Table 3: Number of surveys conducted on each transect

Number of transect	Length of transect (km)	Number of surveys
1	1.73	8
2	1.51	10
3	2.4	8
4	1.47	10
5	1.46	6
6	1.75	6
7	1.32	5
TOTAL	11.64	53

Table 4: Mean encounter rate of clusters

Species	MER	n	CV
C.monticola	0.3305	29	16.8
Red duikers	0.2815	25	18.3

MER: Mean Encounter Rate / km
n: Total number of sightings of clusters
CV: Percentage of coefficient of variation

Table 5: Mean encounter rate of clusters for each transect

	C.monticola			Red duikers		
Transect	MER	n	CV	MER	n	CV
1	0.29	4	37.9	0.51	7	25.5
2	0.33	5	45.5	0.20	3	50.0
3	0.36	7	25.0	0.21	4	76.2
4	0.48	7	31.2	0.07	1	100
5	0.23	2	60.9	0.46	4	30.4
6	0.10	1	100	0.38	4	50.0
7	0.45	3	66.7	0.30	2	60.0

Table 6: Mean cluster sizes of blue and red duikers

Species	Mean cluster size	n	CV
Blue duiker	1.21	29	6.34
Red duikers	1.16	25	6.45

Table 7: Group and individual densities/km² in Lékédi park for blue and red duikers and *Cephalophus* spp.

Species	Group	% CV	Individual	% CV
Blue duiker	9,87	19,23	11,44	19,99
Red duikers	8,51	21,18	9,87	22,14

Cephalophus spp.	19,06	16,36	22,46	16,94

Cephalophus spp. include the two undetermined duikers.

Table 8: Component percentages of the variance of density

Species	Blue duiker	Red duikers	*Cephalophus* spp.
Detection function	25.9	21.1	36.1
Encounter rates	66.6	70.4	57.2
Cluster size	7.5	8.5	6.7

Table 9: Estimated biomass (kg/km²) in Lékédi park for blue and red duikers

Species	Estimated biomass (kg/km²)
Blue duiker	46.9
Red duikers	142.1

Annexe 4

Article en cours de rédaction

« Bushpig and red river hog as potential production animals »

BUSHPIG AND RED RIVER HOG AS POTENTIAL PRODUCTION ANIMALS

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Summary

Wild suids from the gender *Potamochoerus* such as the bushpig (*Potomochoerus larvatus*) or the red river hog (*P.larvatus*) are widely distributed throughout most of sub-Saharan Africa and colonise all kinds of forested habitats from equatorial forest to dry shrubland.
Both species appear to be promising taxa for local meat production since they are widely used as a favourite game species in many countries in West Africa, Central Africa and Madagascar and contribute substantially to the domestic economies and diet of local people. Moreover, these wild suids are resistant to particularly decimating diseases for other conventional livestock in Africa such as African Swine Fever (ASF) and Trypanosomiasis. This fact is important since they could be exploited as a source of protein in areas of the African continent where this diseases are endemic or in forested areas where livestock grazing is not possible.
Wild suids from the gender *Potamochoerus* are not endangered and many southern African countries consider as pest animals. This fact could be beneficial in terms of legislation related to exploitation. Its high tolerance to hunting pressure and its ability to thrive in secondary forest make them a very suitable species to be exploited under ranching schemes.
So far, attempts to exploit red river hog under controlled conditions have been few. An initial experience for cropping red river hog in wildlife ranch in Gabon is presented and data are provided about its transport, management and reproduction. In Gabon, bushpig can breed twice a year, giving litters of 3 to 5 young/litter. The species shows good prospects for production in half intensive and intensive conditions. In natural conditions, the bushpig is monogamous and only dominant females are able to mate with the dominant male. Therefore, several difficulties need to be solved for optimising production of this species. Priorities for research in the field of reproduction, behaviour and design of facilities for herd capture and intensive rearing are suggested.

1. INTRODUCTION

1.1. Importance of Bushpig and Red River Hog

a. Meat consumption

- Meat consumption : B & RRH in the consumption surveys in Africa

Culturel
Coadaptation avec un milieu difficile

b. Crop damage

- Lahm, S
- Lagrange, M
-

b. Diseases

African swine fever

1.2. The bushmeat issue

- To produce meat at local level in environments not suitable for conventional animal husbandry : forest environments
- Bushmeat crisis task force: wild bushmeat currently non sustainable
- Sustainable use of B: several production systems proposed (consumptive uses)

2. SUITABILITY OF B & RRH FOR SUSTAINABLE USE

2.a. Positive criteria : assets

Anatomical

The bushpig, with 6 teats, has the largest number of teats in Suids.

Adult male/female mass ratio is 1,06 (SEYDACK,1990), so the reformed? female has a good financial value.

Biological:

Compared to the same sized ungulates, Suids show a higher reproductive potential: early sexual maturity, polyoestrous females, big size of litters, short pregnancy and lactation, and birth at the best season for young survival (MAUGET, 1991).
Bushpig has a lower reproductive potential than warthog. But as their thermal regulation is better than in warthog , they have a weaker young mortality.

For Red River Hog, the age of sexual maturity is between 16 to 20 months for males, and between 17 and 22 months for females; the pregnancy lasts 4 months; the average prenatal litter size is 3,2 (SEYDACK, 1990), the litter can reach up to 5 piglets (MAUGET, 1991); mean fecundity rates (number of live births per female per year) are comprised between 1,59 to 2,70, respectively in Southern Cape foothills and Eastern Cape of South Africa (SEYDACK, 1990); lactation lasts between 4 months (in free-ranging females) and 5,5 months in captive bushpig; the bushpig milk is more concentrated, especially as regards fat and protein, than for other suid species (SEYDACK, 1990).

Males exhibited no seasonality in sexual activity. According to SEYDACK, 1990, in South Africa there is a spring farrowing peak. The seasonal cycle of births apparently serves to correlate the nutritional and energetic requirements of mother and young during gestation and lactation with seasonal pulses of nutrient availability and energetic demands. So if the nutritional and energetic requirements are covered, we may suppose that births could occur all along the year.

Adaptation to endemic diseases

Bushpig is tolerant to trypanosomosis. (BIBLIO??)

