PROJECTO
CARNIVOROS
DO NIASSA

The status of lions and their threats in Niassa National Reserve, Mozambique

Technical report

2007-2011

In collaboration with :

Reserva Nacional do NIASSA Moçambique

S.R.N.

The status of lions and their threats in Niassa Reserve, Mozambique

This technical report provides analyses of the research data collected on the status of lions and their threats in Niassa National Reserve, Mozambique by the Niassa Carnivore Project between 2007 and 2011. Full details of NCP conservation activities are provided in annual reports (Appendix A for full list of outputs).

The project is administered by The Ratel Trust, South Africa. The Niassa Carnivore Project activities in NNR are governed by an MOU with Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo (SGDRN) and the project is supported by the Ministry of Tourism, Maputo.

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EXECUTIVE SUMMARY

NCP has been working in Niassa National Reserve (NNR) since 2003 with a focus on carnivore conservation. Our mission is to secure lions and other large carnivores in NNR by promoting coexistence between carnivores and people and directly mitigating human induced threats. We work in close collaboration with the Mozambican management authority (SRN) and local communities. We have a small team of seven local men and are based in a simple camp in concession L5-South, which is our intensive study area. This report is a technical report that provides analysis of the scientific data collected by NCP between 2007 and 2011. Research is only one aspect of NCP's activities, which also include education and outreach (storybook, posters, conservation fun days), mentoring and training and implementation of mitigation measures (living fences, goat corrals etc.).

Large carnivores are among the most difficult species to conserve and the need for practical, locally derived grass roots solutions has never been higher as carnivores continue to decline across the world. Lions are now classified by the IUCN as vulnerable with a declining population trend and experts estimate the population size as **less than 40 000** with an estimated range of 23 000 to 39 000. Only six lion conservation areas in Africa currently support more than 1000 lions, these are the strongholds for lion conservation and Niassa Reserve is one of them. The large carnivores act as valuable indicators of the status of Niassa Reserve as a whole. Their position at the top of the food chain, large range and prey requirements, relatively low population densities and sensitivity to human- wildlife conflict make them a barometer or indicator of the "health" of the Niassa. In addition, a decline in lions and leopards will result in a loss of revenues for conservation management and a lost opportunity for Niassa Reserve to be an international tourism destination. However the costs to communities of living with carnivores can be considerable through the loss of life and livestock due to carnivore attacks.

NNR currently supports 800-1000 adult lions. Lions showed an increasing trend between 2005 and 2008 (693 lions (577-810) in 2005 to 871 lions (730-1013) in 2008 with an overall increase in density from 1.7 lions / 100km^2 to 2.1 lions / 100km^2, . There was little increase in the spotted hyena population over this same three year period. Overall 22 prey species have been identified for lions in NNR with the main prey being warthog, bushpig, buffalo and waterbuck. The lion population is currently below ecological carrying capacity predicted from prey biomass. In the past two years, orphaned elephant calves and scavenging from elephant carcasses has become an increasingly important source of food for lions as a direct result of the increased elephant poaching.

Between 2005 and 2011, 28 lions (10 females; 18 males) and 8 leopards (five males, 3 females) were radio-marked. The density of the adult lion population in the intensive study area has been stable but there has been significant mortality and turnover in males suggesting immigration not recruitment. Blood samples from immobilized lions (n=36 samples) have all tested negative for canine distemper, canine parvovirus, feline calcivirus, and Corona virus and there has been no evidence for disease in this lion population. However, the disease threat for NNR has increased substantially with the increase in domestic dogs inside NNR from 144 in 2006, to 583 in 2011. In addition the number of villages that now have dogs has increased from 16 villages in 2006 to 34 villages in 2010/ 2011. The presence of an unvaccinated population of domestic dogs in NNR is not compatible with conservation goals. This has been highlighted as a concern by NCP since 2004.

Lion density is very low compared to other areas and this is cause for concern. The mean home ranges of Niassa lions are four times larger than those recorded in Selous Game Reserve (207.2±16.0km2 vs. 48.5 km2) and densities are 4.6 times lower. This is easier to visualize by comparing the 112 lions known to be within a 800 km2 study area in SGR in 2010 with the 20-22 lions supported in an area of the same size in NNR.

In total 27 known lions have died or disappeared from the intensive study area of only 800 km2 between 2005 and 2011. Snaring was the cause of death for at least 52% of these animals. Lions are not targeted but are caught in snares set for bushmeat by NNR residents. The number of lions snared by Mbamba residents is 2-5 lions per year, which is 0.002-0.005 lions killed / resident. This suggests that 40-70 lions may be killed in NNR each year. Inadvertent snaring in bushmeat snares is therefore the biggest and most immediate threat to lions in NNR. Buffalo, zebra, porcupine, impala and guinea fowl are the preferred meat species. Domestic meat protein is scarce and expensive and bush-meat is more readily available and cheaper. It costs Mt 100-150 ($3-4) to buy a chicken but only Mt 20 ($0.60) to buy a guinea fowl or Mt20-Mt50 ($0.60-1.6) for a small to medium portion of fresh bush-meat (250 -300g). A portion of dried bush-meat costs only Mt 10 ($0.32) and an entire impala leg Mt 300 ($10; 2 chickens).

A survey of meat consumption in the dry season revealed that the majority of people interviewed (N= 1128 people, 34 villages) had eaten beans (88%) and fish (86 %) at least once in the past week. In addition, nearly half had eaten bushmeat (47%) at least once. On average, fish and beans are eaten about 3 times a week while bushmeat is consumed 1.1 times (range: 0-4) a week. This amounts to an estimated minimum of 1760-2640 kg of bushmeat eaten per week. This is the same amount of meat eaten by at least 36-54 male lions per week and illustrates the growing threat of bushmeat consumption in NNR.

Human-carnivore conflict remains an issue in NNR though attacks on people are relatively rare but may be increasing. In total we have recorded 89 lion attacks with 44 people killed and 45 people injured since 1970. A minimum of 17 lions have been killed in retaliation but this is likely to be vastly underestimated. On average, there have been 2 lion attacks a year (N=42 years; standard error 0.34; range: 0-8). Since 2000 there have been 34 lion attacks with 21 people injured and 13 people killed with an average of 2.9 attacks / year which is slightly higher than the 30 year mean. Overall, 86 % of the victims were male and 85%were older than 45 years. Less than 5% of the victims were children (0-7 years) or youths (8-15 years). The majority of attacks occurred in the village itself or in the village fields (76% in total) with only 23% of attacks occurring in the bush. Risky behaviours include sleeping outside (50%), sitting around a fire at night in the open (12.5% of attacks), and walking alone both at night to the toilet and during the day (22%). Using these data solutions have been identified and there is ongoing implementation i.e. living fences, safe shelters, safe behaviours, educational materials.

In NNR, lions are not only killed in retaliation, and in snares but are also legally killed as sport hunted trophies. NCP ages and measures all lion trophies before they leave NNR (53 lions from 2004-2011). In 2004 when trophy monitoring began, 75% of the lion trophies seen were under the age of 6, with only 2 of the 8 trophies six years of age or older and sport hunting of lions was unsustainable. In 2006, SRN instituted the lion regulations and points system for assigning quotas developed by NCP. Our goal was to reduce the number of underage trophies taken to less that 20% of the off-take by 2010. This was achieved with only 12.5% of the 2011 trophies younger than 6 years. No trophies were under the age of 4 years. There is a clear relationship between the darkening of lion nose and lion age, and nose pigmentation is positively correlated with the percentage chipping of the enamel ridge

(tooth wear). Visual aging cues for Niassa lions have been validated and communicated to SRN and NNR hunting operators through ongoing presentation, personal communication and development of an aging pamphlet. Sport hunting is currently sustainable in NNR and potential negative impacts on lion population structure due to sport hunting alone have been minimized.

Our data suggest that the growth of the lion population and their prey are being suppressed by off-take and mortality primarily due to bushmeat snaring. The additional off-takes from sport hunting, and retaliatory killing are additive to the mortality from snaring and may be exacerbating the problem.

The Niassa Carnivore Project has been working in NNR since 2003 and we remain deeply committed to supporting the conservation of carnivores in NNR and Mozambique in collaboration with the Mozambican reserve management authority (SRN) and the Ministry of Tourism. We value NNR as one of the most significant and unique protected areas left in Africa, the most important protected area in Mozambique and one of the last great wilderness areas on earth. Lions are not secure in NNR at present, threats are increasing and combined mortality from legal and illegal off-take is not sustainable. If we are to secure the lions and other carnivores in NNR then bushmeat snaring must be addressed.

REPORT STRUCTURE

This report is made up of 2 sections:

Section A is the introduction to the Niassa Carnivore Project and an overview of how NCP is structured and managed. An overview of our most important achievements and outcomes are also summarised here.

Section B provides the technical report and analysis of the scientific data collected by NCP between 2007 and 2011. The data presented in this report are in the process of being written up for publication in peer reviewed scientific papers. These will be provided to SRN in due course. This report focuses almost exclusively on lions although some data on the status of spotted hyenas is also provided. A detailed report on African wild dogs was prepared in 2007 and is updated in annual reports (Begg & Begg 2007). Data on leopard density and sport hunting have been provided in annual and sport hunting reports and have been analysed in detail by Agostinho Jorge as part of his Master Degrees due to be completed February 2012. Detailed information on sport hunting was provided in 2007 and a sport hunting memo prepared in 2010 for SRN.
It must be noted that research is only one aspect of NCPs activities. Our program also includes education and outreach, mentoring and training and implementation of solutions (living fences, goat corrals etc). Details of our other important conservation activities are provided in the detailed Annual Reports (Appendix 1)

Accompanying DVD:

A DVD accompanies the printed version of this report with the final databases used for the analysis and questionnaire forms provided for SRN use. The data belong to NCP and cannot be published by SRN without permission and acknowledgement to NCP but can be used as needed for management of NNR. In addition a full complement of digital versions of educational material is provided in pdf format: rabies poster, safe behaviour poster, storybook, lion aging guide.

PROJECT OBJECTIVES (SRN PROPOSAL 2007)

NCP has a holistic approach to conservation that includes, research and monitoring, education and outreach, direct mitigation of threats and mentorship and training, these are reflected in our nine objectives for Phase II (2007-2011). In this report we report only on the research data that are primarily the focus of Objective 1 and research portion of Objectives 2, 3, 4, and 6.

1. Use targeted research and surveying to investigate, and monitor large carnivore status and density (**Chapter 1, Chapter 2, Chapter 3)**
2. Examine the local contexts of large carnivore attacks **(Chapter 4)** and identify, and test locally derived practical solutions to threats with the active participation of specific local communities.
3. Assess inadvertent snaring and bush-meat consumption to understand level of lion off take and identify possible solutions and areas for further research **(Chapter 2, Chapter 3,** added as an objective in 2009)
4. Assess and minimize the levels of disease risk (canine distemper, rabies, canine parvovirus) to carnivores (particularly African wild dogs and lions) through analysis of blood samples and management of the domestic dog population (**Chapter 2;** Begg & Begg 2007).
5. Extend and refine the MOMS (Management orientated monitoring system) community-monitoring program in collaboration with SRN to provide ongoing assessment of human-carnivore conflict and status of special species with 80% coverage of the NNR villages and to ensure local communities are engaged in carnivore conservation (Not reported on here, see Annual reports, Jorge and Begg 2009).
6. Assist SRN with the development and implementation of sport hunting guidelines and trophy monitoring systems for lion and leopard to ensure sustainable sport hunting (**Chapter 5** - summarised results of Points system).
7. Initiate environmental education and extension work in Niassa communities to build a relationship between wildlife and people based on accurate ecological information and successful mitigation methods (Nor reported on here, see Annual reports.)
8. Facilitate sustainable and consistent monitoring by providing appropriate training, mentorship, equipment and detailed surveying and monitoring protocols to SRN (the management authority of NNR) (Not reported on here, see Annual reports and DVD of questionnaires)
9. Disseminate the findings, mitigation strategies and protocols to inform broader national and regional carnivore conservation strategies wherever possible (Not reported on here, see Annual reports)

CONTENTS

SECTION A:

INTRODUCTION AND OVERVIEW

Large carnivores are among the most difficult species to conserve and the need for practical, locally derived grass roots solutions has never been higher as carnivores continue to decline across the world. Concern for the future of the African lion (*Panthera leo leo*) is increasing and urgent action is needed. Lions are now classified by the IUCN as vulnerable with a declining population trend (Bauer et al. 2008). Experts estimate the population size as **less than 40 000** with an estimated range of 23 000 to 39 000 (Bauer et al., 2008) lions left in the world today. This charismatic, icon of Africa is in serious trouble. Escalating rates of habitat loss, reduction in available prey-base, retaliatory killing, snaring, and unsustainable sport hunting off-take are resulting in ongoing population declines and fragmentation of lion populations across their range (Bauer et al. 2008). Only six lion conservation areas in Africa currently support more than 1000 lions, these are the strongholds for lion conservation and critically important for lion conservation efforts. Niassa Reserve is one of them (IUCN 2006b).

While lions are one of the best studied carnivores in the world, research has failed to be translated into conservation action in most cases. We feel strongly that while research is important to inform our actions, at this point we need action. Theoretical, scientific studies have their place but researchers need to move from the "recommendations section" in their reports to actually finding the funds, and partnering with the management authorities to implement the needed actions and monitor the effects. Given the overwhelming challenges faced by conservation managers today and extremely limited funds it is irrational and simple not feasible to implement recommendations for lions and other large carnivores without assistance. Conservation of lion and other carnivores is being hampered by a reluctance and negativity to new ideas, and a failure for researchers (either because they don't want to or aren't allowed to) to go the next step and provide the funding, expertise and training to implement their recommendations in partnership with local management authorities.

More practical lion research and monitoring is needed including information on lion numbers, illegal killings, human lion conflict and sport hunting (Baldus 2004). This has been the focus of the Niassa Lion project which was initiated in 2005 in Niassa National Reserve, Mozambique, a protected area that is one of the last strongholds of lion left in Africa due to the large area protected (42 000 km^2), increasing prey populations and viable lion population of between 800-1000 individuals. We feel that through our strong, productive partnership with the NNR management team and SRN, we have been able to translate research results into the testing of potential solutions and collaborative implementation of solutions (living fences, safe shelters, effective goat corrals, points system for sport hunting of lions) with ongoing monitoring.

This project was initiated in 2004 based on the first carnivore survey completed in 2003 (Begg and Begg 2004) which showed that NNR supported a relatively low density of lions. Unsustainable sport hunting and illegal killing of lions were identified as potentially significant threats to lions in NNR. The need for more information on legal and illegal off take, lion density and movement patterns and an environmental education program were highlighted (Begg & Begg 2004). The potential risk of unsustainable sport hunting of lions was highlighted as of particular concern given the recent research in Tanzania (Whitman et al 2004) and Zimbabwe (Loveridge et. al. 2007) that had shown convincingly that sport

hunting was not sustainable if lions younger than 5-6 were taken as trophies and when quotas were too high. In the context of declining lion numbers across Africa, and the potential for the NNR lion population to be important in global conservation efforts, more information was clearly needed.

Why should we care about Niassa's carnivore populations? A decline in the large carnivores in Niassa Reserve should raise alarm bells that all is not right within the protected area and action is necessary. Lion density is positively correlated with lean season prey biomass. Any decline in the lion populations suggests that prey populations are declining or human-mediated mortality is increasing above sustainable levels. A decline in the top predators (lion, leopard, spotted hyena, crocodile and African wild dog is likely to result in cascading changes in ecology and loss of biodiversity and ecosystem functioning. In addition, in a place like Niassa Reserve which relies on tourism, primarily through sport hunting, a decline in lions and leopards will result in a loss of revenues for conservation management and a lost opportunity for Niassa Reserve to be an international tourism destination in future. A wilderness without or with very low densities of lions, leopards, crocodiles and African wild dogs is not going to be able to compete with other tourist destinations in the region.

While communities in Niassa Reserve are generally neutral to large carnivores or believe that their lives would be better without the large carnivores, particularly lion, this is unlikely to be true in the medium to long term both for ecological and financial reasons. That said the costs of living with carnivores should not be ignored, particular the loss of life and livelihoods as a result of carnivore attacks. The reality is that these communities will not be relocated out of the protected area and particularly in the eastern section of the reserve where soil quality is low; wildlife remains the most viable land use. It is true that at present few benefits from carnivores are accruing to communities and they are paying all the costs of human-carnivore conflict and this need to be resolved either through more equitable and direct revenue sharing from tourism operations (particular sport hunting), through development of alternative local livelihoods linked to tourism businesses or through more recent suggestions like the payment for ecosystem services and performance payments (Dickman, 2011). Niassa Reserve relies on donor funding and funding from concession fees for conservation management funds. The charisma of the large carnivores and global concern over recent declines and the very real role Niassa plays in global conservation efforts of these species can anchor and provide impetus for funding and conservation campaigns. This should not be underestimated. It is difficult to find funds for a place and much easier to find funds for a species, especially a charismatic species such as the lion, leopard or African wild dog. This will have benefits to Niassa Reserve as a whole, including communities. On all levels a collapse of the large carnivore populations is not in the interests of Niassa Reserve and their conservation should be a priority.

That said, we acknowledge that the large carnivores are not the only indicators and we do not suggest that securing lions in Niassa will necessarily secure the elephants or the Mecula Girdled lizard without additional conservation actions specific to each species. However, many of the threats affecting the large carnivores are the threats affecting Niassa Reserve as a whole i.e. food security, bushmeat snaring, human population growth and growth of settlements and habitat fragmentation, fire, lack of alternative livelihoods for people, and human wildlife conflict. Mitigation of these threats will go a long way to securing NNR as a whole. It is impossible to secure lions and the other large carnivores in NNR without securing NNR as a whole. But we suggest that the reverse is also true. Securing the large carnivores in NNR is necessary to secure Niassa itself.

In conclusions, the Niassa Carnivore Project has been working in NNR since 2003 and we remain committed to support the conservation of carnivores in NNR and Mozambique in collaboration with the Mozambican reserve management authority (SRN) and the Ministry of Tourism. We value NNR as one of the most significant and unique protected areas left in Africa, the most important protected area in Mozambique and one of the last great wilderness areas on earth. We believe the large carnivores act as valuable indicators of the status of Niassa Reserve as a whole. Their position at the top of the food chain, large range and prey requirements, relatively low population densities and sensitivity to human-wildlife conflict make them a barometer or indicator of the "health" of the Niassa

Based on our achievements to date we hope to continue with our work in NNR in partnership with the Reserve Management Authority. We have a long term view and believe that conservation is a process not an end goal. By writing this and other reports, we are not suggesting the work is done, there is much still to do. Ever changing conditions on the ground mean that adaptive management and ongoing monitoring is needed. We hope in this report to convince you, that the lions, leopards and other carnivores in Niassa are in trouble but there are feasible, practical solutions. Our long term vision is a unique wilderness where lions and other carnivores continue to thrive with the full participation and support of Niassa's local people.