Anderson and al., 1998, showed that bushpig can be experimentally infected with the African Swine Fever virus and develop a viremy, without showing any symptoms of the disease. Goutard, 1999, explains that after a short viremy, the virus stays in lymphoid organs (mainly the spleen), but is not excreted.

Reaction to Brucella suis type 1, existing in domestic pigs, has not been reported in african wild swines (FOWLER, 1996). THAL, 1971, in GUIDOT, 1975 did a serological survey in R.C.A, all the sera were negative.

Diet

Bushpig is omnivorous. Its food covers a wide range of items comprising roots, bulbs, seeds, fruits, ferns, grasses, small vertebrates, eggs and carrion.

Red River Hog is a monogamous species. KLEIMAN, 1977, in (SEYDACK, 1990) , discussed evidence suggesting that Type II monogamy is favoured whenever the carrying capacity of the habitat is not great enough to permit another female simultaneously to raise a litter in the same home range. So in captivity where supply of feed is enough several females in a group may reproduce.

SEYDACK, 1990, described two bushpig populations in two different regions. In Southern Cape, prenatal litter sizes tended to be smaller than those in Eastern Cape population, the percentage of reproductive females, of lactating females and of cases with two generations of young per group were lower in the Southern Cape. The likelyhood of breeding clearly increased with age in the Southern Cape, but this trend was only poorly developed in Eastern Cape females. Survival of both juveniles and adults appeared to be higher in the Southern Cape.

He suggests that the superior reproductive performance in bushpigs of the Eastern Cape, is primarily the result of higher protein availability, and possibly also phosphorus, in this environment.

Social behaviour

Red River Hog is a gregarious species.

The male assists in the rearing, and the boar/juvenile association functions to enhance offspring survivorship and in sharing the energetic burden with the female, thereby it allows the latter to maintain a higher breeding frequency. SEYDACK, 1990, suggests that the male protects juveniles against heat loss through huddling, particularly during periods of temporary absence of the sow.

The non-breeders may help the breeders in care and rearing of their current offspring, they increase the probability that the offspring will survive if one of the breeders dies (SEYDACK, 1990). The experience gained by the non-breeders in rearing young could improve their ability to become successful breeders in the future.

2.b. Constraints: problems to be solved

Anatomical

Males and females have fully functional canines serving as a weapon. They can seriously injured man and animals.

Biological

Potamochoerus porcus lives in all types of dense forest and shrubland, so observation is quite difficult in their natural environment even in an enclosure. It is very dependant of water (d'HUART, 1991).

Bushpigs show a high mortality rate in piglets. Mortality estimates for 1 and 2 year old bushpigs varied both between 41% and 45%, it is mainly due to starvation, inclement weather and predation (SEYDACK, 1990), but its nocturnal habits and very "close" habitat could explain a longer life expectancy for this species than for other african wild pigs (d'HUART, 1991).
Adult mortality rates varied between 19% and 27% (SEYDACK, 1990), mainly due to starvation and intraspecific strife.

Suids are very sensitive to stress. There are several kind of stresses:

- Climatic

Young are subject to thermal stress, and thermal homeostasis (nests, huddling, preferential day activity) are crucial to juvenile survival.

- Anaesthesia.

BOURGEAIS and al., 2000, had 50% of death after anaesthesia of four animals with Zoletil IM. 2 males of 80 and 90kg were anesthesié with 12mg/kg Zolétil, they awake in three hours with no problem. 2 females of 55 and 60kg were anesthesié with 9mg/kg Zolétil. One died 6 hours after, the other one 26 hours after, Dopram was used with no effect.

- Transport and capture

As shown below in table Wonga Wongue, a mortality of 2,9% was recorded after capture and transport of 238 Red River Hogs.

- Man

Sow and boar show aggression towards human observers during the initial stages post-partum, or when handling juveniles emitting distress squeals (SEYDACK, 1990).

- Social: introduction of a new animal

BOURGEAIS and al., 2000, reported that two females from a group were killed probably by the newly introduced dominant male.

- Nutritional: (BIBLIO??) quantitative and qualitative: carence in iron for the most of the young suids.
- Health: ORTLEPP,64, TRONCY et al., 72

The stress due to life in captivity of wild animals reduces the natural defences of the organism. The vaccinations, even so often necessary, could be a danger for bushpigs as they could reduce their own immunity (FOWLER, 1996).
Suids hosted many external parasites, but their pathogenicity is not well known.
They also hosted many internal parasites, such as:

Echinococcus sp.,
Trichinella spiralis, which can contaminate man
Oesophagostumum aethiopicum for which bushpig is the principal host,
Globocephalus urosubulatus hématophage, in the big intestine
Physocephalus sexalatus,
Gnathostoma hispidum,
Setaria congolensis, Setaria castroi

Bushpigs experimentally inoculated with viral souches (SAT2) of foot and mouth disease show clinical signs of the disease (HEDGER, CONDY and GOLDING, 1972, in GUIDOT, 1975).
Bovine plague is known to affect african suids. Several cases of clinically sick warthog have been observed (THAL, 1971, in GUIDOT, 1975).
Rabies cases have been described for warthog (CHAMBRON et DOUTRE, 1967, in GUIDOT, 1975).
African suids are sensitive to many arbovirosis. Antibodies against yellow fever and West Nile disease have been detected in bushpig.
It seems that african suids are sensitive to *Mycobacterium bovis* and *M. avium*, agent of tuberculosis.

Social behaviour

Monogamy is the mating system of bushpig. In the wild, there is no other adult females in the group (SEYDACK, 1991).
As only the dominant female reproduces, there is an important loss of reproductive potential and fertility in a population.
This feature also leads to high intensity fighting between females.

In captivity, it may be necessary to entretenir a higher number of males: one for each reproducing female, may be for 2 or 3 if several can reproduce in a group.

If the weather is cold or rainy, the preparation for parturition involves the building of a farrowing nest, to conserve neonate body heat during the first few days when they are believed to have difficulty in stabilising their body temperature on their own.
The sow-neonate unit is mostly alone during the farrowing nest phase, which lasts between one and three days.

The male rearing input in the bushpig appears to be crucial and females may terminate the current reproductive event whenever this input is no longer available. Pregnant females may abort or early lactating females desert their young in such an event (SEYDACK, 1990). Solitary rearing females were never observed. This means that the familial unit has to be maintained at least until the weaning. And paternal care may be reduced if the sow-neonates unit is isolated in a maternity more than few days.

The replacement of the reproductive couple in a group often leads to the loss of a reproduction season, it means a year.

Two litters per year have never been reported even when the feed was abundant (SEYDACK, 1990).

Cannibalism is frequent in bushpigs from the dominant male, but also from other females, especially the dominant (BIBLIO??) (suspicion BOURGEAIS and al., 2000?).

Bushpigs need a large territory, the usual population densities are less than 1 individual per km² (d'HUART, 1991). So animals density in an enclosure has to be low.

The habit of digging the soil looking for roots damaged quickly the enclosure, and it is quite difficult to maintain a park with a sufficient vegetation.
The frequent mud baths provoke an increase of the mud area. This attracts insects such as flies, mosquitoes... and so can lead to health problems.

3. SUSTAINABLE USE OF BUSHPIG AND RED RIVER HOG : CURRENT EXPERIMENTS

3.1. Production of Bushpig under extensive conditions

a. Hunting Bushpig in Madagascar

Bushpig is the biggest of mammals living in Madagascar and is present throughout its territory. Its origin is unclear: Some authors claim that it was introduced from the Africa continent by the first human settlers about 2000 years ago, while others maintain that bushpig is endemic in the island.
According to Garbutt(1999), two subspecies would prevail in the island: *P.larvatus larvatus* mainly in the West coast of Madagascar and Commores Island and *P.larvatus hova* with a rather reddish coat and smaller, being circumscribed to the western coast of the island. The description of those two subspecies seems to be linked with the popular description of two kinds of bushpig: One bigger and darker called "lambosui" and another one smaller and redder called "lamboala".
Genetic studies based on microstallites and mytochondrial DNA would be necessary to confirm the origin and taxonomy of the Malagasy bushpig and verify this taxonomic hypothesis.
Another hypothesis that needs to be confirmed by genetic studies is these wild suids species is the confirmation of hybridation possibility between domestic pig and species of the gender *Potamochoerus*. While both species have a different number pairs of chromosomes (34 for the pig and 38 for *Potamochoerus*) several cases of hybridation of the two species have been described in the African continent (Vercammen, et al., 1993) and Madagascar (Jori, F, 1999) and need to be verified by a genomic study.

In Madagascar, the bushpig plays an important nutritional and socio-economic role in the life of local populations. The species is widely hunted in most of the island. Every bushpig provides at least 55% of its body weight in meat (approximately 22kg for an averag individual of 40 kg).
Since the recent ASF outbreak in 1998, the commerce of bushpig meat has considerably increased and prices have practically doubled in the area of Mahajanga (North east). Animals are captured by means of traditional cage traps and transported alive to urban markets of where they are sold at prices between 20.000 and 60.000 FM. During the dry season of 1999, bushpig trapping represented between 150.000 and 300.000 FM par month, for rural hunters living in the outskirts of forested areas. Each hunter would have 10-12 traps and would capture between 5 and 10 bushpigs /month.

b. Cropping Red River Hog in Gabon

b. 1. Presentation of the Lékédi Park

Creation and activities

SODEPAL, (Société d'exploitation du parc de la Lékédi), the company running the park, was initiated in 1990 to maintain 110 employment after the closure of the cable car of COMILOG, a mining company, conveying the manganese from Moanda (the site of extraction of the ore) to Congo. A strategic site for COMILOG, until the construction of the gabonese railway.

Activities of the SODEPAL are as various as:
- Production (bushmeat, fish, mushrooms)
- Wildlife protection and management
- Research (Red River Hog breeding)
- Ecotourism, education and sensibilisation to environment

Localisation

The Lékédi park is located near the village of Bakoumba, in Lekoko Department, in the Province of Haut-Ogooué, in south-east of Gabon.

Located on the edge of the Chaillu massif at an altitude of 600-700m, the zone shows a morphology of plateau.
The dominant vegetation is a dense primary and secondary forest. Bush is present on the top of some hills.
Lékédi river and its numerous tributaries cross the zone.
Soils are characterised by a sandy-clayey to clayey texture, assuring a good hydric outcome.

The Lékédi park covers 14000 ha of forest and savanna entirely enclosed with 86km of iron net (Cyclone type) of 1,9m high. It is divided in three modules of 650 ha for the first, 1750 ha for the second and 11600 ha for the third.

b.2. Massive capture of Red River Hog

A capture took place in Wonga Wongue, the presidential park of Gabon, between the 10th and the 26th of November 1993 to increase the stock of bushpigs of the ranch of Lékédi. It was organised by Namibians. 5 bomas were built and animals were pushed inside by an helicopter.

Table: Numbers of captured and dead bushpigs in Wonga Wongue

Capture number	Captured bushpigs	Dead bushpigs
1	2	
2	0	
3	38	1 in cage 1 in truck
4	33	
5	0	
6	23	
7	40	
8	0	
9	0	
10	0	
11	76	1 in boma 1 in truck
12	11	
13	15	
		3 in enclosure
TOTAL	**238**	7

231 animals flew on 11 flights from Wonga Wongue to Bakoumba on a small cargo plane. They travelled in wood cages containing 7-8 animals. As we can see in the table below, 4 animals died during the first trip, the cages were dry. For the next trips, they contained some wet sand.

Table : Bushpigs numbers arrived in Lékédi park from Wonga Wongue in 1993

Flight number	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Males												
Adults	1	5	6	11	7	8		5	2	5	6	**56**
Juveniles	4	1	1			2		3	3	2	5	**21**
Dead	4										1	**5**
Females												
Adults	6	6	12	5	12	7	12	8	6	2	3	**79**
Juveniles	9	8	2	5	2	5	9	6	11	11	1	**69**
Dead											1	**1**
TOTAL dead	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**6**
TOTAL alive	**20**	**20**	**21**	**21**	**21**	**22**	**21**	**22**	**22**	**20**	**15**	**225**

The animals were transferred from the airport to the park (5km) by truck and relaxed directly from the cages into the park. About 80 were relaxed in module 1 and the reminder in module 2.