Table 1a: Current ranked threats to large carnivores in Niassa National Reserve based on data collected by NCP 2005-2011

Threat	Ranking
Inadvertent snaring and poisoning	**Very High**
Targeted snaring for skin trade	**High (for leopard and lion)**
Human –Conflict / Retaliatory killing	**Medium**
Sport hunting of leopards and lions	**Medium**
Disease – rabies and canine distemper	**Medium**
Road causalities	**Low**
Traditional medicine	**Low**

MISSION STATEMENT AND VISION

The Niassa Carnivore Project serves to secure and conserve lions and other large carnivores (leopard, spotted hyena and African wild dog) in Niassa National Reserve, northern Mozambique in collaboration with Mozambican conservation authorities by promoting coexistence between carnivores and people and directly mitigating threats. We acknowledge the costs to Niassa communities who live with carnivores while recognizing the potential of these carnivores to provide substantial ecological, cultural and economic benefits to Niassa Reserve and Mozambique. This mission is being achieved through direct mitigation of threats particularly human-carnivore conflict, targeted pragmatic research to understand threats, development of locally based monitoring systems, mentorship and training of local conservationists and community outreach (education and awareness).

ADMINISTRATION

The Niassa Carnivore Project (NCP), is administered by The Ratel Trust (TRT), a not for profit conservation trust based in South Africa with a local branch currently being set up in Mozambique. The aim of TRT-Mozambique is to facilitate carnivore conservation in Mozambique with a primary focus on securing large carnivore populations in Niassa National Reserve. TRT South Africa is represented by three trustees (C. Begg, K. Begg and attorney S. Clark). Financial auditing and tax returns are compiled annually by LPG chartered accountants in Cape Town, South Africa.

MAIN ACHIEVEMENTS AND ACTIVITIES (2003-2011)

1. Completed the first biodiversity survey of Niassa carnivores with 24 carnivore species identified, including a viable but relatively low population of lions (2003).

2. Lions identified as a research and conservation priority for NNR by SRN (the management authority of NNR; 2004) and NNR is identified as a priority Lion Conservation Area in Southern and eastern Africa (IUCN Cat Specialist Group 2006) on the basis of data provided by the Niassa Lion Project.

3. NCP collaborated with the National Government on the development of a National Lion Conservation Strategy and Action Plan (2009) based on survey of the status of lions in Mozambique (2008) and the National Wild dog and Cheetah Action Plan (2010).

4. A Human-lion Conflict Toolkit detailing more than 30 practical solutions to reduce conflict was produced and distributed to all lion projects in the region by NCP and Rufigi Man-eating project based on collaborative workshop funded by NCP for 10 conservation projects and 18 fieldworkers and researchers.

5. In collaboration with SRN, a community scout program (MOMS/ SMOG) was initiated in 2006 to monitor human wildlife conflict and status of special species. NCP has provided $37000 to SRN in support of this program. The community monitor team now consists of 19 monitors from 17 villages and is fully funded and mentored by NLP but managed by SRN. A three year strategy for further development of the SMOG system was completed by NCP (2009).

6. Niassa Lion sport hunting regulations were developed by the Niassa Lion Project and implemented in collaboration with SRN and Niassa tourism operators (2006). This system includes a points system for assigning quotas based on lion age. Niassa Reserve becomes the only sport hunted area in Africa where a mandatory six year age limit for lion trophies is strictly enforced and receives the Markhor Award from CIC (2008) for trophy monitoring, the lion regulations and Points System. Since the Points system and monitoring was instituted the percentage of underage lions taken as trophies has reduced from 62% to 14% with no lions under the age of four taken since 2006.

7. A two morning festival of conservation games and activities in Mbamba village was initiated in 2009 to provide an opportunity for Afra Kingdom to interact with Niassa children to enable her to pitch the Niassa Conservation storybook at the correct level. The Lion Conservation Fun days have now become a highly successful annual event run by NCP in partnership with the Houston Zoo, Mbamba teachers, and Paula

Ferro. They consist of two mornings of races, games and craft activities with conservation theme. The aims are to engage children in conservation, build tolerance though knowledge, and make conservation fun. In future visiting school and teacher groups from other villages will also attend.

8. The first and only Wildlife Club was initiated by two teachers in Mecula Village and NCP were asked to be the patrons. Activities include field visits to NCP and Mbatamila HQ, DVD documentary film evenings, spreading information on human wildlife conflict and solutions, sale of a leopard calendar.

9. A detailed questionnaire survey of lion attacks on humans and livestock in NNR was completed detailing 89 lion attacks on people between 1970 and 2010. These data allowed us to assess the main risk factors for lion attacks (sleeping outside, walking alone at night) and to design and implement targeted education materials including a Safe behaviours poster that has been distributed to schools and clinic inside NNR, as well as to protected areas across Mozambique with the support of the Ministry of Tourism.

10. Targeted research provides long term monitoring of the status and density of lions, spotted hyenas and leopards in NNR (2005-2011) call-up and camera trapping surveys and individual recognition in intensive study area. This information is provided to the NNR management authority. NNR is the only protected area in Mozambique where this type of information is available. The lion population increased between 2005 (693(577-810) and 2008 (871 (730-1013).

11. The Niassa conservation storybook was commissioned by NCP, and written and illustrated by Afra Kingdom. It is a fictional story that through the adventures of a small village girl touches on many of the many conservation challenges facing Niassa Reserve. Issues to be targeted were identified by NCP and SRN and include human-carnivore conflict, disease from domestic dog, fire, safe behaviours, safe shelters and snaring. 900 copies have been distributed to all schools inside NNR after three teacher meetings and with teacher guidelines.

12. Fences are identified as successful at reducing bush pig and warthog damage in machambas and therefore reducing attraction of lions into fields where they come into contact with people and attacks occur. *Commiphera africana* is identified as an effective “living fence”. Test fences have been planted in Mbamba village and in collaboration with NNR management team and traditional leaders; fences have been planted in four additional villages. A boundary fence is being planted around Mbamba village in partnership with the 4 traditional chiefs of the village.

13. Ongoing serological (disease) analysis from lion blood samples monitors the disease threat. To date 36 lions have been tested and currently all tests are negative for canine distemper, canine parvovirus, feline calcivirus, and Corona virus. NCP conducts a regular survey of domestic dogs by visiting all villages in NNR (2006, 2007, 2011), has supported to two vaccination campaigns (2007, 2008) and development of a strategy for NNR management authority (canine distemper, rabies) (2009) in collaboration with Dr Rui Branco.

14. NCP identifies bushmeat snaring as a major threat to lions and other carnivores based on data collected on lion mortality, hunting activity, meat preference and bushmeat consumption. Data suggests that more than 2.5 tons of bushmeat are being

eaten each week inside NNR. Potential solutions are identified that include provision of increased domestic meat protein and alternative income for local hunters.

15. NLP has provide 10 GPS units, 2 computers, 1 scanner, 2 cameras, 2 binoculars, predator call up system, predator cages and solar equipment worth $130 000 (through WCN Solar project) to support local conservationists and SRN.

16. As part of our mentorship and capacity building program Agostinho Jorge is completing his MSc degree on leopards supported by NCP and SRN and supervised by C. Begg. Our team consists entirely of 7 local staff from Niassa villages, who receive on the job training. Three have obtained drivers licenses, one is completing a computer course, and two are due to complete mechanics courses.

PROJECT TEAM

The NCP project team is made up of local Mozambicans with lead by Keith and Colleen Begg (South African). Skills' training is provided on the job.

Name	Position	Nationality	Education/ Training	Responsibilities
Project leader and management				
Colleen Begg	Project leader, Trustee of The Ratel Trust	South African	PhD in Zoology, 18 years of experience in carnivore conservation and project management.	All aspects of project, scientific design, coordination, implementation, fund raising financial reporting,, dissemination of results, training., photography
Keith Begg	Project leader, Trustee of The Ratel Trust	South African	Film maker, 18 years experience in carnivore conservation, Diploma in Nature Conservation, Certification of capture and restraint of wild animals.	All aspects of logistics, animal capture, trophy monitoring, fund raising, coordination and practical implementation, publicity and public awareness.
Camp maintenance, visitors, children				
Alberto Mussoma	Camp cook and logistics of food supplies, guard	Mozambican, Guebuza village, local resident	On Project Training: 2003-2011. No schooling, illiterate, cooking taught on project	Cook, camp maintenance, guard, management of food supplies and rations
Pedro Sandali	Camp Assistant – visitors and radio communicatio n	Mozambican, Mbamba village, local resident	Completed Grade 4. On project training: 2008-2011 Driver's license. 2009	Daily radio communication (HF. Motorola, camp cleaning, visitors, Child minding, community report back to Mbamba
Extension, education, research assistants				
Euzebio Waiti	Field Assistant: research and monitoring	Mozambican, Mbamba village resident.	Completed Grade 3. On project training: 2006-2011 on all aspects of field research. Driver's license 2008., mechanics course 2012	Monitoring of all lions in study area (track transects, radio tracking, GPS, capture), surveys, trophy monitoring, community liaison.
Oscar Muemedi	Field assistant-Transport	Mozambican, Mecula Village resident	Completed Grade 4 On project training; 2003-2011. Drivers license, 2006mechanics course on project	Car maintenance, servicing and repairs, driver, extension work, questionnaire surveys
Joaquim Auassi	Extension worker		Grade 12, Two years, Marrupa Ecotourism College, Computer Course January 2012	On project training: 2010-2011. Assistant to Agostinho for Master research (2010) camera trapping, questionnaire surveys) NCP 20Extension work,

				distributing school books and posters, assisting with mitigation of human carnivore conflict, pao pike implementation
Franscisco Laini	General Assistant	Mozambican-Mbamba Village	None	On project training: 2011 Assists in all aspects of project work.
Batista Amadi	General Assistant	Mozambican-Mbamba Village	Grade 5, Drivers license on project	On project training: 2010-2011 Assists in all aspects of field research

INTENSIVE STUDY AREA

Surveying and monitoring of the status and threats to large carnivore populations in NNR and implementation of successful mitigation measures and outreach activities occurs throughout the protected area. Research on lion and leopard density, mortality and testing of mitigation measures is focused in a study area (800 km2 situated along the Lugenda River in concession block "L5-South" in partnership with the Mbamba village community.

The study area borders two sport hunting concessions on the south bank of the Lugenda River (L8, L7) with ecotourism concessions to the west (L4) and east (L5-north). It includes Mbamba village, a major village inside the protected area which supports approximately 1040 people (2007 census; 410 households) and encompasses a mosaic of habitats. The southern boundary of the intensive study area is a 30 km stretch of the Lugenda River, which is the most intensively fished area along the 350 km of the Lugenda River contained within NNR. The river provides a critical protein and income source for several communities. The intensive study area therefore represents many of the larger challenges faced by NNR but it is not sport hunted. NCP has a four-pronged approach of research and monitoring; outreach and education, mentoring and training and direct mitigation of threats.

SECTION B:

CHAPTER 1: STATUS OF LIONS IN NIASSA NATIONAL RESERVE: DENSITY, TREND AND CARRYING CAPACITY

INTRODUCTION

Direct counts of large carnivores over long time periods and extensive areas are extremely difficult to achieve (Funston et al. 2010). Large carnivores, particularly lions are notoriously difficult to census and it is impossible to provide an exact number of how many lions there are in NNR at any one time or how many are "being" saved" by conservation actions. Lions and other carnivores in Niassa are not habituated to people, are seldom seen, there are relatively few roads and the logistics of following lions off road are high. What is more important and practical in a Niassa context is long term monitoring of the trend in carnivore populations using indices of abundance. There are a variety of different methods that estimate abundance of large carnivores, most commonly used are camera trapping, call up surveys (Ferreira & Funston 2010) and track transects (Funston et al 2010). All these techniques have inherent assumptions and practical strengths and weaknesses that need to be taken into account and none are perfect. However used consistently over time, a particular technique will provide an indication of whether a population is increasing, decreasing or stable and will provide a broad indication or snap shot of the population size (< 100, 100-500, 500-1000, more than 1000) for regional and national conservation strategies and priority setting.

Between 2005 and 2011, NCP has been monitoring the status of lions and spotted hyenas in NNR through call up surveys conducted throughout NNR (2005 and 2008), and through long term monitoring of a lion population in the intensive study area (L5-South, 800 sq.km2) using individual identification assisted by radio collaring. Leopard density and turnover has been monitored through camera trapping (2008, 2009, 2010, Jorge et al in prep) and is not discussed further here. Individual recognition is the preferred method of determining lion density but is not feasible over large areas particularly in wooded habitats. Instead a number of indirect measures to estimate the density of lions have been developed and call up surveys or playback response surveys are currently the preferred method in East Africa (Ogutu *et al* 2005; Whitman et al 2006, Kiffner *et al* 2009, Brink 2010) and is the method used in NNR. These call up surveys are a well established, well documented technique for assessing lion densities and data analysis has recently been standardized by Ferreira & Funston (2010) to take into account variable responses by females with and without cubs and different group sizes. In addition to monitoring the trend in the overall population, calls up surveys also allow us to monitor sex ratios, age structure, and condition of the lions (presence of snares and snare wounds). They have the added advantage of allowing monitoring of spotted hyenas and opportunistically call in African wild dog packs allowing us to photograph pack members.

Long term monitoring of the lion population in the intensive study area (800 km2) is used to ground truth the call up survey and provide more detailed information on the density, turnover, mortality, aging cues, and recruitment and movement patterns. We monitor what happens to individual lions through radio-marking. This data forms the baseline against which the success or failure of mitigation measures (i.e. fences, environmental education, safe behaviours) can be evaluated in future.

Review studies have shown that lions preferentially chose prey between 190-550g. While warthogs are below the weight range they are taken in accordance with their availability and are frequently preferred prey, possibly because they are slow and have low levels of awareness of predators are relatively easy to catch (Hayward & Kerley 2005). By estimating the lion carrying capacity in NNR we can provide an estimate of "conservation success" by comparing observed population density with expected density. Lion population density is directly correlated with lean season prey biomass (Orsdol *et al* 1985; Hemson 2003; Hayward *et al* 2007,) and lean season prey biomass can be determined through direct surveying (aerial census, prey counts) or predicated based on rainfall and soil fertility (Loveridge & Canney 2009). It is therefore possible to estimate the potential carrying capacity of lions in NNR using low season prey biomass provided by the SRN aerial census data (Craig 2009).. Given that prey populations in NNR are unlikely to be at carrying capacity due to extensive fires and substantial illegal use, a theoretical carrying capacity can also be calculated using the area protected, rainfall and vegetation types. This has been done by Loveridge & Canney 2009.

METHODS

Call up surveys

A standardized playback technique was used that has been widely used in other areas (Kiffner et al 2011, Brink 2010. Ferreira & Funston 2010). Care was taken to match the survey protocols used in other recent studies to ensure comparable results. Call up surveys were conducted in the dry season months of July- August in 2005 and 2008 along the existing road network in NNR (Figure 1a and 1b), following pilot tests of the survey technique in 2004. At predetermined 10 km intervals (straight line, measured using GPS) the vehicle was stopped at a suitable point (as open as possible on high ground , Fig. 1) and calls known to attract lions and spotted hyena were broadcast through loudspeakers. A 10 min long tape of sounds known to attract lion and spotted hyena were used. The calls broadcasted were the bleating of a wildebeest calf, a squealing pig, an interclan fight between spotted hyenas, the "whooping" call and hyenas competing on a kill. The recordings were played back at full volume through a digital Mp3 player attached to a 12-volt amplifier (TOA model CA130) with a rated output of 30 watts and connected to two 8 ohm horn speakers (TOA Model SC615) with a RMS rating of 15 watts (112 dB). The horn speakers were connected in parallel to produce a 4-ohm low impedance to improve sound quality. The horn speakers were attached to a pole 1 m above the vehicle roof (2.5 m from the ground) and pointing in opposite directions.

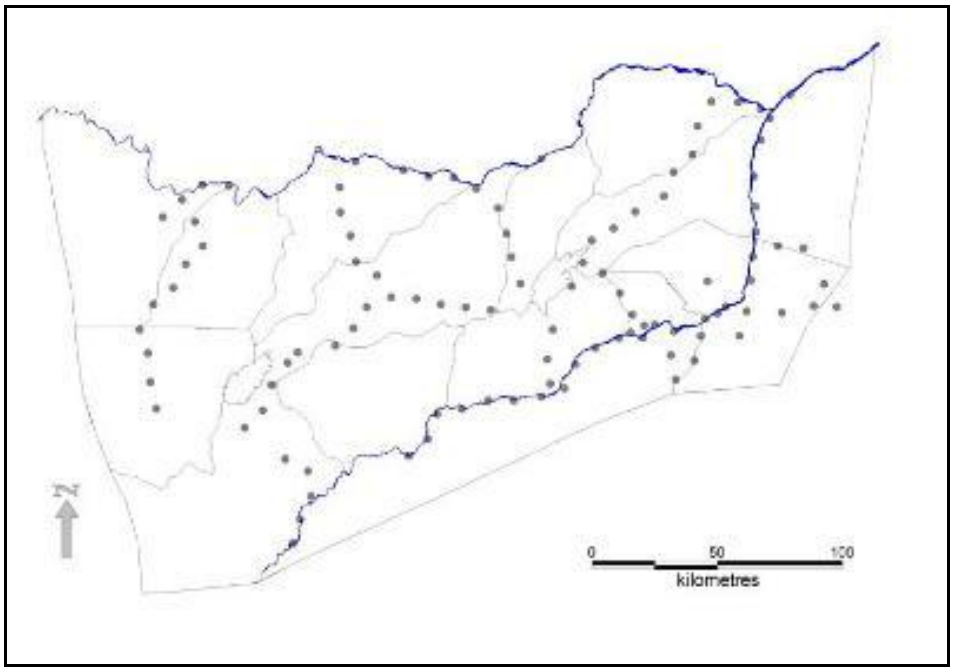


Fig. 1. Position of call stations (black dots) used during the 2008 Lion and Hyena call up survey showing the coverage of the call up survey along available roads.

An hour was spent at each call station with calls played for 10 minutes, then no calls for 10 minutes while scanning for carnivore using a spotlight with a red filter and so on until the 60 minutes had been completed. Since lion density is known to be affected by water availability as a result of prey densities, sampling was stratified into two habitats – areas within 10 km of permanent water and areas in watershed area (Kiffner et al., 2008). A goat meat bait was hung at each call station to encourage carnivores to approach close enough to be aged. At each call station we recorded the number of incoming lions and determined their sex. We visually estimated their age (cubs- < 2 years, young adults -2-4 years, mature adults-4-6 years, and older 6 years) by size (Smuts et al., 1980), mane development (NCP 2009) and nose colouration (Whitman et al., 2004; validated for Niassa lions between 2005-2010 (see chapter 5). Lion densities are known to be higher in areas close to water where there are higher prey densities and high prey "catchability" (Hopcraft et al 2005). Sampling was therefore stratified to ensure equal numbers of call stations in within 10 km of permanent water sources (2005: 57% of call stations; 2008: 52% of call stations) and miombo watershed habitats.

Data were analysed using the statistically robust model developed by Ferreira & Funston (2010), to estimate population size with confidence intervals and further statistical analysis was done using WinStat add-in for Excel. The model takes into account differential response probabilities of different sexes and cubs and accounts for the different number of calling stations used in 2005 and 2008. Lion density was calculated for NNR overall in 2005 and 2008, and for each of the two habitats separately (riparian and miombo watershed). Calibration experiments on habituated lion prides were not possible in NNR to test responses to playback sound. However, on 15 opportunistic occasions when lions were known to be in the near vicinity due to spoor, roaring or visual observation earlier in the day, we played the distress calls and recorded whether the lions responded Lions responded on 11 occasions provided an estimated response probability of 73%. This is similar to the response probability calculated in other studies using similar equipment (Ferreira & Funston 2010, Brink 2010, Kiffner *et al* 2009) and suggested that this was a reasonable probability response to use in NNR as elsewhere. Model parameters used to calculate lion

densities in 2005 and 2008 are shown in Table 1 below based on the specific call up equipment used.

Table 1: Model parameters used to analyse Niassa call up survey data using model (Ferreira & Funston 2010)

Parameter	Value used
Probability adult lion will arrive at call station	0.734
Probability cub will arrive at call station	0.286
Effective area sampled at each call station	32.17
Maximum distance calls can be heard	3.2 km
Distance between call stations	10 km straight line

Monitoring of lion density in Intensive study area

The lions in the intensive study area (800 km2) have been monitored since 2005 using individual recognition of individuals (scars, freckle patterns) and wherever possible radio collars. The density of lions in the intensive study area is determined by call-up associated with capture, opportunistic sightings by researchers and fishermen, and the radio-marking key individuals (see Chapter 2 for details of radio-marking techniques). There are some lions in the study area that have not been positively aged or sexed but their presence is inferred from spoor, roaring, and sightings by fishermen when all known animals are accounted for. Lion density is calculated each year as the total number of adult lions per 100 km2 of the study area in November of that year as there is substantial turnover during the year with immigration of new individuals and deaths of residents in snares.

Prey and Carrying capacity

We used incidental observations of lion prey from our project, other researchers, tourism operators and NNR staff to determine the prey of lions in NNR. While data collected from continuous follows of lions is considered superior this is impossible in Niassa due to the wooded habitats, rugged terrain, lack of roads and un-habituated lions. Incidental observations are known to be biased towards large prey but bias against small prey is often alleviated by under counting the small prey species in aerial census surveys and even continuous studies find only a small proportion of kills are of small species (Hayward & Kerley 2005). Since lion density is correlated with lean prey biomass, an expected ecological carrying capacity can be calculated. This assumes no top down limitations or mortality from human-lion conflict, snaring and sport hunting off-take which has been shown to decrease lion densities (Creel & Creel 1997, Whitman et al 2007, Loveridge et al 2007).
Carrying capacity can be modelled indirectly using a regression model developed from data on lion densities across multiple study sites provided that information on prey biomass is available. In our study we have used the regression model of Hemson (2003) which excludes elephants, hippo and in other areas, giraffe.

Log (lion density) = -1.69216 + 0.80916 x log (prey biomass)

We believe this model is warranted as none of the species excluded are prey items for lions in NNR under normal circumstances (but see effect of elephant poaching on lion prey). To obtain data on available prey biomass for lions we used the prey density data from the 2009 SRN aerial census of NNR (Craig 2009). Following convention, the mean density of each species were converted to biomass density by multiplying the density value by 75% of the average female body weight of each species where average female body weights were provided by Hayward & Kerley (2005). This convention of using 75% of the female body weight accounts for sub-adults and males and females being taken as prey.

RESULTS AND DISCUSSION

Density

In 2008, a total of 104 calling stations (1040 road transect; Fig. 1) were completed, and 36 lions, 59 spotted hyenas, 23 leopard and three packs (16 individuals) of African Wild Dogs responded. An area of 3346 km2 was covered by the call up with almost equal coverage of riparian and woodland areas. There was a slight increase in the number of calling stations between 2005 and 2008 (97 compared to 104 calling stations, however this is unlikely to be affecting the density estimates other than increasing precision due to the model being used (Ferreira & Funston 2010). The average lion response time during the 2008 survey was 32 minutes (range 6 minutes to 54 minutes) almost exactly the same as the average hyena response time (35 minutes; range 6 – 1 hour).

Based on the results of the call up survey, the Niassa lion population increased from an estimated 693 lions (577-810) in 2005 to 871 lions (730-1013) in 2008 (Table 2). Overall density of lions increased from 1.7 lions / 100km2 to 2.1 lions / 100km2. There was little increase in the spotted hyena population over this same three year period.

Table 2: Overall population estimates for lions and spotted hyenas in 2005 and 2008 in NNR based on call up surveys, with data analysed using the model of Ferreira and Funston (2010).

Parameter	Call up survey Lion		Call up survey Spotted Hyena	
	2005	**2008**	**2005**	**2008**
Number of call stations	97	104	97	104
Effective area sampled	3120	3346	3120	3346
Number of animals that responded	27	36	60	69
Proportion of total area	0.74	0.80	0.74	0.80
Population Estimate	693	871	1193	1279
(95% confidence limits)	(577-810)	(730-1013)	(1081-1305)	(1165-1394)
Density (adults / 100km2)	1.7 (1.4-1.9)	2.1 (1.7-2.4)	2.8 (2.6-3.1)	3.0 (2.8-3.3)

The call up surveys revealed that there are significantly more lions within 10km of the Lugenda and Ruvuma rivers and major tributaries (2008: 2.2 lions / 100 km2 vs. 0.9 lions / 100km2) than in watershed areas (2005: Chi square test; $X^2=6.26$; $p<0.01$; 2008: $X^2=8.3$, $p< 0.05$; Table 3) and this was true for both 2005 and 2008. This was expected due to higher prey densities in riparian habitats (Spong 2002; Jorge *et al in* prep) and higher prey "catchability" (Hopcroft 2005). However, the same pattern was not seen in the spotted hyenas (2005, p=0.12; 2008, p = 0.54) and this is difficult to explain without further information on the prey preference of hyenas in NNR. Spotted hyena densities varied

between 2.8 - 3 hyenas / 100 km2 but with less difference between habitats. Similar results were found for leopard, with double the density of leopard in riparian habitats compared to miombo woodlands based on prey densities (Jorge et al 2012, in prep). These data are important because while the densities of carnivores are higher in the riparian with higher prey densities these are also the areas with the highest mortalities from snaring and sport hunting off-take, which may affect population increases in future.

Table 3: Differences in lion and spotted hyena density in areas close to permanent water and in watershed areas of NNR showing the mean density estimate and the standard error of the mean as calculated by Ferreira and Funston (2010).

Habitat	Lion population estimate		Spotted Hyena estimate	
	2005	**2008**	**2005**	**2008**
Riparian	443 (± 50)	533 (±61)	1793 (±196)	1552 (±171)
Watershed	103 (±14)	172 (±21)	918 (±117)	1345 (±157)

The adult lion population in the intensive study area (800 .km2) situated in concession L5-South has been stable over the past 6 years at 2-3 lions / 100 km2 but has not increased and there has been significant mortality and turnover in males suggesting immigration not recruitment (Table 4). In 2011, the population declined slightly compared to 2010, and this needs to be monitored. The sex ratio in the intensive study area is approximately 1 male: 1.6 females.

The lion density calculated from individual recognition in the intensive study area in 2008 (2 lions / 100 km2) was exactly the same as the overall density of 2.1 adult lions (1.7-2.4) / 100 km2 estimated for NNR from the call up survey. In addition the mean density of lions in the intensive study area (2.4 lions / 100 km2) between 2008 and 2011 is similar to the lion density calculated specifically for habitats within 10 km of permanent water estimated from the call-up survey (2.2 lions / 100.sq. km). These results validate the call-up survey data and provide confidence in using this survey technique in NNR. We strongly recommend that call up surveys be continued in NNR at regular intervals either by Reserve staff or NCP to monitor the trend in the NNR lion populations using the same technique.

Table 4: Lion population in intensive study area in November of each year (2005-2010)

Category	2005 (500 km²)	2008 (800km²)	2009 (800 km²)	2010 (800 km²)	2011 (800 km²)
Adult Males	4	4	4	8+2 **	6 +2**
Sub adult male	3	3	2	1	1
Adult female	5	6	10	10	9
Sub-adult female	3	5	4 c	0	0
Unknown lions	?	?	5	3	2
Cubs		3	0	2	3+1*
Overall density (adult s/ 100 km2	3 km^{-2}	2 km^{-2}	2.7 km^{-2}	2.7 km^{-2}	2.2 km^{-2}

***** F-pride had two cubs, one cub was killed by incoming males in July 2011, paw was found, territorial male was killed in a snare, and new coalition of 2 arrived.

****** Two males were radio-marked in the intensive study area at an elephant carcass but they are not territorial residents, although they return once or twice a season, one was snared on the boundary of the Reserve in 2011. An additional two males that were collared in the intensive study area in 2010, are currently the territorial males on the south bank.

Use of the call up technique also allows us to directly compare our results to lion densities in Selous Game Reserve (Brink 2010), Kruger National Park (Ferreira & Funston 2010) and Katavi National Park (Kiffner *et al* 2009). Lion densities in NNR are low compared to other conservation areas in the region. Using the same method, the recent density of lions in Selous Game Reserve (SGR) varied from 2- 10 lions / 100 km 2 in the northern and western sections of SGR with a density of 14 lions / 100km2 in the photographic area (Brink 2010). An 800 km2 study area in SGR supported 115 lions compared to only 20-22 lions in NNR. This is cause for concern.

Lion prey and carrying capacity

Overall 22 prey species have been identified for lions in NNR (n = 142; Fig. 2). The four most common prey species eaten overall are warthog (19%), elephant calves (11%), bush pig (18%) and buffalo (12%). If the elephant calves are removed from the analysis, 60% of lion prey is comprised of only four species (warthog, bushpig, buffalo and waterbuck). 12 species have only been recorded 1-2 times. The majority of the prey records come from sightings in the eastern section of NNR where NCP is based. It is likely that reedbuck might be more important sources of prey in the western section where they are more common (Craig 2009). Between 2004 and 2008, only two elephant calves were recorded as lion prey, however between 2009 and 2011 this has increased exponentially with at least 14 elephant carcass have been recorded as lion prey in total (Fig 3). In the past 3 years, at least 25 elephants have been killed for ivory in concession L5-South alone and on several occasions, NCP staff and other researchers and professional hunters have seen orphaned elephants wandering in the bush. These are easy prey for lions that would normally not have access to calves that are defended by their mothers. Elephant carcasses also pull lions in as scavengers. In the last two years in the intensive study area, ten lions have been darted while feeding on elephant carcasses. Four of these lions have since proven not to be residents.

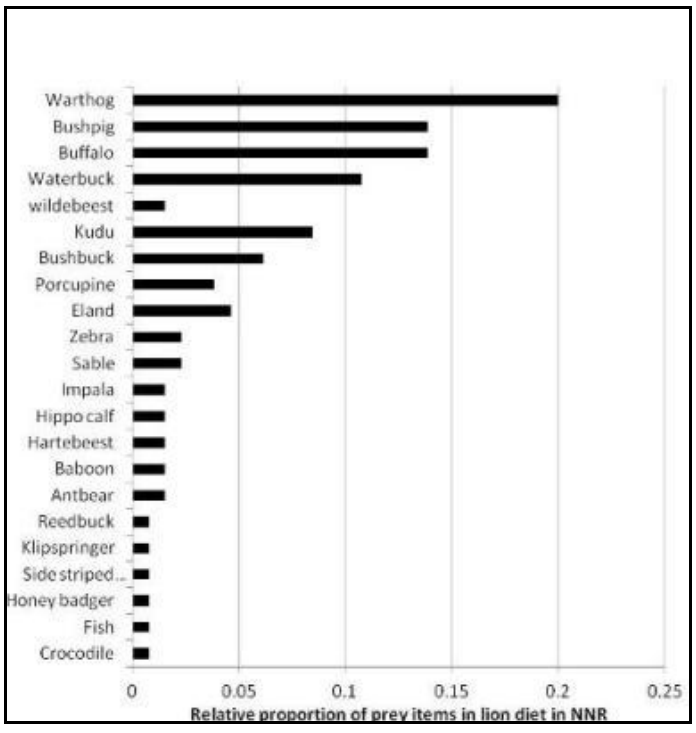


Fig.2: Relative proportion of prey items in lion diet in NNR (n = 145) showing the predominance of warthog, bushpig, buffalo, waterbuck in the diet.

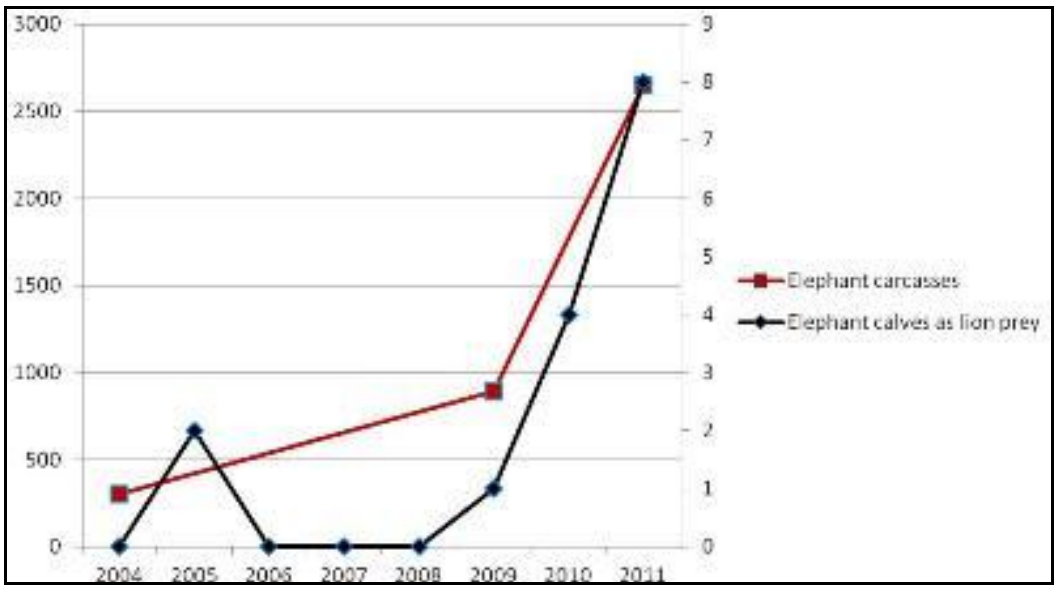


Fig .3: Increase in number of elephant calves recorded as lion prey items in Niassa Reserve between 2004 and 2011, as a direct result of increased elephant poaching (data on elephant poaching from Craig et al 2012).

In 2009, Loveridge & Canney produced a detailed model to predict lion density based on soil and rainfall surrogates (NDVI index) which in turn reflects prey biomass. From this model it is predicted that NNR should support a density of at least 3-5 lions / 100.km2 or 1260-2100 lions. Ecological carrying capacity is more commonly estimated using prey biomass. The biomass density of ungulate prey species were calculated using the 2009 SRN aerial census data (Table 5). Using the model of Hemson (2005), NNR could support a lion density of 1084 lions (679-1479). This is likely to be an underestimate given that two of main prey items (warthogs and bush-pigs) are not accurately counted by the aerial census and are relatively common in NNR (per obs.). The actual lion density is 80% of the potential lion density suggested by the available prey biomass and 69% of the possible prey biomass for NNR estimated by Loveridge & Canney 2009. Based on our data on bushmeat consumption and snaring, we believe that the growth of the lion population and their prey are being suppressed by off-take and mortality primarily due to bushmeat snaring. The additional off-takes from sport hunting, and retaliatory killing are additive to the mortality from snaring and exacerbating the problem.

In 2008 the lion population appeared to be increasing overall, particularly in the watershed habitats where human mediated mortality is lower and is tracking the recovering prey populations up to this point as shown by the bi annual aerial census results. However, our data suggest that bushmeat consumption is significant and increasing and this increasing trend is unlikely to continue. We are interested to see the overall results of the 2011 aerial census which are not yet available to see whether prey populations are still increasing. It is likely that bushmeat consumption will continue to impact on the density of lions and their prey. It is unlikely that lions in NNR will reach carrying capacity unless bushmeat snaring is mitigated. In fact we believe that the lion population will begin to decline in the near future as current off-takes are unsustainable in areas near human settlement and along the Lugenda River. Continued long term monitoring of the intensive study area lion population as well as reserve wide surveys are essential.

Table 5: Biomass density of lion prey in NNR estimated using the 2009 Aerial census data (Craig 2009) for prey items identified from prey records (n = 140).

	Estimated prey numbers (Craig 2009)			Average Biomass 75% female	Biomass density		
Prey species	Mean	Max	Min	(kg)	Mean	Max	Min
Buffalo	6833	9571	4095	432	70.28	98.44	42.12
Bushback	366	510	221	46	0.40	0.56	0.24
Bushpig	711	1079	343	46	0.78	1.18	0.38
Duiker	22082	23706	20457	16	8.41	9.03	7.79
Eland	5856	7959	3754	345	48.10	65.38	30.84
Hartebees	85	6257	3764	95	0.19	14.15	8.51
Impala	2175	2881	1470	30	1.55	2.06	1.05
Kudu	2928	3661	2195	135	9.41	11.77	7.06
Reedbuck	2041	2509	1574	32	1.56	1.91	1.20
Sable	14686	16541	12830	180	62.94	70.89	54.99
Warthog	10089	11415	8763	45	10.81	12.23	9.39
Waterbuck	2952	3727	2177	188	13.21	16.68	9.74
Wildebeest	1124	1863	383	135	3.61	5.99	1.23
Zebra	6229	7425	5033	175	25.95	25.95	20.97
Total					257.22	336.23	195.51

CHAPTER 2: LION HOME RANGE, MOVEMENTS AND MORTALITY IN THE INTENSIVE STUDY AREA , L5-SOUTH.

INTRODUCTION & OVERVIEW

Lions are one of the most well studied carnivores in the world with population density data from a wide variety of protected areas from 11 countries (Packer et al, in prep). Detailed information is available on almost all aspects of their biology, social organisation and ecology. It is not the intention of NCP to collect detailed ecological information on lion biology but rather to collect specific information needed to mitigate threats. We initiated the radio-marking program in 2005. Radio collars allow us to track individuals over time, this would be impossible through opportunistic sightings alone due to the woodland habitat, lack of habituation roads and high pedestrian traffic which causes the lions to move into thick bush and keep a low profile. A description of an individual's home range is also useful as it provide an indication of the number of animals an area can support and since lion density and home range are directly correlated to lean prey biomass, it can give an indication of the prey available. The most commonly cited definition of an animal's home range is that of Burt (1943) which is "that area traversed by an individual in its normal activities of food gathering, mating and caring for young. Burt (1943) suggests that it does not include occasion exploratory forays, although this is difficult to define (Kie *et al* 2010) In 2010, to obtain objective data on mortality of lions, we attempted to catch and collar as many lions as possible in the intensive study area. Dr Guy Balme (Director of Lion Program, Panthera) spent three weeks in the field (July) teaching us how to catch elusive lions using a highly specialized technique using leg hold traps. We would like to continue with this intensive monitoring of the lion population given permission from SRN as we believe this is

the only way to objectively monitor lion mortality in the intensive study are given the logistical constraints.