2.b The cropping system

Every night some wheat bran is placed in a hangar with a door which can be opened and closed with a pulley. There are 5 wood cages in the hangar. Every night bushpigs come to eat the wheat, and the door is let open. The day of capture it is closed, then the bushpigs take refuge in the wood cages, their sliding doors are closed manually by somebody above the cage. The next morning, animals are freed (usually the females), slaughtered (the males) or transferred (young and subadults). A small cage for transfer is placed in front of the door of the cages. This door is open so that animals enter the small cage, a sliding panel can isolate animal one by one. Transferred animals are driven to station C, and freed by opening the door of the cage at the entrance of a tunnel (10 meters long) in concrete with rectangular holes allowing to see and to push animals forward. So usually there is no contact with human and no anaesthesia. All the animals captured the same day are transferred in the same enclosure.
No deaths during capture have been reported. Except when anaesthesia with Zoletil IM was used (see chapter 2.b).

Figure 1: Trap scheme for capturing bushpigs in the hangar

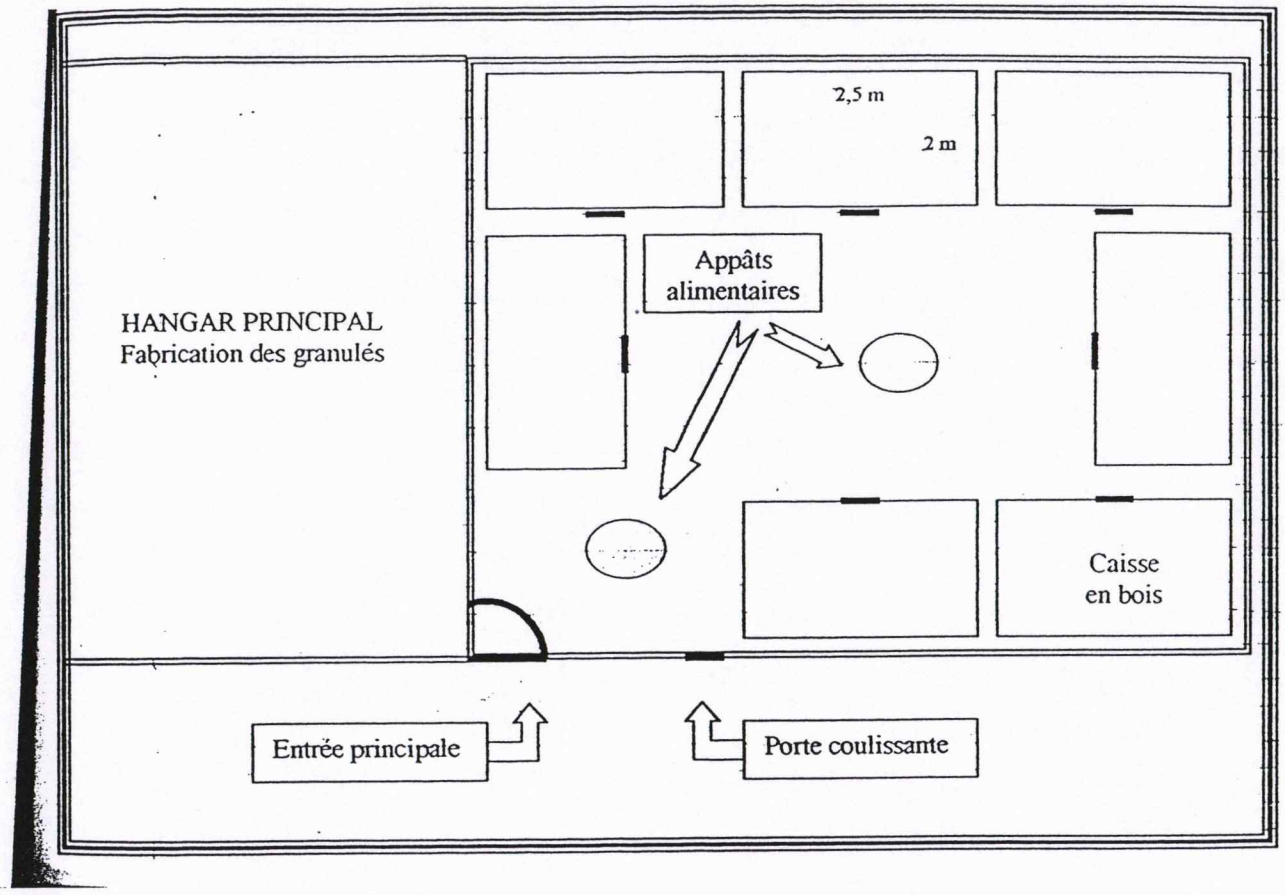

Table : Outcome of captures in the hangar:

Date	AM	AF	SAM	SAF	YM	YF	Total
01/06/97		2			1	2	5
14/07/97	1	2		1	1	3	8
17/09/97	1			1			2
21/01/00	2	3					
31/10/00	1	1		1		3	
17/11/00	1	1				1	

A: Adult
SA: Sub-adult
Y: young
M: male
F: female

As extensive exploitation is selective, the females number will proportionally increase, so production for the same area (:for the same feed quantity) will increase.

3.2. Production of Red River Hog under intensive conditions

Bushpigs are kept in two sites in enclosures with iron netting with square mesh (height 1,90m, banded at 600kg) and built on a 50cm under ground concrete base as bushpigs dig deeply). A second galvanised iron netting with smaller mesh reinforce the first one at the base on 1,50m to avoid the passage of young from an enclosure to another.
In both sites, they are fed with about 3-5 kg of wheat son and about 0,4 kg drêche per animal per day, with some fish about every two days (the waste of fishing and females fish issued from manual sexing), sometimes they also eat the wastes of the Sodepal restaurant (fruits, bread...). 6-10 kg of wheat son are given if there is no fish and no dreche.
Piperazine is given in the feed every 3 months against worms. When there is a birth, the animals of the enclosure are treated twice 3 weeks and 6 weeks after birth.

Half-intensive conditions:

Station C is installed on a edge of a gallery forest in module 2, on a slightly sloped land. The station extends from the edge of savanna down to the river and swamp. This site is supposed to be close to the habitat of bushpigs, but some enclosures contains no water or no dense shrubs.
It was built in January 97 and is divided in 5 enclosures E1 to E5 each one communicating with the following one.