By collaring all individuals known to use the area within 10km of Mbamba village with a combination of VHF and GPS collars, equipped with a mortality signal that will indicate a lion death within 24 hours, we will collect the first accurate data on the number of lions being killed and their movement patterns around a typical Niassa village. At the same time, we will assess the risk of disease through analysis of blood samples taken from these captured lions. These data can be extrapolated to determine a more accurate figure for the level of off-take of lions in NNR. The data collected on movement patterns of lions within the village and surrounds will also provide a baseline against which mitigation methods can be assessed.

The aims of the radio-marking program radio-marking lions in the intensive study area are three-fold:

1) To monitor mortality, and turnover of lions in the intensive study population over time

2) To investigate home range size (which is related to prey density) and movements around the Mbamba village and across the Lugenda River

3) To validate visual aging cues of male lions by following the same individual male lions over time to assist with implementing sustainable sport hunting practices in NNR (Chapter 5).

The data collected were used to validate parameters for a lion population model, SimSimba. SimSimba is a highly detailed lion population simulation model that was created in 2002 at the University of Minnesota and has since been used in numerous studies to investigate effects on threats on lion populations most recently in the investigation of TB on the Kruger National Park lion population (Ferreira & Funston 2010) and the effect of underage sport hunting lions (6 year age minimum paper; Whitman *et al* 2004). Using data collected by the Niassa Carnivore Project over a 6 year period (2006-2011), as well as data on prey density, hunting off-take and mortality we are currently assessing the Niassa lion population using a computer model called SimSimba in collaboration with Margaret Kossmala, University of Minnesota). The model is incomplete and results will be provided in due course. However, we have included here the preliminary data to build the model. These data will be published in due course and results provided to SRN. Preliminary data used in the model are provided here. In due course this model will allow us to assess the potential impact of legal and illegal on the current lion population.

METHODS

Capture

In general lion captures are all done within concession L5-south between the Mbamba and Msangezi rivers. Lion captures cannot be done on demand (unlike buffalo, elephant etc where animals can be located from the air. All captures are done opportunistically when lions are seen or heard. It can take months of effort before elusive village lions can be immobilized. For this reason it would be impossible to continue with this radio marking program if it was required that a vet be present at each capture. As is the norm in many carnivore projects across the region, captures are done opportunistically by researchers

after receiving specialized training. Keith Begg completed a certified course in the Chemical and Physical restraint of Wild Animals (Zimbabwe, 1994) and he does all the immobilizations. Veterinary assistance and on-site training was also provided at the start of the program by Dr Mike Kock (WCS Field Vet program) and Dr Rui Branco (2008). Most commonly lions are captured using baited call up, free darting and in soft hold leg hold traps. In addition on-site training in the use of soft hold leg hold traps was provide by capture specialist, Dr Guy Balme (Panthera) in the field over a three week period in July 2010. Soft hold leg hold traps are essential to catch nervous, persecuted lions particularly around villages Snare assemblies are modified to reduce possibilities of catching non-target species. Leg hold traps were custom built using 5-mm-diameter, stainless-steel aircraft cable permanently clamped with swaged aluminium ferrules. Aluminium cable stops restrict the capture loop from closing completely. This minimises the chance of injury to animals, and reduces the possibility of catching smaller-footed, non-target species. During baited call up, a goat carcass is tied to a suitable tree and standard animal distress calls are broadcast at night to attract animals to the baits.

Lions are darted in the shoulder with a Dan-Inject CO_2 injection/ dart rifle (Dan-Inject RSA, Skukuza, South Africa) to deliver the dart from 20-40m away. The Dan-Inject rifle allows for adjustment of the force of the air dart dependent on distance from the lion or leopard to ensure minimal impact. All lions were immobilized with Zoletil, with dosage dependent on size and sex of individual (range: 250 – 500mg). Zoletil has a wide safety margin and is recommended for use by non-vets (researchers). Recumbence occurred 7-15 minutes after darting and animals were immobilized for 1-2 hours. Once the animal is completely immobilized, the dart is removed and the small wound treated with antibiotic cream. Breathing and muscle tone are regularly checked, eyes are covered by a cloth with eye drops placed in each eye to prevent them drying out. If immobilization takes place during the day, the animal is placed in the shade and doused in water when/ if necessary. Once all procedures have been completed, the animal is watched from a vehicle from a short distance away until able to walk to ensure that no other animals cause injury while still under the influence of the immobilizing drugs.

The following information is collected from each immobilized lion:

- Age and sex (nose pigmentation, teeth wear, mane development)
- Morphometric measurements: body-head length, tail, girth, shoulder height, canine height, width, mass (leopards).
- Photographing and assessment of tooth wear, mane development, nose pigmentation scars or identifying features, and body condition.

Disease analysis

Blood samples consisting of 1-2 vials of blood are taken from the vein in the foreleg and manually centrifuged. Serum is removed with a syringe and samples are refrigerated. In addition lions were tested for FIV using Whatman blotting papers placed on the bullet wound in sport hunted lions.

Samples are analysed by the Dept. of Veterinary Tropical Diseases, Faculty of Veterinary Science, Onderstepoort, South Africa. Samples are tested for canine distemper, canine parvovirus, feline calcivirus, and feline carona virus. A regular domestic dog survey is done by NCP by visiting all the villages and counting all the dogs visually by walking through the village.

Collars

Lions are fitted with either VHF (Telonics Mod 500), GPS or Satellite (Vectronics) collar. All these collars have been all been used successfully on lions in other studies. Wherever possible, collars are removed before the end of battery life through re-immobilization. No emergencies have been encountered during a collaring exercise however one lion died as a result of getting his collar stuck in his mouth. The collar was removed but the lion did not recover from the immobilization. This was immediately reported to SRN and is the only mortality directly due to research activities.

All the collars have a built in mortality signal that sends a fast pace radio signal from the collar when the animals has not moved for 24 hours. When a mortality signal is received, the lion carcass was investigated, cause of death ascertained and the collar recovered. Ongoing community outreach in Mbamba villages has resulted in the return of collars found on snared animals (3 leopard, 3 lions, 1 buffalo).

Monitoring of radio -collared lions

The VHF collars provide a line of sight signal which allows us to locate the lion through radio-tracking on the ground or through triangulation from radio tracking from two inselbergs. The GPS and Satellite collars are programmed to collect at least 4 points a day, with the schedules changed to every 2 hours during the wet season when lions are known to enter the fields around the villages. GPS collars store the location information on board the collar memory and this can either be downloaded by connecting the collar directly to the computer on removal from the animal or can be downloaded remotely through a UHF aerial and receiver when lion is within 5 km. The satellite collars upload the location data to a satellite and an email is sent when 10 location have been collected.

GPS and satellite collars provide data to analyse home ranges and movement patterns. Data collected from VHF collars is observer biased as there are many areas in the study area where lions cannot be located with a vehicle. Regular radio tracking from the air was not possible. As a result VHF collars are used primarily to monitor presence of lions and to provide an index of mortality. Satellite collars provide the most efficient way to monitor lions in NNR given the lack of an aeroplane however the cost is prohibitive ($4500 / collar) and they are only placed on male lions due to their weight. In 2011, two satellite collars were purchased to assist Thomas Prin in his buffalo project in SRN. These collars were placed on male lions (both part of two coalitions) in the areas where there are collared buffalo to determine whether the lions were following the buffalo.

Inselbergs are climbed several times a week throughout the study area to monitor radio collared lions. The intensive study area was chosen in 2005 in part due to the arc of inselbergs which provide good coverage of the area close to the Lugenda River. Wherever possible lions are approached in a vehicle to monitor cubs, other adults and locate potential prey items. However, in many cases it is impossible to get to the lions due to the limited road network, and thick bush. In these cases simply monitoring of the radio signal provides information on whether the lion is alive or dead, and its position can be estimated from triangulating signals from high points and from the direction and strength of the signal. Aerial tracking (radio-tracking from an aircraft) is the most efficient, and conventional way to monitor radio-marked animals. A flight at least once every two weeks would provide significant data on all the radio marked in the study areas. However, regular aerial radio-tracking has not been possible in this study as there has not been an aeroplane stationed in NNR. In 2010, the NNR ultra light was used for aerial radio tracking when the time schedule

of the pilot allowed. However still only 5 flight sin 2010 were accomplished and the plane was grounded for most of 2011.

Analysis of data

Movement and home range data were analysed using RANGES 8 v. 2.7 (Anatrack Ltd, Kenward *et al* 2008) software and imported into MapInfo Professional vs. 10.5 GIS program. Statistical analyses (ANOVA, Chi-square, t-test) were done using WinStat 200 for MS Excel (2001).Home ranges and territories were calculated using minimum convex polygons (100% and 95%) to ensure the data can be compared with other studies as this is the most historical technique used. However, this technique tends to overestimate home range size. Kernel analysis provides a utilization distribution and is the preferred method. Here we used the 90% kernel as the home range / territory boundary and the 50% kernel as the exclusive use zone as suggested by Spong (2002) and Brink (2010). Spong (2002) suggested that at least 60 independent GPS points with 24 hours between them (2 months of data at least) are needed to obtain an accurate indication of home range. We therefore only calculated home ranges on lions which had been followed for more than 2 months, with GPS collars. Data collected on mortalities from radio-collared lions, reports received from the village community on lion snared and ongoing monitoring of known individuals provided an indication of causes and rate of mortality in lions.

RESULTS AND DISCUSSION

Capture and collaring

Over the past seven years (2005-2011) 28 lions (10 females; 18 males) and 8 leopards (five males, 3 females) have been radio-marked. We have immobilized lions on 43 occasions to collar new individuals and replace collars (Table 6). Overall 9 lions have been 6 years and older at first capture, 9 have been in the 4-6 age category and 10 were between 2-4 years old (Table 7). Standard measurements are collected during immobilization and these are shown in Table 8.

Table 6: Number of lions captured each year from 2005 to 2011. Note this is the number of individual captures not individual lions as some lions have been immobilized on several occasions.

Year	Lion captures		
	Male	Female	Total
2005	5	1	6
2006	2	0	2
2007	2	1	3
2008	0	6	6
2009	2	1	3
2010	10	4	14
2011	6	3	9
Total	27	16	43

Table 7: Age (at first capture) and sex of lions immobilized between 2005 and 2011

Age category	Female	Male	Total
Younger than 4	5	5	10
4-6 years	2	7	9
6 years and older	3	6	9
Total	**10**	**18**	**28**

Table 8: Standard lion measurements taken during immobilisation

Measurement (mm)	Female mean (SE; N)	Male mean (SE; N)
Head-body	1668 (26.4; 10)	1826 (24.6; 18)
Girth	1031 (23.9; 9)	1171 (19.8; 16)
Shoulder height	838 (93.8; 10)	1038 (21.5; 18)
Neck circumference	596 (8.9; 10)	728 (20.3; 18)

In general, all lions are captured in the intensive study area (Concession Block L5-South) between the Mbamba and Msangezi Rivers with the Lugenda River forming the southern boundary (Fig. 4). One male (LICM03) was immobilized on the south bank of the Lugenda River in Block L7 in 2005 as he was a direct neighbour to the study population and it was important to determine when and if he crossed over the Lugenda River. He was subsequently injured and snared in Nkuti village, and finally snared and killed in Mbamba village in 2008 within the study area. Two male lion coalition (S-coalition; p-pride coalition) were captured and collared at dead elephants within the intensive study but subsequently moved out of the study area, They had been attracted in by elephant carcass. P-Coalition are the territorial males on the south bank in L7 concession and are regularly seen on baits and heard by fishermen and researchers within the study area.

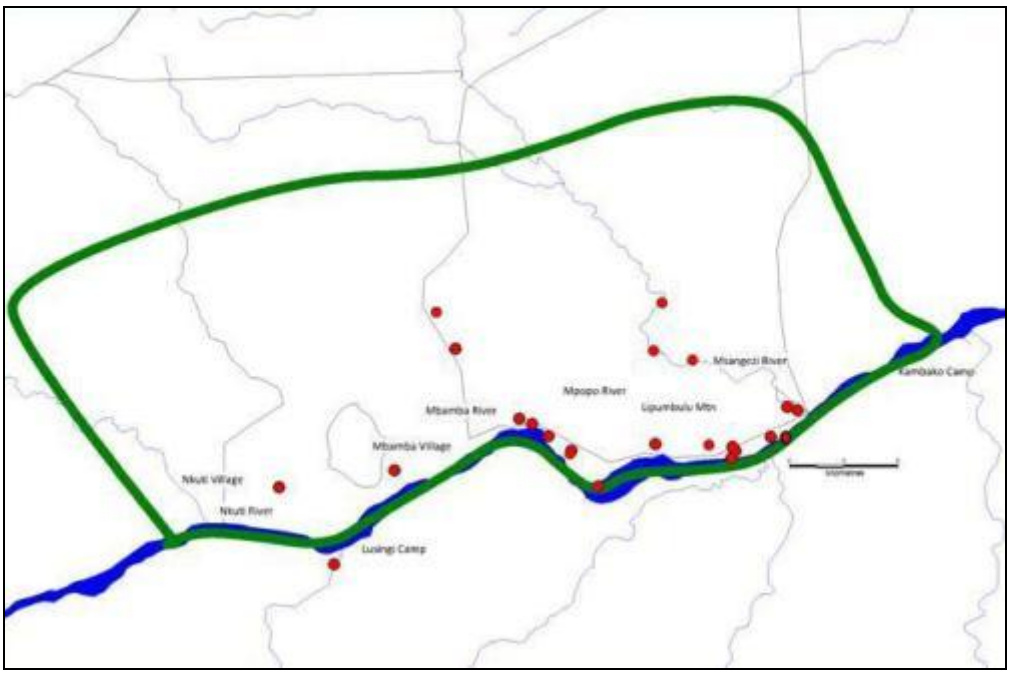


Fig.4: Position where lions were captured and collared inside the intensive study area of 800 km2 between 2005 and 2011.

Home range and movement patterns

In NNR, lions are seldom seen in a classical pride structure. Males are seldom seen with females and they frequently feed (and hunt) alone, away from the female groups. Female groups are fluid and small (mean= 1.57; range 1-6; n = 253 opportunistic sightings). It can take several months to determine which female belongs to which pride as they are seldom all seen together. This is likely to be due to the predominance of relatively small prey items such as warthogs in the diet and high human pressure. We have observed that lions avoid people by moving into thick bush when people appear which might constrain their activities. This has also been observed in other areas with high pedestrian traffic (Mana Pools National Park, Zimbabwe: N. Monks. Pers. Com and Laikipia: A. Cotterill pers. com).

Date from radio-marked lions (and leopards Begg & Begg 2008, 2009: Annual reports) clearly show that the Lugenda River forms an important territorial boundary (Fig. 5; Fig. 6). While lions can cross during the dry season, are pulled across by elephant carcasses and do spend considerable time on the islands of the braided channels, they can generally be identified as either south bank or north bank lions. The exception was LICM01 (Campo) who utilised both sides of the river. During this period (2005-2007) there does not appear to have been another territorial male along the south bank near the Luambezi River perhaps due to high sport hunting pressure. Between 1998 and 2006, at least 7 lions were shot as trophies from one site. LICM01 was also seen on sport hunting bait in this area and was only not shot because he had a collar and was under the age of 6 (Begg & Begg 2007).

Three prides have been identified in the study area (Fig 5; 2011 F-Pride: 2 adults, 1 cub; M-Pride: 3-adults, 3 Subadults; A –pride: 2 females, 3 cubs). The numbers of individuals in each pride varies on an annual basis due to mortality with high unnatural turnover. In 2006, F – Pride consisted of two adult females and two groups of cubs (2 + 3), in 2008 the pride consisted of 1 adult female and 3 sub-adults, the other adult female had died and the cubs had disappeared. In 2011, the pride consists of two of the sub-adult females now adults, with one cub, two females have disappeared and one cub was killed due to infanticide. The Mbamba pride shows a similar pattern with four radio marked individuals killed in (one adult female, one sub-adult male, and two adult males), in addition two collared lions have disappeared in this area and two un-collared lions were found just outside the electric fence. Local hunters report that 5-6 lion skins are moving through the village each year. During this same seven year period there have been three changes in adult males. In other areas with low mortality from snaring and persecution, female groups can defend the same territory for many years and can consist of 2-18 females (Whitman & Packer 2007).

While data on recruitment is anecdotal as the lions are not generally habituated and we do not regularly see them, cub mortality appears high. Over the duration of seven years (2005-2011) we have recorded only 4 sets of cubs (3+2+2+3; 10 cubs) from the three prides in the intensive study area and to date only three cubs are known to have reached adulthood and remained in the pride (F-pride). Since males and females are seldom seen together, hunt separately and show slight differences in movement patterns, we analysed the territory size separately for males and female (Table 9). However, overall there were no significant differences in the mean home ranges of radio-marked male and female lions (Table 9; t-test, 90%: $F=1.11$; $p=0.96$; 50%: $F=1.524$; $p=0.87$).

It can clearly be seen in Fig. 5 and Fig. 6 that lions in the M-pride are avoiding the area to the south of Mbamba village between the village and the Lugenda River during the dry season. This is probably due to high pedestrian traffic in this area as people move to the river to tend extensive tobacco fields, collect water and bathe. Members of the M- pride are elusive

to catch and seldom seen in the dry season but are regularly seen in the mashambas during the wet season and regularly snared in close proximity to Mbamba village surrounds (2008-2011; n = 6). In 2008, lions were observed in Mbamba mashambas on 15 occasions between January and April; in 2009 there were 13 sightings inside the Mbamba mashambas. Lions are entering the mashambas to catch bush-pigs and warthogs that are significant crop pests.

In Fig 7, the territories of two consecutive coalitions of male lions of A-pride are shown. The M2-coalition consisted of two over eight year old lions that took over when LICM01 disappeared (2008-2009). In 2010, these two old lions had been replaced by the J- Coalition of two younger males (4-6 years). Lion movement patterns are frequently centred along the major Lugenda tributaries, particularly the Msangezi, Mbamba and Nkuti River. This can clearly be seen in Fig 6 and Fig. 7, where the J-Coalition spends much of their time along the Msangezi River. These tributaries still have pools of water late into the dry season (Fig. 8).