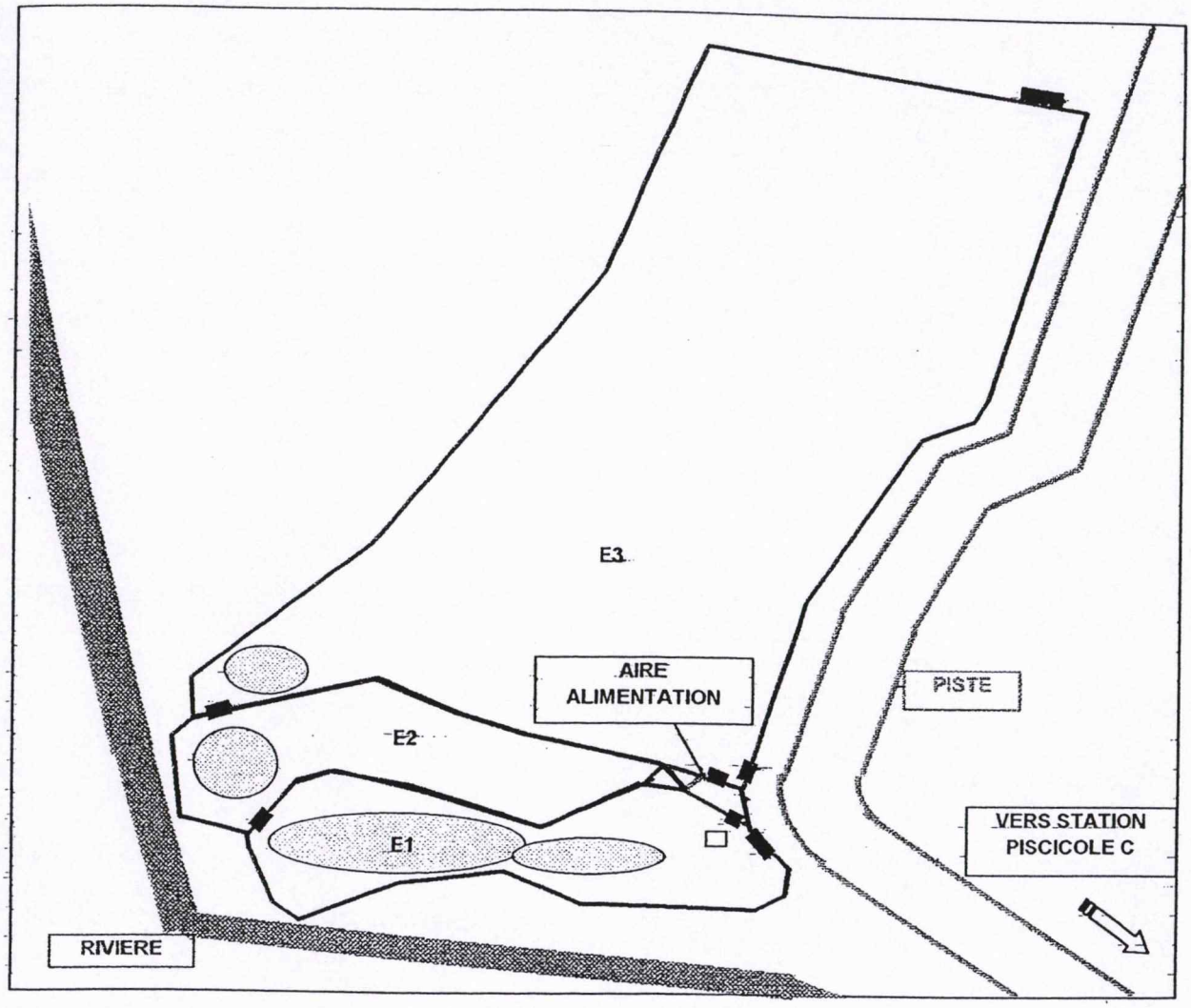

Figure 2: Bushpig enclosures (station C) in Lekédi park

Animals from station C were trapped directly in the enclosures through a funnel or a gate, or in the hangar and transferred.

Suids are very sensitive to stress. So animals are captured as "softly" as possible.
In station C an funnel was installed through the fence of E3 between the exterior of the station and a paddock, and two gates in E1-2 and E5. The animals were attracted inside with wheat bran every day until the capture (around 2,5 months). This is stressless as the trap is placed in the natural habitat of bushpigs, there is no direct contact with man and animals can hide in the vegetation and take time to get used to their new place. So captured animals do not feel directly aggressed.

Group n°1- Enclosure 1 and 2 (swampy land, few shrubs and trees, around 0,2ha)

The animals were captured in march 1997 through a small sized funnel .
3 young females and 8 young males around a year old, 2 females and 1 male nearly adults were trapped. In 1998, this group was tamed, after 3 months, animals were calm and easy to approach.
First births took place in September 1998, the 4 neonates survived only few days. According to BOURGEAIS and al., 2000, deaths are probably due to a very flooded land.
A second capture took place in April 1999 in order to introduce an adult male. 2 adult females and 1 male were captured and kept 2 weeks in the enclosure 1 (the trap between enclosures 1 and 2 was closed). After this time, the three animals were introduced in group n°1.
2 adult females were killed, probably by the new male BOURGEAIS and al., 2000. This latter older than the males of the group immediately became dominant.
Both the new females were separated in another enclosure to deliver, all the new born died after 2 or 3 days, probably because of a flooded land, (very heavy rain with 930mm in two months), (BOURGEAIS and al., 2000).
Two domesticated primipare females delivered the same day, respectively 4 and 5 new born. One of each litter died after few days, on day 21 two other were found dead, and 5 disappeared (hypothesis: death due to cold, flooded land).

Group n°2 – Enclosure 5 (1,4 ha. 50% savanna - 50% gallery forest with dense cover. No permanent swampy zone, the artificial water pond has to be regularly filled in dry season)

Animals were captured through a larger gate allowing to capture adults. No death due to the capture were reported .

Table: Reproduction of red river hog in Lékédi park

Group n°1 (Young) **Date of capture:** March 1997 (funnel) 1YM, 2YF, 3sm, 8sf **First delivery:** 02/01/99 with 4MA and 9FA mean age: 3-4 years old. **Births:** 02/01/99: 4 babies – survival: 0 02/07/99: 1 babies – survival: 0 12/09/99: 2 babies – survival: 0 12/12/99: 4 babies – survival: 0 13/12/99: 5 babies – survival: 0 **Synthesis of results:** In 12 months, 5 delivery with four females; a female delivered twice .	**Group n°2** (Adults) **Date of capture:** June 1998 (gate) 1MA, 7FA, 4YF, 1YM **First delivery:** 18/11/98 **Births:** 18/11/98: 15 babies – survival: 8 (2 deliveries) 15/12/98: 12 babies – survival: 0 06/04/99: 1 babies – survival: 1 01/06/99: 3 babies – survival: 0 18/06/99: 3 babies – survival: 0 22/06/99: 3 babies – survival: 0 13/07/99: 1 babies – survival: 1 15/08/99: 4 babies – survival: 0 09/11/99: 8 babies – survival: 0 16/12/99: 6 babies – survival: 1 10/01/00: 2 babies – survival: 0 6/12/00: 9/12/00: **Synthesis of results:** In 14 months, 13-14 deliveries with 7 adult females; two deliveries per female for an adult group. Mortality of young between D4 and D10, cannibalism (by the dominant female?) The 01/03/00 weaning of the litter of the 18/11/98 It seems that only the dominant females keep their young
Group n°3 (Adults) **Date of capture:** 22/04/99 (gate) 1MA, 2 FA 2 F introduced in group 1, 20 days after capture **First delivery:** 05/11/99 **Births:** 05/11/99: 3 babies – survival: 0	
Total of deliveries: 20 delivery with 77 babies, an average of 3-4 babies per litter. 11% of survival. **mounte period:** July to September, February and March **Delivery period:** June, July, November to January	**Total of capture:** 30 individuals 100% of survival for capture with funnel or gate 50% of survival when Zoletil is used **Total number on the 30th of November in E1 & E2:** 2 Adult males 5 Adult females 2 Young males 2 Young females **Total: 11 animals** **Total number on the 30th of November in E5:** 2 Adult males (1 dominant) 7 Adult females 1 Young males 3 Young females **Total: 13 animals**

Nests were built by man in the forest of enclosure 5 in straw or with a skip forming a shed. They were never used.
Females do not build nests except in enclosure 5 in the savanna part, probably because they do not find the material to build it and a dry place far away from other animals. As the feeding place is also in the savanna, females are disturbed and leave the nest the very day of birth.

Intensive conditions:

Station A is in a large savanna in module 1. This station was built on an old poultry park, so there is no shrubs or trees as the bushpigs like. But the advantage is that the eventual observations are easy.
Two enclosures (280m²) and an awake room (200m²), used also for the transfert of animals were built in November 1999. There is also a small place to stock feed (wheat son).

The 12th of January 2000, 6 bushpigs were transferred from group n°1 station C to station A, 1 male and two females in each enclosure.
The 7th of March 2000, a female gave birth to 4 piglets. 3 of them were found dead 33 days latter.

An old manganese skip opened on one side with some herbs in it has been set up to serve as a nest. There has been no birth since.

A slight loss of weight of the males were noted during after the transfer in this open savanna, they probably suffered from heat and a less wet environment (BOURGEAIS and al., 2000). They have now a good body condition.

4. PROSPECTS FOR EFFICIENT PRODUCTION SYSTEMS

1.1. Technical improvements: production systems

A. Half intensive and intensive productions

Some improvements are proposed to alleviate constraints, increase the productivity and allow researches.

Infrastructure:
- Build new enclosures near the entrance or the pools for:

-habituation to man, to his voice, in order to decrease the stress after the first weeks of habituation
-decrease fuel costs and time of manpower
If located near the pools, lisier can enrich the water improving productivity and directly feed fish. On the other hand fish is an excellent protein source for bushpigs.
It is necessary that enclosures contain dry space.
It is possible to build Caillebotis in the enclosure so that animals can have a permanent dry place whenever they want to.
It would be interesting to make some trials to see if muddy places are necessary to bushpigs or if they can have good performances in a completely dry enclosure.
If not, it may be interesting to replace muddy places with a concrete pool filled with wet sand. Mud sticks to the skin and animals are always wet, especially the young. Sand will not stick to the skin and animals will dry quicker.
It should be a shed in the enclosures to protect animals from sun, wind and rain.
- Cover all feeding areas with concrete and protect them from rain so that the feed will be clean and the losses decreased.
- Separate feeding areas for young, it will allow to give them a diet appropriated to their needs.
- Build enclosures for quarantine for sick animals, for the fattening animals and for new captures.
- Separate all enclosures in two so that one part can be transformed in maternity when needed (it will avoid cannibalism from males or other females).

Alimentation:
Alimentary need for bushpigs are not well known. Nevertheless the diet seems to be correct regards to the body conditions of animals, but there are many wastes.
The problem is that diet is variable. To keep a constant diet, it is proposed to collect regularly fruits in the park and to produce achatines (a kind of snail), these snails are appreciated by bushpigs and very easy to produce.

A study need to be conducted to determine the best diets for each category of animals at the lowest prices, the best rhythm of distribution…

Reproduction:

- Reform females when their reproductive performances start to decrease and the male about every 5 years.
- Capture young males (6 months old maximum) in the nature and introduce them in the herds, in order to have new blood when they will reproduce and avoid consanguinity problems.
- Appropriated vegetation to build nests is needed in the enclosures (herbs, branches) of half-intensive conditions.
- Wean the young after 3 months, keep some females for renewing of the herd, put the other females and the males in the fattening enclosures.

Production:

- Slaughter all the fattening individuals during their second year.

Researches:

Frequent manipulations of animals, especially the young, will get the animals used to human and allow a better follow

It is necessary to mark animals at birth or when caught and set up a follow of reproduction, of GMQ…

Researches should be conducted to:

- study criteria of heat detection to adapt diet at this period,
- have the scientific confirmation of two delivery per year,
- determine the maximum number of females able to reproduce with one dominant male in the group,
- determine the best time for the stay in maternity (first days up to weaning),
- study paternal care in captivity,
- determine the causes of young mortality.

B. EXTENSIVE

Traps should be installed on the external fence of the park to catch animals from outside (Pas de loups, funnel).