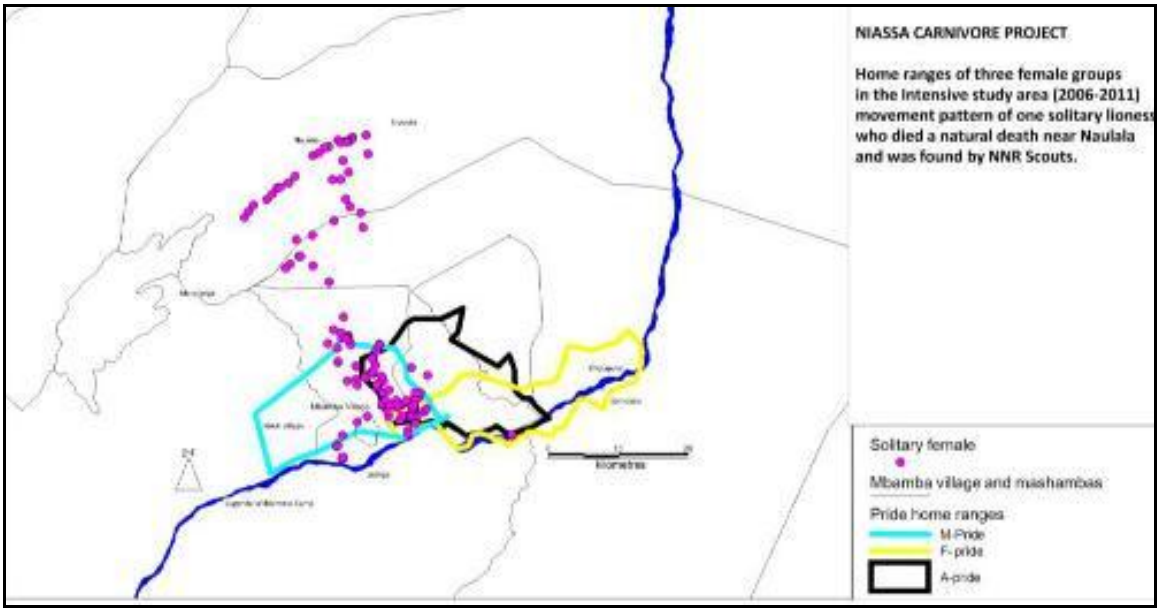


Fig. 5: Home ranges of three female prides in the intensive study area as determined from positions provided by GPS collars on selected individuals in each pride between 2005 and 2011. The movements of an old female lioness that was solitary are also shown. She was marked at an elephant carcass on the Lugenda River and was found dead (natural death) by NNR scouts.

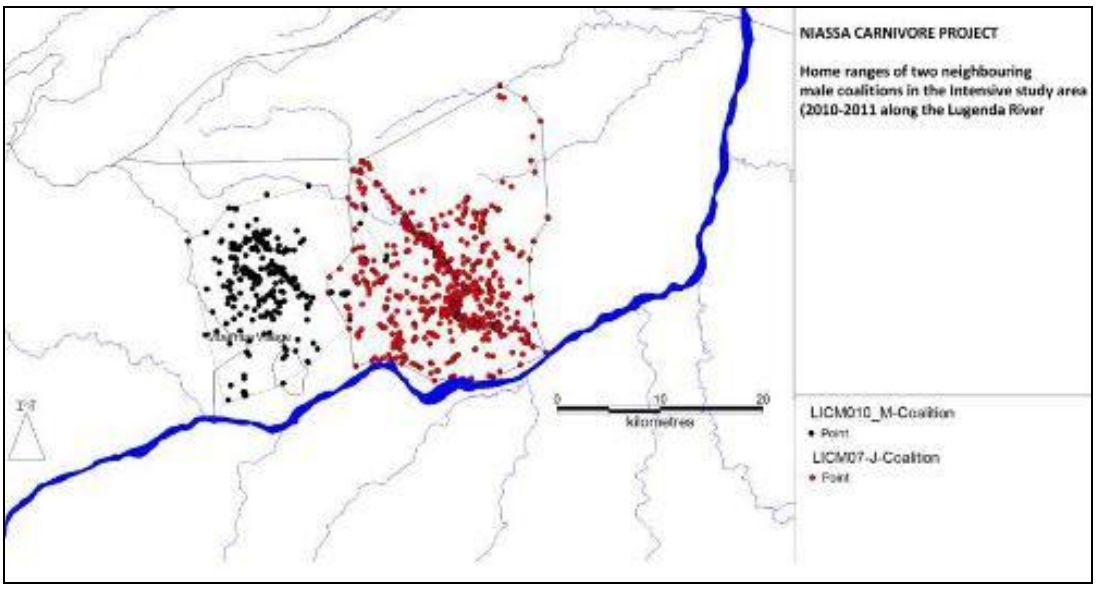


Fig. 6. Home range of two neighbouring male coalitions (M-Coalition and J-Coalition). Note the concentration of activity along the Msangezi River for LICM07-J-Coalition (red) and overlap of the home range of the M-group with Mbamba village. These males and the M-Pride (Fig 2a) are the Mbamba village pride.

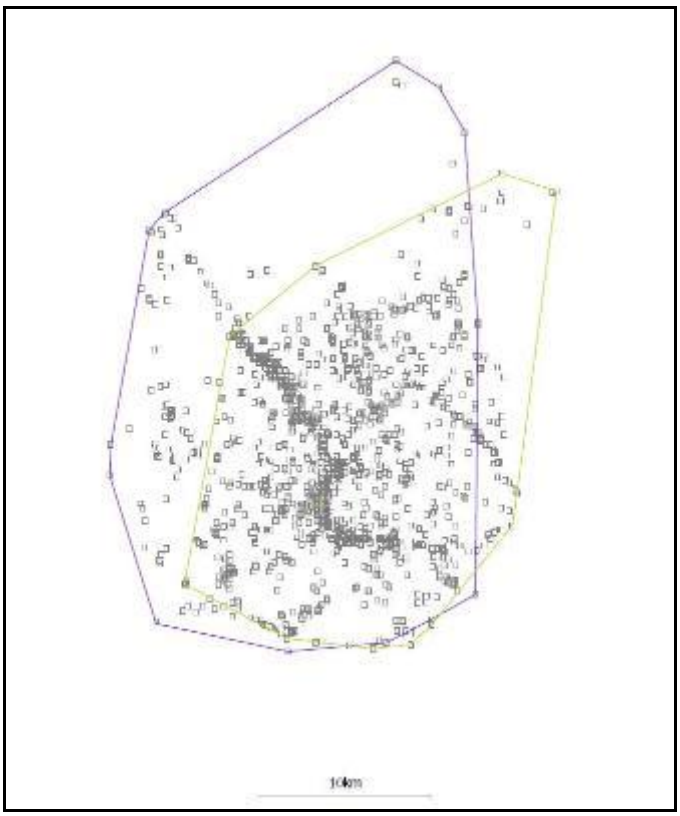


Fig.7: Territory boundaries of two consecutive male coalitions of A-pride, with the purple boundary M2 Coalition (2008-2009) and the green outline J-Coalition (2010-to January 2011).

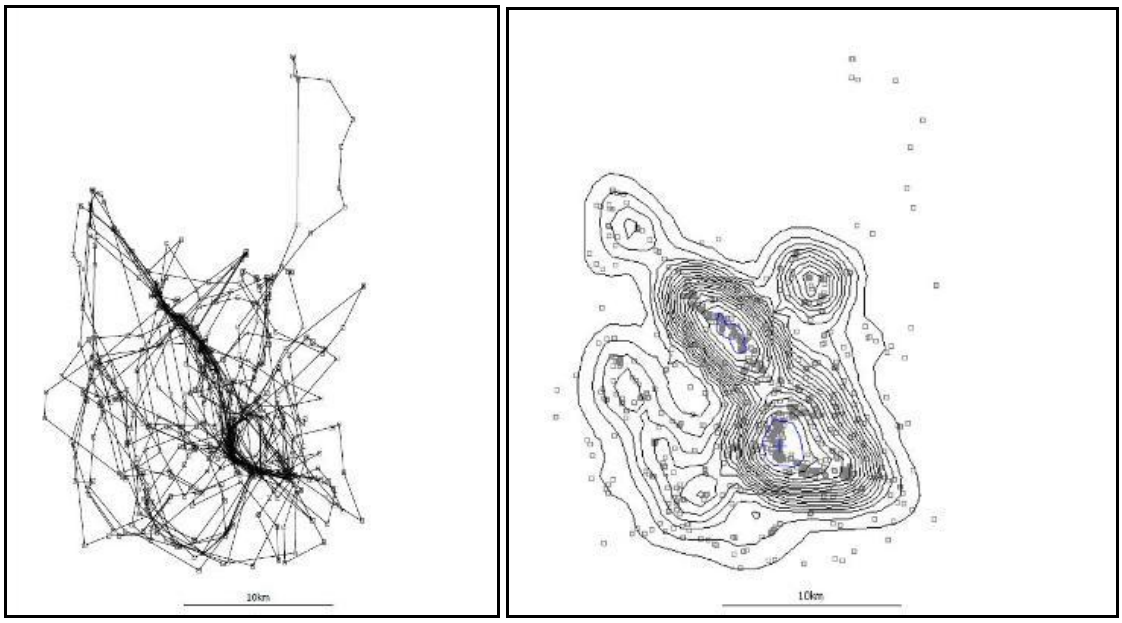


Fig. 8: Track plot and kernel analysis of J-Coalition (2 males) positions over a seven month period showing the high utilization around rock pools on the Msangezi River.

The mean home ranges of Niassa lions are four times larger than those recorded in SGR (207.2±16.0km2 vs. 48.5 km2; Brink 2010; kernel analysis 90% utilization). Core areas follow the same pattern (64.2 ±7.8 km2 vs. 12.7 km2). This also follow the density estimates for NNR (Chapter 1), which are 4.6 times lower than the densities of adult lions in SGR . This difference becomes easier to visualize when you consider that in 2010, a 800km2 intensive study area in SGR supported 112 adult lions while an area of the same size in NNR only supported 22 adult lions. As suggested by Chapter 1, this is likely to reflect low prey biomass and illegal off-take of both prey and lions in bushmeat snares.

Non territorial males

The S-coalition males are nomadic males with an extensive home range that extends across the Lugenda river through L8-concession out of the Reserve into Negomano safaris concession (90%:1110km2; 50%: 236 km; Table 9). Their home range is 5 times larger than the mean home range of territorial male lions. These two males were caught and collared on an elephant carcass in the centre of the intensive study area, and subsequently monitored for more than a year (Fig. 9). The collared male was killed in a snare in October 2011. The movement patterns of these two lions are of particular interest as they follow a north-south pattern, similar to a collared buffalo herd (Thomas Prin, NNR buffalo study, pers. Com). The track of this male's GPS positions shows that while they use an extensive area, they are regularly moving through this area revisiting areas they have been to previously (Fig.10). They have been recorded feeding on elephant carcasses on three occasions.

Table 9: Home ranges of three adult females and six adult male lions in intensive study area calculated using minimum convex polygons and kernel methods. Note the large home range of the nomadic male coalition.

Id. No.	Sex	Group	No. Indiv.	No. Locations	Total months followed (+ is still collared)	Type of collar	Status	Home range analysis (sq.km.)			
								Minimum Convex polygon		Kernel Analysis	
								100%	95%	90%	50%
LICF03	Female	F-pride	4	1532	13+	GPS+VHF	VHF collar	323.75			
LICF06	Female	M-pride	5	153	4	GPS	Died, natural	303.25			
LICF04	Female	A-pride	4	940	4	GPS	Died, snare	382.28			
Mean Female								336±23.7	285±11	236±23.2	79.5±96
LICM07	Male	Territorial	2	1579	18+	VHF+SAT	SAT collar	480.77	283.59	165.36	49.53
LICM01	Male	Territorial	1	715	29*	GPS	Disappeared	560.39	173.09	135.59	51.28
LICM10	Male	Territorial	1	355	7	GPS	Died, snare	264.78	194.31	196.21	31.59
LICM06	Male	Territorial	2	1154	11	GPS+VHF	Disappeared	336.69	357.63	204.73	54.47
LICM03	Male	Territorial	1	2222	10	VHF+GPS	Died, snare	452.38	378.57	248.21	88.39
Mean Male								419±52.6	277±41.5	190±19	50±9.2
LICM12	Male	Nomadic	2	1934	15	GPS+SAT	Died, snare	2873	208.79	1110.03	236

* LICM01, first lion collared and followed between 2005-2007, In wet season 2007, pride was taken over by 2 new males, he disappeared and was eventually only relocated in August 2009 near Mbamba Village. He was re-collared, frequented Mbamba mashambas during wet season before disappearing, believed snared in mashambas from village reports, collar not recovered.

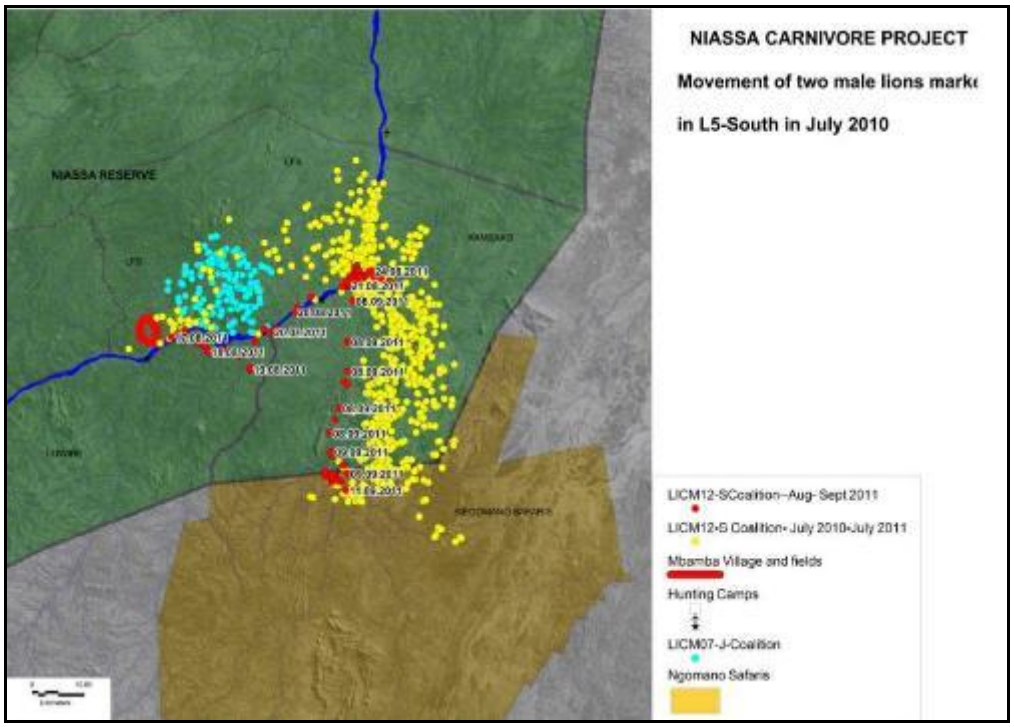


Fig. 9: Positions of a nomadic male coalition over a 14 month period showing the lions movement outside of the Reserve boundary.

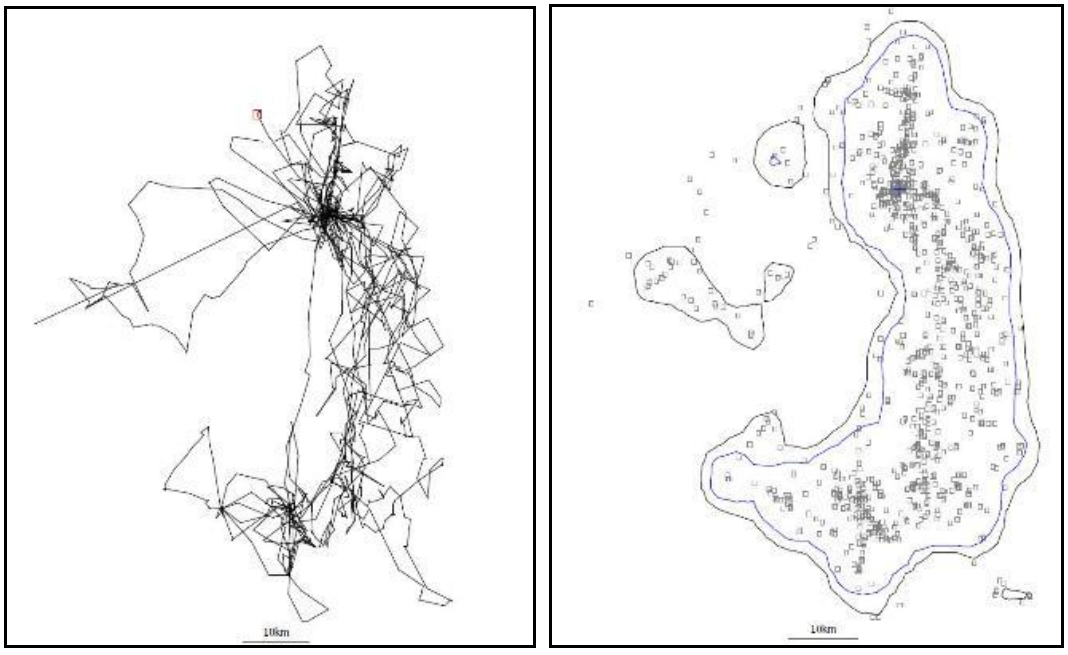


Fig.10: Track of the nomadic male over a 14 month period showing the repeated north south movements and 90% kernel home range outline. Compare this with Fig 2d of the territorial males.

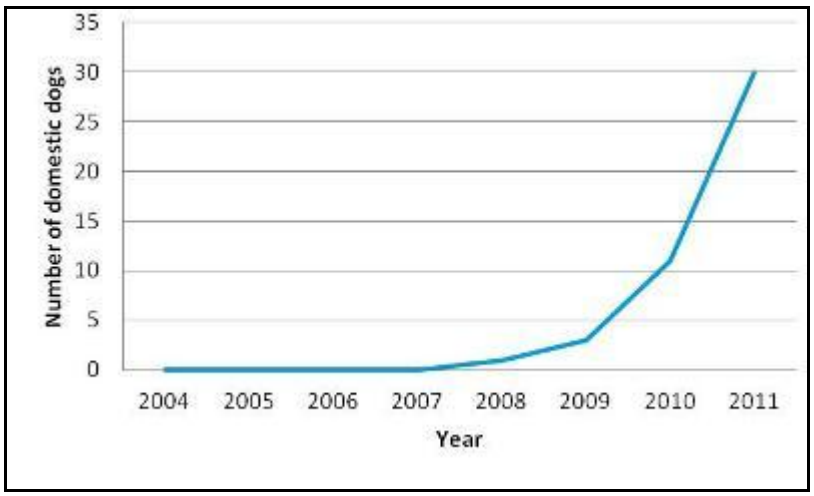
Disease and domestic dogs

Despite suggestions that disease is a major cause of mortality of lions in NNR and that NCP has not been addressing this issue (V. Booth pers. com), no records of lions dying from disease or suspected of dying from disease have been recorded in the intensive study area. In addition, blood samples from immobilized lions (n=36 samples) have all tested negative for canine distemper, canine parvovirus, feline calcivirus, and corona virus. 35 lions (both research and sport hunted) were tested for FIV ("Feline AIDS") and 15% tested positive. FIV is therefore present in the NNR lion population however prevailing opinion is this is unlikely to be having any negative effect on the lion population.

The potential disease threat remains real, due to the presence of a growing and unvaccinated population of domestic dogs inside villages in NNR and this needs to be addressed. Domestic dogs are known to be the reservoirs of these disease and spread of canine distemper and rabies to carnivores in NNR. The potential threat these dogs raise for wildlife populations particularly carnivores has been highlighted in every NCP annual report as well as in special reports provided in 2007 and 2010. (Begg et al 2007).

NCP has conducted two domestic dog surveys by direct counting of dogs in villages across NNR (2006, 2011). The results show that the number of domestic dogs inside NNR has increased from 144 in 2006, to 583 in 2011. In addition the number of villages that now have dogs has increased from 16 villages in 2006, to 28 villages in 2011 with 6 additional villages that did have a few dogs in 2010 but they died from carnivores or disease (Gomba, Matondevela, Naulala2, Mucoria, Cuchiranga and Chamba). While the eastern village in the Mecula district were largely dog free (except for Mecula, and one dog in Chuchiranga) in 2006, dogs are now spread throughout the eastern villages where there are high densities of game.

The number of domestic dogs in Mbamba village has been monitored since 2004. The first dog arrived in 2008, and the domestic dog population has increased to 30 dogs in 2011, with an associated increase from 1 to 10 owners (Fig. 11). The dogs are primarily kept to protect fields from baboons. It is imperative that the disease status of lions continues to be monitored in the intensive study area given the high levels of contact between people and lions in the Mbamba village. It is hoped that the living fence program will reduce this contact in future.



Fig, 11: Exponential increase in the domestic dog population in Mbamba village, in eastern NNR.

Along with monitoring of the disease status of the carnivores in NNR, mitigation of the disease threat is essential. An urgent decision needs to be made by SRN for the way forward with regards to the domestic dog population in NNR as an unvaccinated domestic dog population in a protected area is not compatible with conservation goals. This is of particular concern for the NNR African wild dog population that is of vital worldwide conservation importance. Various documents have already been produced by NCP and Rui Branco in this regard. When a decision is reached by SRN, NCP remains committed to assist wherever possible, particularly with fund raising.

Mortality

In total 27 known lions have died or disappeared from the intensive study area of only 800 km2 between 2005 and 2011 (7 years; Table 10). This is a minimum estimate as we only began an intensive radio collaring effort in 2010 because we were concerned about the levels of mortality. This is also an area that does not have the added off-take of males from sport hunting. A minimum of 41% of deaths are known to have been from snaring with an additional 11% of the unknown deaths believed to be from snaring due to the proximity of the lions to the Mbamba village. Snaring is therefore likely to have resulted in 52% of the deaths.

It is difficult to calculate the proportion of the population dying on an annual level as there is a constant influx of new individuals. The density of lions in the study area is remaining relatively constant at present (Chapter1) despite this extreme mortality due to immigration of new lions from neighbouring areas. This level of mortality is preventing the population from increasing. In November 2009, 25 lions at least were identified within the intensive study area, by November 2010, four of these individuals had disappeared (18%; 1 unmarked breeding female, 1 unmarked resident male, 2 marked resident males). In addition three individuals (not known in 2009) but marked in June/ July 2010 were dead (1 male part of a male coalition, 1 resident male, 1 female (old female, no pride). In total a minimum of seven lions (5 males, 1 female) from an estimated maximum population of 25 lions in 800 km2 disappeared or died (28%) in one year. In 2011, a similar picture emerged, in a year period between November 2010 and November 2011, two adult males were snared, one 8-month old cub died of infanticide, and two males (one collared, one un-collared) and one female (collared) disappeared. In comparison natural background mortality from the Serengeti lion population is 5% for resident adult males, and 1.4% for adult females with a total adult mortality of 6.4%.

Table 10: Known mortality of lions in the intensive study area in a seven year period (2005-2011)

Age & Sex	Cause of Mortality					Total
	Natural	Snare	Research	Unknown	Infanticide	
Adult						
Male	0	5	1	3		9
Female	2	1	0	3		6
Unknown	0	5	0			5
Subadult						
Female	0	0	0	1		1
Male	1	0	0	1		2
Cub	2			1	1	4
Total	5	11	1	9	1	27

In total, 16 of the 28 animals collared (57%) are dead or missing (5 females and 11 males). Snaring is known to have killed six collared lions with a further three lions believed to have been caught in snares from village reports and proximity to village. This means than 56% of the collared lions that have died have been killed in snares while only 18% have died natural deaths. Data from the radio-marked populations suggest that more adult males than females are being killed in snare (10% of females; 44% of males). The rapid turnover in territorial males has the added effect of infanticide of young cubs.

The lack of an aircraft in NNR has been a major constraint on this portion of the project as it has limited our ability to monitor the radio-marked lions on a consistent basis over their large home ranges and download data-points regularly before the collars fail or lion is killed. Suggestions that NCP should be monitoring lions that move outside NNR and in more central areas of NNR (Cumming 2010, Booth pers com, 2010) are simply not possible at present given limited funds and time. At this point the protected area itself is not secure due to human mediated off take inside the protected areas. Resolving these threats should be the priority.

It is not only lions that are being heavily affected by snares as all three of the radio-marked adult female leopards were snared and killed in 2010 and turnover in the leopard population in L5-South monitored in 2008 -2010 is high (A. Jorge in prep).

While our initial predication was that high levels of snaring were only found within close proximity of villages and fields, i.e. within a 10 km radius, the reality is that bushmeat snares are being set throughout the intensive study area due to the heavy presence of pedestrian traffic and fishermen along the Lugenda River (Fig. 11). As noted in our 2004 report of fishing activities within L5-South (Begg *et al* 2004) and recently updated, there are more than 40 fishing camps along a 37km stretch of the Lugenda River (L5-South southern boundary). These fishermen are also the hunters and honey gatherers and human impact is widespread throughout the study area. There is no core area in the intensive study area or L5-South at present that is fully protected.

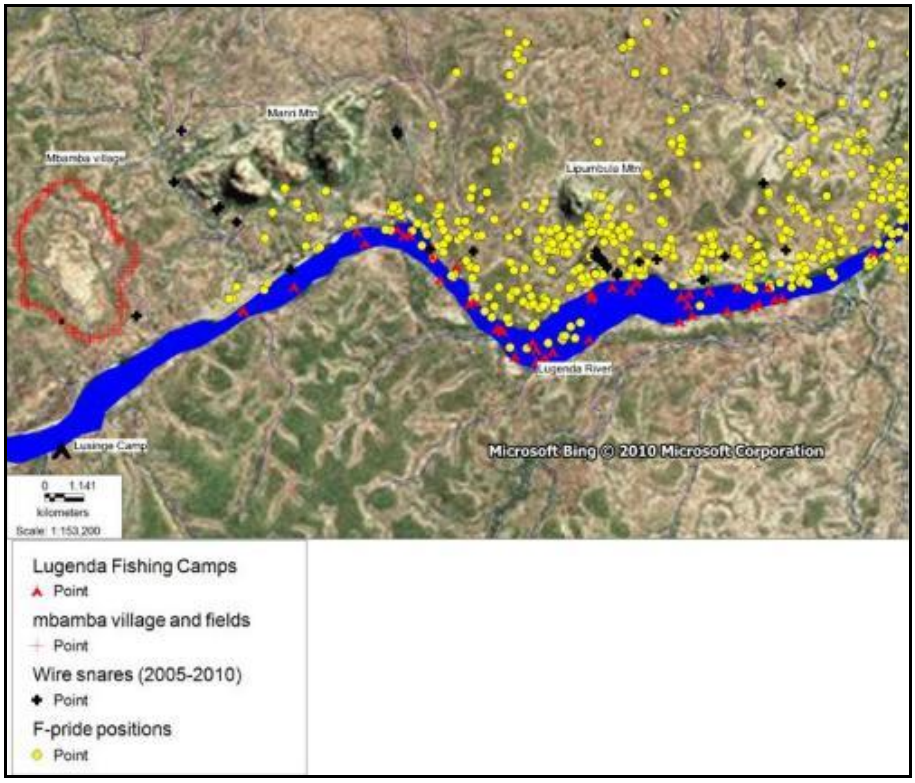


Fig.11: Human influence in the intensive study area (fishing camps, snare lines and Mbamba village) between 2005 and 2010. The positions of the F-pride (4 females) are shown to illustrate that movements of lions occur in an area of high human presence.

For lions, at least, they are not targeted but "by catch" of the snares set for bush-meat. Skins are sold when lions are caught (Mt 3000 – Mt 5000 / skin; $96- $160). In contrast leopards are caught in specific leopard snares as well as in bush-meat snares.

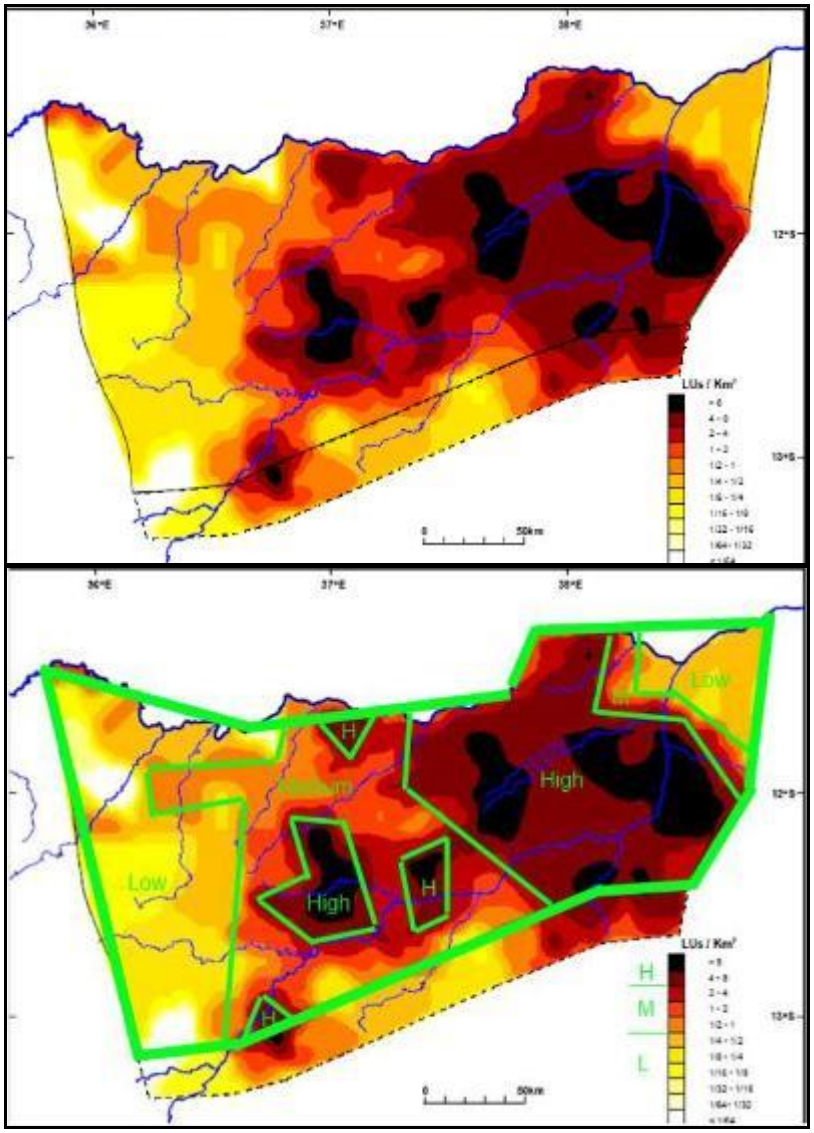
Snaring is obviously related to human population pressure and the need for bushmeat. It seems reasonable to predict that snaring is higher around large villages than smaller ones due to the increased demand for income and bushmeat. To obtain a ballpark estimate on the possible number of lions snared across NNR in a year we used the information on snaring around Mbamba village (1040 people; Census 2007). The number of lions snared by Mbamba residents is 2-5 lions per year, which is 0.002-0.005 lions killed / human resident. This suggests that between 70-175 lions may be killed in NNR each year. The upper end of this estimate is extreme and is unlikely but the lower number is entirely possible. It is likely that the intensive study area represents the upper extreme of lion snaring in NNR given the size of Mbamba village (more than 1000 people), position (on the Lugenda River in high game density area) and level of pedestrian traffic and resource use due to the high density of fishing camps in the area.

However, even if only 40 lions are killed through snaring each year (one lion per village), this combined with sport hunting (6 -8 lions of a quota of 22) and 6% natural mortality may not be sustainable. NCP is currently modelling these effects based on this information using the program SimSimba (see below). Even without full details of the model available, these data confirm NCPs view that bushmeat snaring is a significant conservation threat to wildlife in NNR and needs urgent attention. This is discussed in more detail in Chapter 3.

SimSimba Model

Landscape Map:

To develop a theoretical “”natural “” lion population for NNR against which current legal and illegal off take levels can be tested we used data collected in the intensive study area and from other studies to fit parameters to the SimSimba simulation model (Table 11). To run the model, a landscape map of NNR needs to be created showing a theoretical lion populations with “normal” mortality. Given that lion density is positively related to lean season prey biomass (Chapter 1), we used the wildlife density distribution map created by Craig (2009) from the SRN aerial census to map high (3 lions/ 100km2), medium 2 lions / km2)and low l 1 lion/ km2) lion densities across NNR. We would have preferred to use a map of potential lion prey biomass but this was not provided despite several requests for the data. The aerial census shows a gradient in the density distribution of wildlife with more wildlife in the east than the west and lower around villages (Fig.12, from Craig 2009). This is a finer scale version of what we are seeing in the lion call up survey with different densities in watershed and riparian habitats.



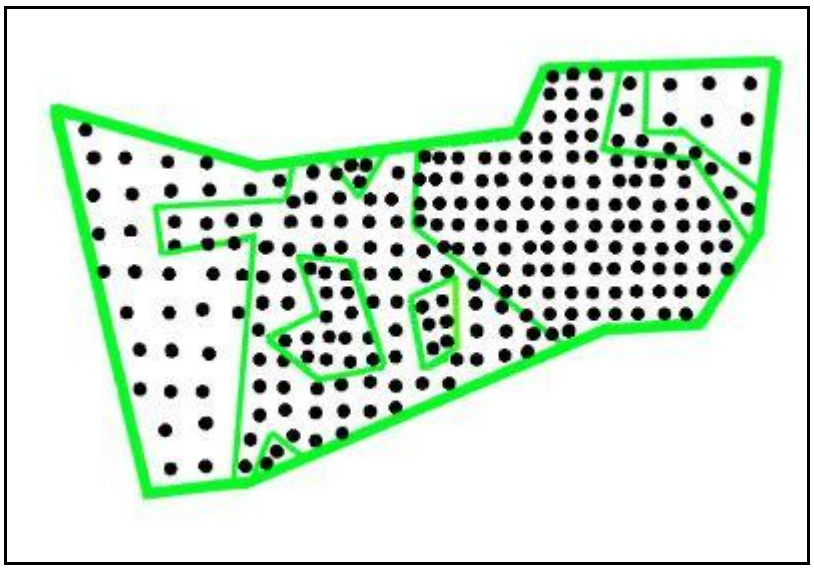


Fig 12: Shape of Niassa National Reserve and density distribution of game from the SRN aerial census (from Craig 2009) with a lion density overlay of low (0.009 lions / km2), medium (0.02 lions/ km2) and high (0.03 lions/ km2) and populated with 215 prides according to the density estimates.

Table 11: Parameters used in the SimSimba model with the Niassa values in bold. Where no information is available Serengeti data has been used as the convention for use of the model.

	Niassa Values	Serengeti Values	Unit
MaxAge	13	13	years
FemaleMax	3	6	lions
MaleMax	3	10	lions
Cub2Age	0.5	0.5	years
Cub3Age	1	1	years
SubadultMaleAge	2	2	years
SubadultFemaleAge	2	2	years
MaleReproduceAge	3.5	2.5	years
FemaleReproduceAge	4	3	years
AdultMaleAge	5	4	years
AdultFemaleAge	5	4	years
SurviveCub1	0.77	0.77	Per timestep
SurviveCub2	0.83	0.83	Per timestep
SurviveCub3	0.87	0.87	Per timestep
SurviveSubadultMale	0.93	0.93	Per timestep
SurviveSubadultFemale	0.986	0.986	Per timestep
SurviveResidentMale	0.95	0.95	Per timestep
SurviveNomadicMale	0.9	0.9	Per timestep
SurviveAdultFemale	0.986	0.986	Per timestep
SurviveEvictedMale	0.4	0.4	Per timestep
SurviveOrphan	0.5	0.5	Per timestep
SurviveHomelessFemale	0.5	0.5	Per timestep
SurviveTakeoverCub1	0.01	0.01	Per takeover
SurviveTakeoverCub2	0.25	0.25	Per takeover

SurviveTakeoverCub3	0.65	0.65	Per takeover
SurviveDefendingFemale	0.95	0.95	Per takeover
SurviveDefendingMaleWins	0.97	0.97	Per takeover
SurviveDefendingMaleLoses	0.4	0.4	Per takeover
SurviveAttackingMaleLoses	0.5	0.5	Per takeover
SurviveAttackingMaleWins	0.97	0.97	Per takeover
LitterSize1	0.19	0.19	Per litter
LitterSize2	0.35	0.35	Per litter
LitterSize3	0.33	0.33	Per litter
LitterSize4	0.13	0.13	Per litter
CubMale	0.5	0.5	Per birth
CubAbandoned	0.7	0.7	Per timestep
NomadMoves	3	3	Per timestep
SubadultMaleMoves	1	1	Per timestep
ResidentTakes	3 only 2	3 only 2	Per timestep
	0.33	0.33	
ResidentTakes	X	4 or more 2	Per timestep
		0.75	
ResidentTakes	X	4 or more 3	Per timestep
		0.33	
NomadJoins1Resident	0	0.5	Per timestep
NomadJoins2Nomad	0	1	Per timestep
NomadJoins2Nomads	0	0.2	Per timestep
FemaleMoves2	0.8	0.8	Per dispersal
FemaleMoves3	0.3	0.3	Per dispersal
FemaleMoves4	0.15	0.15	Per dispersal
FemaleMoves5	0.1	0.1	Per dispersal

We estimated how many pride territories there could be inside NNR given a possible carrying capacity of 1300-1400 lions (Chapter 1, based on potential available prey biomass). This represents 215 territories. Estimating the average pride size was complicated by small sample sizes and the difficulty in knowing what normal is in NNR given the high levels of snaring that have been a feature since we started the study in 2005. The landscape map was then seeded with a few lions and increased until it reached carrying capacity (Fig 13). It will now be possible to test this model with different scenarios and off takes. These data will be presented in due course. However it must be remembered that this is just a model, and therefore its value lies in experimenting with different values to assess their effect on the population.