Removable iron traps (with sliding panels) could be placed in modules 2 and 3:

- in a place where one comes regularly, to let some feed once a week
- around salty stones

Its size should be big enough to put the bushpigs in confidence to enter and to allow the entrance of a whole group. It should be at least 5m*5m and 2,5m high.

The transfer cages for animal caught in the hangar should have a grid at one extremity so that bushpigs can see the light and go inside more easily.

Animals captured in the hangar and the iron traps should be marked. It will allow a follow, and see how many different females come to feed, see if heats come quicker when young are confiscated…

A census of bushpigs should be made to evaluate the maximum possible taking (prelevement).

1.2. Other improvements

1.2.a. Economical aspects

Demand:

BIBLIO??

Red river hog is red meat and is eaten by some muslims.

17,2 kg bushmeat/year/inhabitant 4P8

Market price:

	LBV Oloumi	FCV	BKA-Brousse	
Thryonomys swinderianus marsh cane-rat	9000	6000	M: 6000 F: 4000	
Atherurus africanus	7000	8000	5000	
Cercopithecus cephus	M:7000 F:8-10000	6500	M: 8-9000 F:7000	
Cercopithecus nictitans		9000	M: 12000 F:9000	
Cephalophus monticola	7000	7000	5000	
Cephalophus dorsalis				
Entire	15-18000	15000		
Leg	7000	3000		
Cephalophus rouge				
Entire			14-15000	
Leg				
Quarter of the animal			3500	
Cephalophus silvicultor		25000		
Smutsia gigantea		50000	40000	
Potamochoerus porcus				
Entire		50000	50000	
Leg	Av.: 12000 Arr.: 16000	8000 10000	10000	
Breast	7500			
Chop	6000	7000	5000	
Quarter			15000	
Head		7000		
Intestine		3000		
Sitatunga		60000		
Buffalo (kg)			4000-4500	
Goat		30-50000	20000-50000	
Chicken		M: 2500 F: 3000	M: 2000 F: 2500	

Commercialisation by SODEPAL:

Table: Sales of Red River Hog by SODEPAL

Year	Quantity (kg)	Price/kg (Fcfa)
1997	184	3500
1998	133	5000
1999	27	5000
2000	416	5500

The sold quantity for the year 1999 is higher than the one indicated in table. Data of sold meat are missing.
At the present time the offer of SODEPAL is very small. They slaughter animals (males) only when they do a capture to have some young to increase their livestock.
They do not regularly capture animals for slaughtering because they do not have a census of the bushpig population.
The clients are supermarkets and restaurants of SODEPAL and of COMILOG in Moanda and some private people in Bakoumba and Moanda.

1.2.b. Legal aspects

A main law referring to regulation of hunting and protection of wild animals and several decrees dating of 1987 to 1994 exist. But a huge gap between written law and reality does exist.
For instance, nobody can have or sale hunted products, if he does not have a licence for capture or a special agreement delivered by administration of Water and Forests and of Trade (article 3, decree 667/PR/MEFE).
The law define game as "an animal without an individual owner living at the wild state and that one appropriates by hunting it". A wild animal does not have an owner, it is "*res nullus*" and then the government is the owner.
But animals originated from a husbandry are a private property and are generally not sold after hunting. Then the word "game" should not be used for animals of husbandry. The expression "game husbandry" should be abandoned and replaced by "fauna husbandry".
A "licence for wild animals capture" is required by the law, it allows capture, detention and commercialisation of alive wild animals. It is delivered to the national people by the DFC (??) (Decree 188/PR/MRFCR, Articles 5, 16, 17 and 18) after a long administrative procedure. By giving this licence administration could do a census of the existing breeders. This licence could be necessary for breeders wishing to get wild genitors to constitute their livestock, but not for animals born from the husbandry.
This procedure should be administratively easy in order not to discourage potential candidates.
Nowadays it does not exist a legislation adapted to game husbandry. Wild animals breeders cannot do their activities within a legislative and regulation frame defining their rights and their duties, they do not own the animals they breed.
Commercialisation of all kind of wild animals products is forbidden during hunt closure periods (Decree 190/PR/MEFCR, article 11). This decree could avoid commercialisation of products issued from husbandry, even so these animals are not wild anymore.
Nowadays hunting of big animals and of integrally protected animals is totally forbidden in Gabon, but it does exist. Hunting of ordinary and partially protected animals is tolerated.

1.2.c. Extension and training

The main difficulty for extension of animal breeding in Gabon is the lack of husbandry habits. People from Gabon are hunters and pickers.
In big cities the typical profile of candidates to animal production projects are executives or high-ranking civil servants who will "finance" the project. They will not involve themselves in the installation works and the exploitation running. They employ somebody to do this job. The workers are rarely as motivated as the owner. So the rearing is not as efficient as expected. Causes are various: low salaries, bad conditions of habitation, lack of material... Hasty departure are frequent and an exploitation with no care, even during few days, registers unavoidable losses.
HOUBEN, 1999, reported that abandon rate in cane-rat breeding installed with the help of VSF is 24%. Causes are motivation decrease, removal and death.
Reasons for which these kind of people want to start such an "affair" are not always the best for success: prestige, politic, insurance for retirement, love of animals... Self-consumption and profitability are not the main objectives. That is the reason why the necessary daily rigour in the husbandry management is missing. Lack of experience and tradition in husbandry is a serious handicap.
Moreover the cost of installation is often too high. It can be decreased if the breeder builds himself the enclosures and if local material is used.
As agriculture is not well developed, there are not many by-products available for husbandry. The only industrial feed available is imported and distributed in the country, so very expensive as transportation costs have be added. Even if bushpigs are omnivorous, regularity of diet, protein contribution and quantity of feed could be a problem.

Annexe 5

Recommandations de l'atelier

« gestion de la faune

dans les exploitations forestières »

Atelier "Gestion de la faune dans les exploitations forestières" La Lopé - Nov. 2000

Les 10 Commandements :

- Créer entre les bailleurs de fonds, les administrations, les exploitants forestiers et la communauté de la conservation, un véritable partenariat avec des droits et devoirs connus et acceptés par tous.