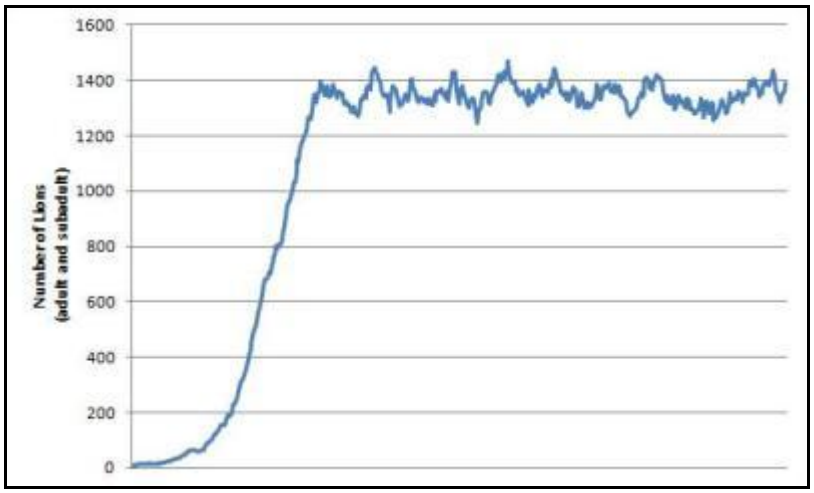


Fig. 13: Theoretical lion population in Niassa Reserve seeded from a few individuals and then reaching carrying capacity between 1300-1400 lions.

CHAPTER 3: BUSHMEAT SNARING AND CONSUMPTION IN NIASSA RESERVE.

INTRODUCTION

Inadvertent snaring has been identified as the main threat to lions in NNR based on the number of lions and leopards dying in snares in the intensive study area (Chapter2). In this chapter we look at snaring from the human perspective i.e. bushmeat consumption. Lions and other carnivores are caught in snares that are set for bushmeat i.e. wild animals eaten as meat. Lions are not the target there are simply caught as by-catch.

As in other areas communities in Niassa are primarily subsistence farmers with small numbers of domestic livestock (no cattle), and large families (5-10 children) and are therefore likely to have high nutritional requirements. Hunting is common in NNR both legal through sport hunting quotas and illegal through snaring, poisoning, and trapping. However, bushmeat is responsible for a much higher off take of animals per year than sport hunting and is a significantly bigger threat to wildlife. As in most areas, bushmeat snaring is not only driven by the availability of alternative protein sources but is also driven by the financial gains to hunters who balance the risk of getting caught against the profits of selling the meat. Other studies have shown that there is also a link between fish stocks and bushmeat consumption that needs to be examined further in NNR. In other areas, fisheries and bushmeat hunting are tightly linked with years of poor fish supply resulting in an increase in bushmeat hunting (Brashares *et al* 2004). As is the case in other areas, bushmeat harvesting in NNR (Redmond et al 2006) is very similar to the fishery in NNR (Begg *et al* 2004) as:

a) it is currently open access and difficult to control,
b) it depends on hidden assets and it is hard to assess stocks accurately,
c) yields will improve with improved technology and better access (roads, transport systems),
d) it is a boom and bust system with likely increase in exploitation until a population crashes and specific species go locally extinct and
e) it causes collateral damage of large carnivores – crocodiles caught in nets, and large carnivores caught in snares.

Bushmeat snaring is not a new problem in NNR but the increasing human population in NNR makes this an increasing threat and one that needs immediate attention. Unfortunately the solutions are neither simple nor immediate. Snaring is unlikely to be resolved by law enforcement alone not only because this addresses the symptom not the cause (Rentsch 2010) but also because of the extensive areas that need to be patrolled with a relatively small budget and scout force.

METHODS

Questionnaire surveys

Snaring, like all forms of wildlife off take except fishing and sport hunting, is illegal. This makes it difficult to collect accurate information on the level of hunting as people are afraid of the consequences of telling the truth. To overcome this problem we conducted two specific but simple surveys in 2010 and 2011. The first survey (n = 40 interviews) was purposefully focused exclusively on fishermen based at fishing camps on the Lugenda River in L5-South. We have known the majority of these fishermen since 2003 and have developed a trust relationship with them. As detailed in Begg *et al* (2004), these fishermen are also the hunters, honey gatherers and our best chance of obtaining objective information on the level of hunting. This preliminary survey was focused on hunting techniques, the drivers of bushmeat snaring and identifying potential solutions through discussion with hunters. This survey would not have been possible with people we did not know well. The initial questionnaire developed by C. Begg was tested on NCP field staff who are all local residents, all have similar levels of schooling to interviewees (0-4 years) and two were significant poachers in the past. We were therefore able to develop and phrase questions that were simple and understandable and had the right local context. All interviews were conducted by C. Begg and Euzebio at the fishing camps. Euzebio is a Mbamba village resident and a former major poacher. While no names were taken, Euzebio knew most of these men personally and knew when they were lying and was frequently able to get the respondents to tell the truth by communicating the importance of truthful information so that we could find solutions. The preferences for different types of meat protein were assessed in two different ways. First we asked what type of meat protein people would buy if they had Mt100 (options given) and the second time we asked what type of meat protein they would choose if they didn't have to buy it i.e. if I had portions of all these different types of meat in my bag and I asked you to share a meal what would you choose?

The second questionnaire survey was completed in July / August 2011 and was focused on the relative consumption of different protein sources. This was a broad survey (n = 1228 interviews, n = 34 villages; range 4-318 interviews per village) conducted across all three districts in NNR. It only asked one question: "How many days in the past week have you eaten a meal with beans, eggs, fish, chicken, and guinea fowl, bushmeat or goat meat? (Rentsch, 2010). The dry season is the period of highest bushmeat consumption; however this questionnaire survey will be repeated on a smaller scale in target villages during the wet season. Bushmeat was not divided into different types and included all wild species except for guinea fowl. Guinea fowl were assessed separately because different snares are used to catch them and domesticated guinea fowl provide a potential alternative source of protein. This technique provides a simple indicator of bushmeat consumption that potentially can be used to track bushmeat consumption over time and in different seasons.

Interviews were conducted by our community extension team, Joaquim and Oscar. The question was asked in whatever language was most appropriate Cyao, Kiswahili, Makua. No

names were taken and interviews were preceded by an explanation of why the question was being asked (i.e.to assess food availability not assess illegal activity).

Data analysis

For the most part simple descriptive statistics were used to describe the data, particularly for the first questionnaire survey. For the second survey on bushmeat consumption, data were analysed as a) the average number of times protein was eaten per week, b) the relative proportion of each type of protein eaten as a proportion of the total number of protein meals recorded, c) Number of interviews where different protein sources were eaten. For comparison of protein consumption between villages, only villages where more than 30 interviews were used (n = 13 villages). A person could only indicate a type of protein eaten a maximum of 7 times (every day). This was done to simplify analysis and ensure that we did not over count the number of portions of meat or chicken those were eaten. When chicken or meat was eaten twice in the same day, this was generally the same portion of purchased meat or chicken eaten over two meals, not two chickens or two portions of meat in a single day. This became important when we came to calculate an estimate of the total kg of meat being eaten.

Results and Discussion

Protein preference

Of the fishermen interviewed (n = 40), 54% had eaten bush meat in the past week and 22% had eaten bush-meat more than once. 78% of the men interviewed would like to eat meat 3-4 times a week even though they had abundant sources of protein in the form of fresh and smoked fish and beans. While 53% of respondents preferred fresh red meat over other types of meat protein (Fig. 8), there does not appear to be any special benefits given to bushmeat over other types of red meat protein (strength, courage, power, immunity from bullets etc), bush meat is simple seen as a source of fresh red meat.

In both questions on preference village chickens were important representing the first choice of at least 29% of the respondents. Interestingly when people had to buy the meat protein, they chose to buy fresh meat (Fig 14), when people were able to choose a meat protein at no cost the choices were more evenly spread across the choice (Fig 15). This suggests that bushmeat provides the best value for money but is not necessarily the preferred choice on all occasions. Only 18% of the fishermen actually owned chicken. 68% of the fishermen did not own any domestic livestock all, with two having a few goats and two men owning both chickens and pigeons. There are no domesticated guinea-fowl in Mbamba village at present but these are present in Nkuti village, which is small neighbouring village.

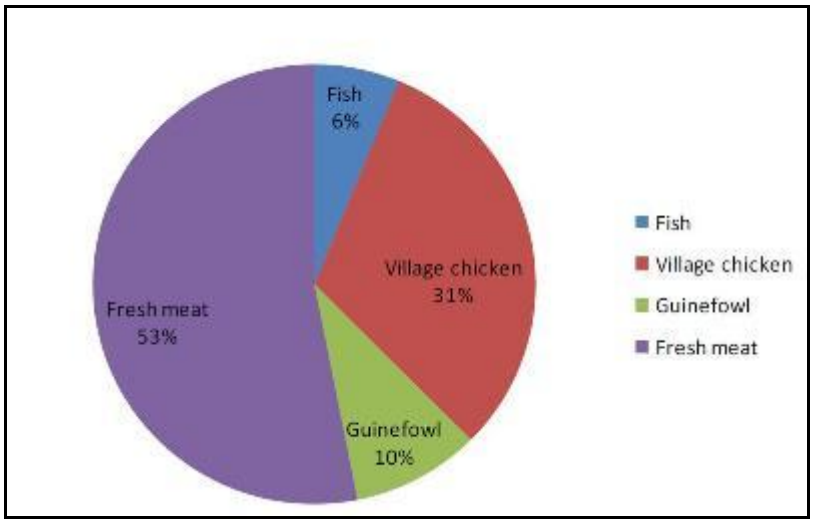


Fig. 14: Preference for types of meat protein that could be bought. The question asked was "If you have Mt 100 what would you buy"?

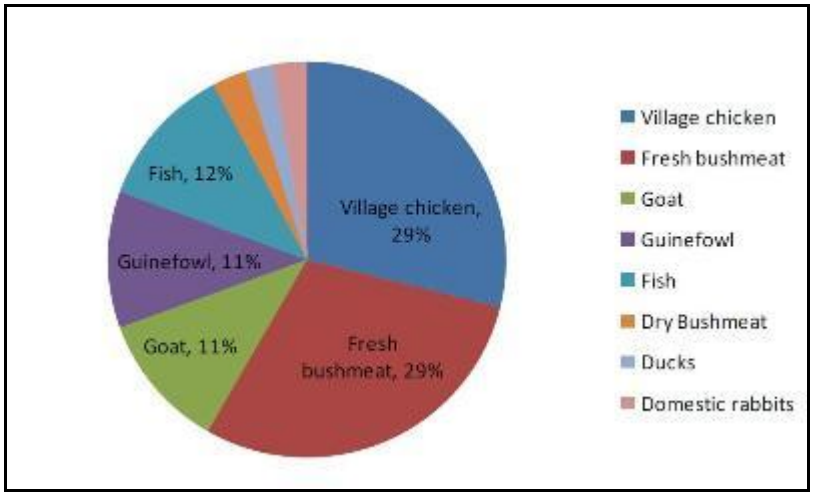


Fig. 15: Preferences for equally sized portions of different types of animal protein that did not have to be bought. The question asked was "I have equal portions of all these types of food in my bag (equal size, no cost) and you need to choose one for us to cook for dinner, which one would you choose"

Domestic meat protein is scarce and expensive. Bush-meat is more readily available and cheaper. It costs Mt 100-150 ($3-4) to buy a chicken but only Mt 20 ($0.60) to buy a guinea fowl or Mt20-Mt50 ($0.60-1.6)for a small to medium portion of fresh bush-meat (250 - 300g). A portion of dried bush-meat costs only Mt 10 ($0.32) and an entire impala leg Mt 300 ($10; 2 chickens). The reasons for not keeping domestic livestock included no money to buy initial stock (particularly relevant for goats), disease and theft (particular relevant for chickens). There appears to be a large die off of chickens every year in the late dry season, which is likely to be due to Newcastle's disease. Bush-meat preferences show that buffalo, zebra, porcupine, impala and guinea fowl are highly sought after (Fig. 16).

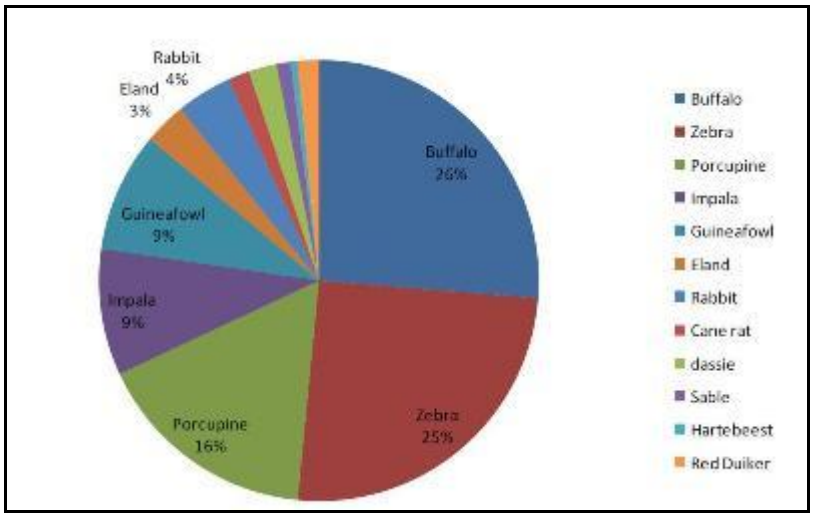


Fig. 16: Preferences for equally sized portions of different types of bush meat. The question asked was "I have equal portions of all these types of bush meat in my bag (equal size, no cost) and you need to choose one for us to cook for dinner, which one would you choose?

Hunting techniques

Eight different types of snaring and trapping were identified over the course of the interviews (Fig. 17). This combined with the 24 different fishing techniques identified on the Lugenda and Ruvuma Rivers (Begg et al 2005, 2006) shows that hunting and fishing in NNR is a highly specialised activity. Only 5 of the 40 people (12%) interviewed knew how to hunt using cable or wire snares *(Makukulula;* Fig. 17). Only one person knew how to construct an elephant pit trap and two people knew how to construct a spike trap for elephants The majority knew how to catch small birds using a specially designed cage trap *(Liululu*), and 30% knew how to snare guinea fowl and ground birds (Changanga; Fig. 17). No questions were asked about elephant poaching with fire-arms (which is currently on the increase in NNR) as this was for ivory not bushmeat. The majority of Niassa residents do not eat elephant meat as they are Muslim.

Since this sample consists entirely of fishermen/ hunters, it is likely that a much smaller percentage of the general Mbamba male population know how to hunt bushmeat. Community meetings and conversations with fishermen and staff confirm that less than 12 men (5-8 specialized hunting) in Mbamba village are engaged in hunting on a regularly basis. These hunters make a significant income from snaring however they do not do it full time, they are also fishing and honey gathering. They spend three weeks in the field snaring, sell the meat and then are occupied with other activities for awhile. Initial discussions suggest that local hunters are trained by experienced hunters in the community through an apprenticeship. They ask for specific traditional medicine to keep them safe. Specialized snaring and hunting is not done by everyone, it is a skill that is learned by a select few. This is important information as it means that solutions to reduce bushmeat snaring must target these specialized hunters particularly.

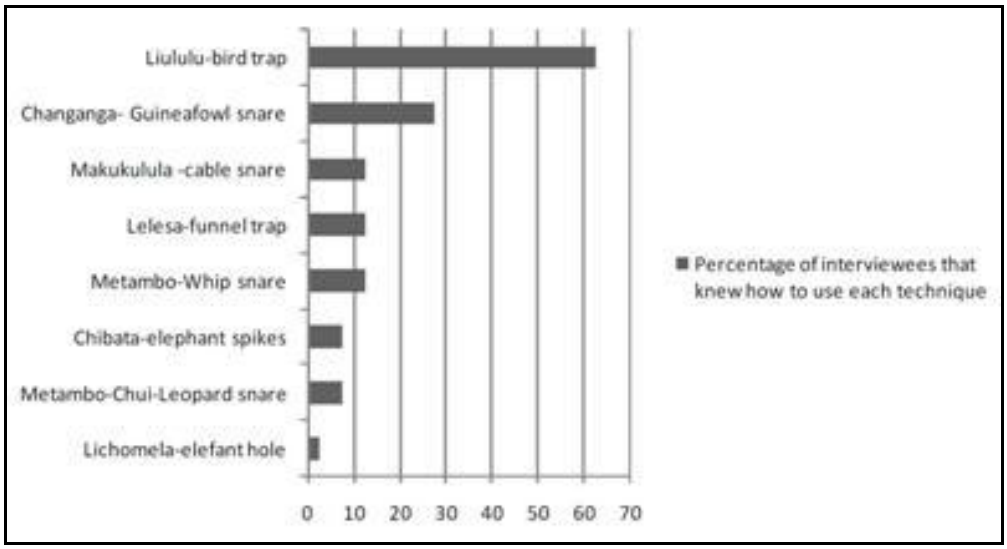


Fig. 17: Percentage of interviewees that knew how to use the different hunting techniques illustrating how specialized hunting knowledge is.

There is little official employment (research, tourism, reserve, and building roads) for men in Mbamba village and bartering is common. In total 11 income-generating activities were identified by the fishermen (Fig. 18). Given that it was fishermen we were interviewing it is no surprise that fishing was their main economic activity. Other important activities are honey gathering (Mt40 / litre), *ganyo (*casual work done in the village for neighbours e.g. digging latrines Mt 150, making bricks (Mt 1000 for 2000 bricks etc.). Transporting goods for other people is a common activity with Mt 1000 paid for the two day trip to Cabo del gado.

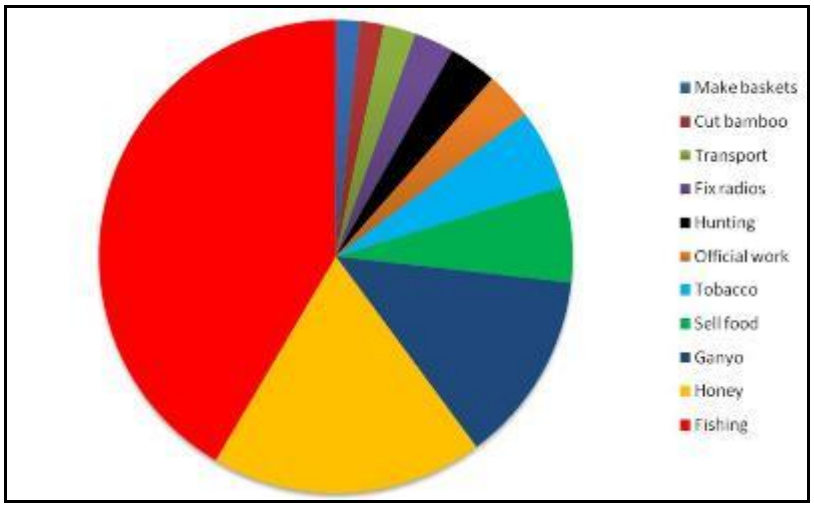


Fig. 18: Preferences for income generating activities based on answers to the question: "If you need cash what do you do, list 3 in order of preference"

Bushmeat consumption

The majority of people interviewed (N= 1128 people, 34 villages) had eaten beans (88%) and fish (86 %) at least once in the past week (Fig. 19). This highlights the importance of the Lugenda River and other tributaries for communities in NNR and the potential negative consequence if it were to collapse. Nearly half of those interviewed had eaten bushmeat (47%) and eggs (44%), while less than 40% of those interviewed had eaten guinea fowl, chicken or goats. On average, fish and beans were both eaten about 3 times a week while bushmeat were consumed 1.1 times a week (0-4) similar to the consumption of chickens (Fig 20). While many of the people interviewed had not eaten eggs, goat, guinea fowl, chicken or bushmeat in the preceding week, everyone had eaten at least one meal of fish or beans in the preceding week.