  - Ne plus opérer en isolation les uns des autres (ONGs, exploitants, administrations) dans le domaine de la gestion de la faune dans les concessions forestières.
  - L'appui des bailleurs de fonds ne doit plus être conditionné par le « politiquement correct » mais par l'aspect technique et les réalités du terrain.
  - Pérenniser un cadre de discussion inter-sectoriel s'appuyant sur les initiatives existantes au niveau national et régional (ADIE, CEFDHAC, OAB, IFIA)
  - Coordonner et appuyer les actions entre les différents partenaires: forestiers, administrations et société civile

Incorporer la problématique "gestion de la faune" dans la conception et la mise en oeuvre des plans d'aménagement.

  - Inclure dans le plan d'aménagement, avec un cahier des charges adapte, un volet gestion durable de la faune
  - Mettre en place un système standard de suivi écologique et socio-économique de la faune et de son utilisation
  - Définir des zones écologiquement sensibles ou importantes (séries de « protection » ou de « production sensible »)
  - Ne pas implanter des infrastructures permanentes près de sites écologiquement sensibles ou importants

Restreindre les accès à la concession

  - Fermer les routes secondaires après exploitation sauf cas exceptionnels (désenclavement et surveillance des massifs)
  - Installer un nombre suffisant de barrières de contrôle
  - Limiter l'accès des routes forestières aux seuls véhicules d'entreprise ou à ceux autorisés par l'entreprise
  - Faciliter le contrôle par les autorités compétentes des voies d'intérêt général (voies publiques, voies fluviales)

Interdire toute chasse commerciale ou utilisant des techniques non sélectives sur la concession forestière.

  - Il faut interdire les méthodes de chasse non sélectives (pièges à câbles, chasse de nuit) et la chasse commerciale sur les concessions forestières
  - Contrôler les armes sur les concessions : enregistrer les armes légales, confisquer et détruire les armes illégales
  - Interdiction d'utiliser les facilités de l'entreprise pour fabriquer des armes de chasse
  - Interdiction d'amener des armes sur les lieux de travail quotidien

Gérer l'immigration vers la concession forestière liée a l'emplacement des bases-vie, campements permanents et sites industriels.

  - Planifier les nouvelles implantations des infrastructures d'exploitation et de transformation:
    - Exploitation : au voisinage ou, éventuellement, dans la concession?
    - Transformation : dans les centres urbains secondaires périphériques à la concession ou les centres urbains majeurs?
  - Eviter la multiplication du nombre de campements forestiers au sein de la concession forestière
  - Favoriser le recrutement de main d'œuvre locale sur le site de la concession

Promouvoir la connaissance et le respect des lois en vigueur dans et hors de la concession forestière à travers une collaboration étroite entre tous les acteurs.

  - Ne plus accepter de laxisme dans l'application des lois
  - Appliquer les législations existantes sur les techniques et périodes autorisées, espèces partiellement protégées)
  - Pas de chasse des espèces intégralement protégées
  - Pas d'attribution de concessions forestières dans des aires protégées
  - Mettre en œuvre et assurer le respect des grandes conventions internationales (Convention d'Alger, CITES, Convention sur la Diversité Biologique, etc.)
  - Diffuser les textes législatifs en vigueur sur la gestion de la faune auprès des exploitants et des populations

Mettre en place dans la concession une réglementation stricte et des dispositifs de contrôle efficaces.

- Définir dans le règlement intérieur les modalités de l'installation de personnes sans relation directe avec les activités de l'entreprise sur les concessions.
- Définir avec le ou les syndicats forestiers des standards de gestion de la faune à inclure dans les règlements intérieurs des entreprises forestières (modalités, sanctions, mesures incitatives)
- Interdiction de transporter des chasseurs, du gibier et armes dans les véhicules de la société (et de ses fournisseurs de service) sauf existence d'un plan de gestion de la chasse agréé par les différents acteurs
- Les exploitants et les employés doivent informer les autorités compétentes des activités de chasse commerciale, braconnage et trafic de produits animaux illégaux (ivoire, peaux, etc.) dans la concession.
- Contrôler systématiquement au sein, à l'entrée et à la sortie des concessions des activités de chasse (mettre en place une cellule de suivi de gestion de la faune)
- Mettre en place des brigades d'écogardes issus ou mandatés par l'administration

Mettre en oeuvre des programmes de sensibilisation / éducation sur le problème de la sur-exploitation de la faune.

- Sensibilisation des populations en adaptant le discours aux divers groupes cibles: jeunes, femmes, entreprises forestières, employés, consommateurs,etc.
- Diffusion dans les écoles de documents pédagogiques sur la faune (chasse, mesures répressives, alternatives a la chasse, connaissance de l'importance de la faune autrement que ressource)
- Etablir et diffuser un recueil de bonnes pratiques de gestion de la faune dans les concessions forestières
- Utiliser les media (publicité régulière à la radio, télévision et dans les journaux) pour sensibiliser l'ensemble de la filière: du chasseur au consommateur

Promouvoir l'utilisation de sources alternatives de protéines pour les besoins des populations.

- L'entreprise forestière doit prévoir une formule interne ou externe de ravitaillement de son personnel et des familles et s'assurer de son bon fonctionnement.
- Mettre en place dans les concessions des économats avec des protéines alternatives à prix coûtant soit par importation soit par production semi-industrielle locale.
- Mise en place d'un suivi sanitaire pour l'élevage et les importations de viande ou poisson
- Soutien aux initiatives locales de création d'élevages d'animaux domestiques (poulets, moutons, chèvres, pisciculture)
- Ces diverses initiatives ne doivent pas se faire au détriment de la foret

Annexe 6 : Références citées

PRINS H.H.T. and REITSMA J.M., 1989. Mammalian biomass in an African equatorial rain forest. *Journal of Animal Ecology*, **58**, 851-861.

RAPONDA-WALKER, A. et SILLANS, R., 1995. Rites et croyances des peuples du Gabon. Coll. Présence africaine, Dakar . 377pp.

SEYDACK, A.H.W., 1990. Ecology of the Bushpig *Potamochoerus porcus* Linn. 1758 in the Cape Province, South Africa. Thesis of Doctor of Philosophy (Forestry), Univ. Of Stellenbosch, South Africa.

WHITE L.J.T., 1994. Biomass of rain forest mammals in the Lopé Reserve, Gabon. *Journal of Animal Ecology*, **63**, 499-512.