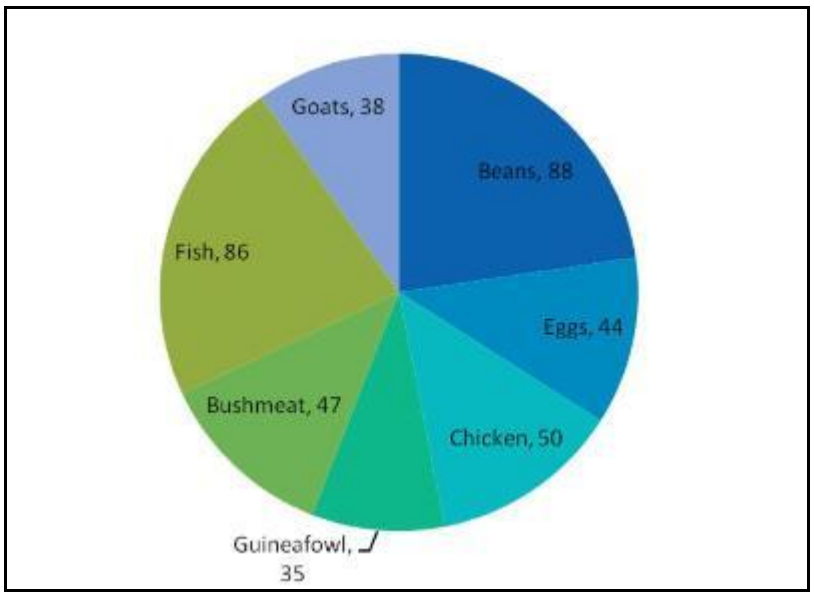


Fig. 19: The percentage of people (n=1128) that had eaten each food type at least once in the preceding week of the survey in July/ August 2011.

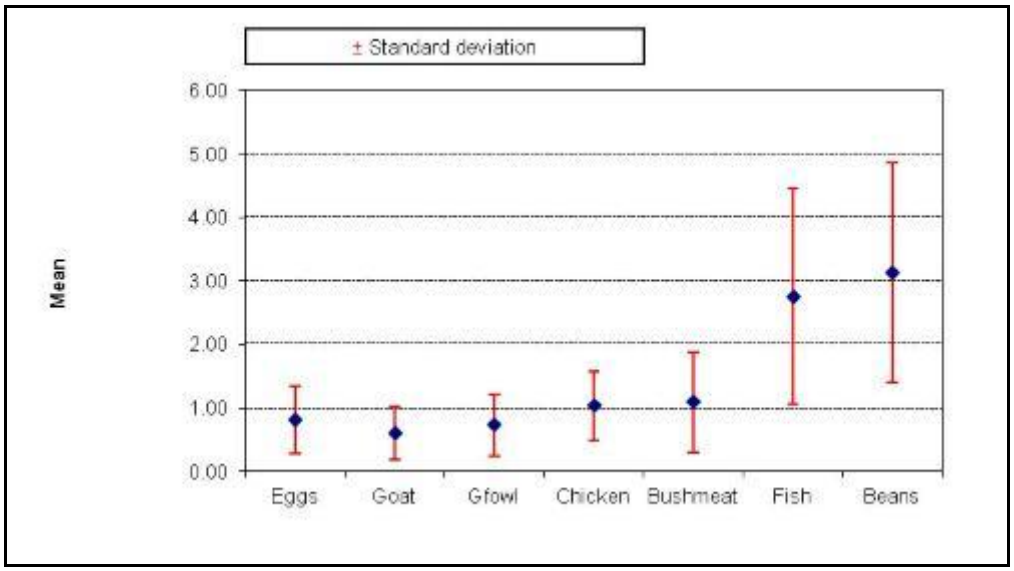


Fig 20: Comparison of the mean number of times people ate different forms of protein in the preceding week, showing the importance of fish and beans in the diet of Niassa Residents.

In Table 12 we show the values for all villages surveyed in NNR ranked according to bushmeat consumption to provide baseline information. A comparison of 11 villages within NNR where we conducted more than 30 interviews (to minimize the bias of small sample sizes) shows the similar patterns of consumption (Fig 21) with the extremes provided by high bushmeat consumption in Mbamba village and very low bushmeat consumption in Negomana. We would suggest that low bushmeat consumption may reflect decreasing prey base around the village. Snaring becomes more difficult as prey declines.

Table 12: The mean number of times protein types were consumed in the preceding week in all villages surveyed in NNR during the 2011 dry season (July-August)

		Average number of times per week protein was consumed						
Village	**N**	**Eggs**	**Goat**	**GFowl**	**Chicken**	**Bushmeat**	**Fish**	**Beans**
Nagete	8	0.63	0	1.13	3.5	4	0.5	6.25
Mussoma	10	1	0.3	0.4	1.2	2.8	7	6.3
Ninga	11	2.45	0.18	0.73	1.64	2.36	2.55	2.91
Chiulucuto	17	1.06	0.53	0.94	0.88	1.88	1.94	2.65
Mbamba	318	0.88	0.91	0.46	1.04	1.41	6.55	6.42
Lichengue	18	0.89	0.94	0.61	0.89	1.39	5.06	3.61
Ansaja	3	2.33	0.33	1.33	0.67	1.33	2	2.67
Chilolo	18	0.83	0.89	1.5	1	1.33	1.06	2.56
Alassima	10	0.7	0.6	1.4	0.9	1.3	1.6	1.4
Guebuza	27	0.63	0.93	0.89	1	1.19	4.63	4.19
Gomba	6	0.33	1.17	0.83	0.67	1.17	2.67	2.17
Chutuche	108	1.47	1.26	1.25	1.44	1.15	1.52	2.52
Macalange	9	1.11	0.44	1.56	0.89	1.11	1.67	0.89
Mahavara	9	0.22	0.44	0	1.44	1.11	2.44	2.89
Chitande	18	0.35	0	1.24	1.06	1	4.06	3.82
Luatize	54	0.87	0.83	1.31	1.41	0.96	1.06	2.24
Naulala 2	14	1.29	1.07	1.21	1.21	0.93	1.14	1.64
Ntacuja	54	0.8	0.91	1.09	0.78	0.89	0.85	2.74
Mecula-sede	63	1.05	1.16	0.98	0.97	0.86	3.59	5.03
Msawize	92	0.24	0.26	0.16	0.97	0.86	2.05	1.52
Mpamanda	27	0.3	0.41	0.3	0.56	0.85	4.85	0.48
Mavago-sede	63	0.78	0.92	1	1.22	0.78	0.63	1.73
Ntimbo 1	36	0.89	1.03	0.17	1.11	0.69	3.33	3.58
Nkalapa	65	0.45	0.57	0.52	0.57	0.68	1.32	1.66
5 congresso	27	0.7	1.11	0.52	0.7	0.63	4.3	5.15
Junta	36	0.67	1.11	0.47	0.31	0.61	4	4.47
Ntuewadembo	10	0.3	0	0.8	0.6	0.5	2.2	7.3
Mitumbati	29	0.55	0	0.07	0.9	0.48	2.62	2.41
Namacambale	18	0.94	0.17	0.22	1.22	0.44	1.67	0.89
Negomano	36	0.58	0.36	0.39	1.19	1.22	3.39	2.5
Cuchiranga	4	0	0.5	0	0.5	0	4.75	2.25
Mucoria	10	0.5	0	0	0.7	0	1.2	3.3

There were no significant differences in the average number of times different protein types were consumed per week in villages from the three districts inside NNR (Mavago, Mueda and Mecula; ANOVA, F=7.37). In all three districts, beans and fish provide the staple protein source (Table 13), bushmeat and chickens are eaten at least once a week, and eggs, guinea fowl and goats were eaten the least often (about once every 1-2 weeks). As expected given the proximity of villages to the Lugenda River, fish are more commonly eaten in villages from the Mecula district (five times a week) and Mueda District (three times a week) compared to Mavago (once a week). The data suggest that Mueda has fewer goats than Mavago or Mecula, as these are seldom eaten (0.2 times per week; Table 13).

It is interesting that bushmeat consumption remains high in the Mavago district, and exactly the same as the consumption in the Mecula district (Fig. 22). This should be of particular concern given that the Mavago district in the western area of the Reserve has the highest human population densities as well as the lowest wildlife population densities. In addition this district appears to consume less fish perhaps due to the distance from the Lugenda or Ruvuma Rivers and bushmeat may be compensating for this. It is unlikely that Mavago can sustain this level of bushmeat off take

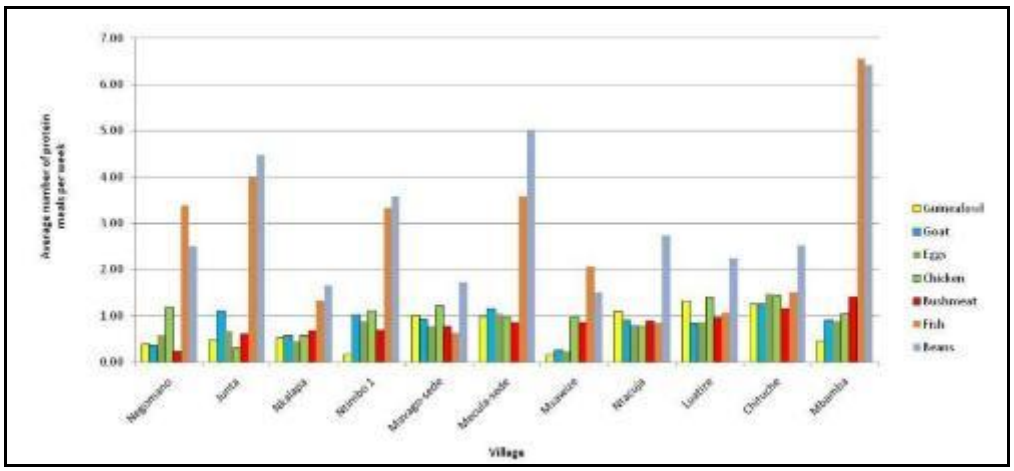


Fig. 21 Average number of times per week different protein sources was eaten in 11 villages inside Niassa Reserve. Villages are ranked in order of increasing bushmeat consumption. Only villages where more than 30 interviews were conducted were used for this analysis. Bushmeat refers to all types of meat from wild animals that are eaten except guinea fowl.

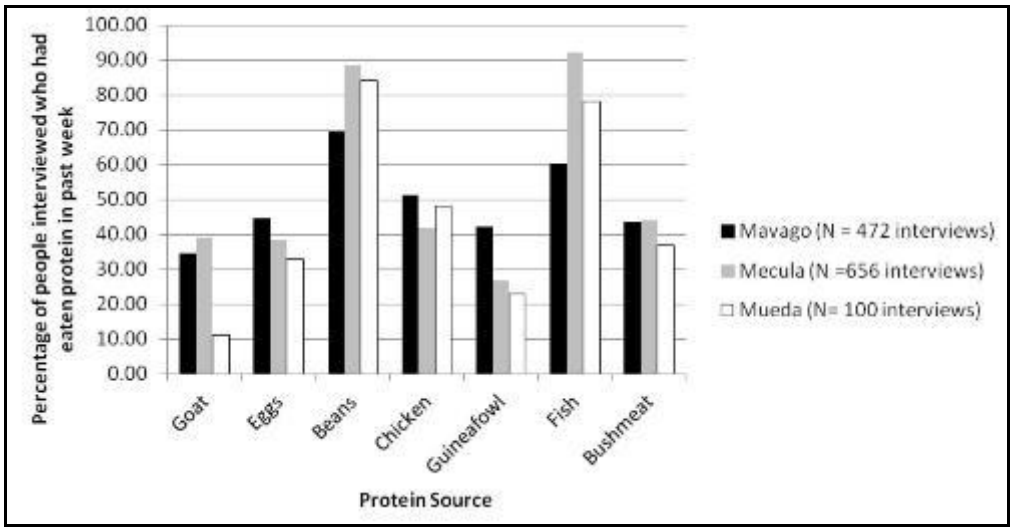


Fig. 22: A comparison of the relative consumption of different types of protein across villages in three different districts inside NNR.

Table 13: Differences in consumption of different protein types in three districts inside Niassa Reserve. Data is presented as the mean number of times each protein type was consumed in the previous week (standard error).

District	Number of interview	Number of villages	Mean number of times consumed per week						
			Goats	Beans	Chicken	G Fowl	Fish	Eggs	Bushmeat
Mavago	472	10	0.78	2.03	1.10	0.86	1.33	0.81	0.91
Mecula	656	17	0.86	4.995	0.95	0.53	5.03	0.82	1.14
Mueda	100	6	0.24	3.55	1.34	0.76	2.85	0.80	1.23
Grant Total			**0.78**	**3.714**	**1.04**	**0.68**	**3.4**	**0.8**	**1.1**

The main value in this survey is to be able to track changes in bushmeat consumption over time in different villages and districts in NNR. However, for interest sake, a very rough analysis can be done to estimate the amount of bushmeat eaten per week in NNR. One portion of bushmeat weighs on average 200-300g (hand measurements are used to designate a portion and these were weighed) and one portion feeds a household for a meal. We do not know how many households there in NNR and this is difficult to assess because of polygamy: one man may have up to five wives. However, we can get a minimum estimate of 8000 households from the number of adult men in NNR (A. Jorge pers.com, from census results).

If bushmeat is eaten on average 1.1 times (range 0-4) per week then this amounts at least 1760-2640 kg of meat eaten per week by 8000 people. This is 1.8-2.6 tons of bush meat being taken out of the bush each week. A lion eats about 5-7kg of meat a day or 35 -49kg of meat per week. This is the same amount of meat eaten by at least 36-54 male lions in a week. The data from Chapter 1, show that lions do not appear to be at the carrying capacity based on predicted prey biomass for NNR (Loveridge & Canney 2009) and it is likely that bushmeat snaring is significantly affecting the prey biomass.

Our data reflect all species lumped together as bushmeat and we cannot determine the level of off-take of specific species. In addition snaring is a technique that regularly catches non target species even though a talented and experienced hunter can increase his probability of snaring a specific species through knowledge of the animal's habits. It is likely that a high number of buffalo, zebra, waterbuck, kudu, porcupine and impala are caught. We do not yet have the 2011 aerial census results for plains game, however given the level of bushmeat off take that we are seeing in concession L5-South and our survey across NNR villages we would predict that numbers of plains game and buffalo are unlikely to show the level of increase that has been seen in previous years. Bushmeat is an increasing threat due to the increasing human population and increasing food security issues. This survey reflects bushmeat consumption in the dry season, the season of highest bushmeat consumption so this is likely to represent a maximum value. On the other hand, some people may have lied and underestimated their bushmeat consumption which will mean this is a minimum estimate for this time period. A similar survey is currently being completed in the wet season to provide an indication of seasonal changes in bushmeat consumption. However it is clear that the current level of bushmeat consumption is not compatible with conservation and must be affecting all the wildlife in NNR.

Lion conservation (if not conservation of most of NNR's mammalian wildlife) is going to come down to reducing bushmeat consumption. This is going to be an uphill battle and is going to require a multifaceted approach. While anti-poaching and security is an effective solution to bushmeat snaring in small conservation areas with a clear boundary and zoning between areas of human use and conservation areas (P. Lindzey. pers. com), this is not going to be successful on its own in NNR due to the large area of NNR that needs to be patrolled, the costs involved and the presence of people everywhere with no zoning. Solutions must include law enforcement, education at all levels, monitoring of both the wildlife populations and the health of human populations (which is currently not done at all), provision of alternative and increased protein sources whether through vegetable protein, improved husbandry of traditional domestic livestock or farming of wild species, possibly sustainable hunting of certain species for meat, and developing alternative business opportunities for local hunters. We are committed to testing possible solutions in NNR with the collaborations of NNR management team as we believe bushmeat snaring is the biggest threat to NNR at present.

CHAPTER 4: HUMAN-LION CONFLICT IN NNR: FINDING SOLUTIONS BY IDENTIFYING VULNERABLE BEHAVIOURS

INTRODUCTION

Human-carnivore conflict is one of the biggest threat facing lions and other carnivore across their range today. In many areas retaliatory killing of lions through spearing, trapping and poisoning in response to livestock loss is the major threat after habitat transformation (Packer at al 2009). While lion attacks on people are rare across the region, lion attacks on people are relatively common in southern Tanzania (Packer *et al* 2005) and in northern Mozambique (P. Israel pers. com). Niassa Reserve is fortunate in that cattle production is not supported due to the presence of tsetse fly, however lion attacks on people are recorded fairly regularly. A single lion attack is a horrific event and can lead to a spate of retaliatory killings of lions in an area and they significantly erode support for conservation efforts. NCP has focused on compiling a detailed database of lion attacks in NNR to be able to assess when and why the attacks occurred so that the chance of an attack occurring can be minimized. Our results have already been provided in detail to SRN in four reports (Begg, Begg & Muemedi 2007 – published in Africa Indaba; Annual report 2009, Jorge & Begg 2009-

Negomano report; and Jorge & Begg 2010-Mavago report). In this report we simply bring the data on lion attacks up to date with a summary of attacks up until Dec 2011 for completeness, full details are not provided and we refer you to the original reports for these.

METHODS

Data was collected initially through three questionnaire surveys specifically focused on lion attacks. The first was conducted in 2004-2007 by visiting the majority of villages in NNR. Data were collected using a simple questionnaire designed to collect the essential details of each attack by NNR management team and NCP. In 2009 a detailed survey of the villages within the Mueda district inside NNR (Negomano village and other small villages) was completed with a similar survey completed in 2010 in Mavago district using a more detailed questionnaire was developed to investigate lion attacks in Mavago and Negomano (Jorge & Begg 2009, 2010). Between March and May, crops are harvested in the fields and this is the critical period for crop protection. To understand why people are vulnerable in the mashambas during this period, a survey and questionnaire (n = 45 interviews) were completed in March 2008 to assess the presence of potential carnivore prey and carnivores in the mashambas as well as to identify human behaviours that might be making people more vulnerable to lion attacks. Questions were asked in Portuguese by C. Begg and translated into Cyao when necessary by E. Waiti. Statistical analysis was completed using Winstat for Excel.

RESULTS AND DISCUSSION

In total we have recorded 89 lion attacks with 44 people killed and 45 people injured from lion attacks in NNR since 1970. On average, there are 2 lions attacks a year (N=42 years; Standard error 0.34; range: 0-8). Since 2000 there have been 34 lion attacks with 21 people injured and 13 people have been killed. Between 2000 and 2010 an average of 2.9 attacks occurred per year. While this is slightly above the sample average, there does not appear to be an obvious increase in the number of attacks at present (Fig 23) but this should continued to be monitored.

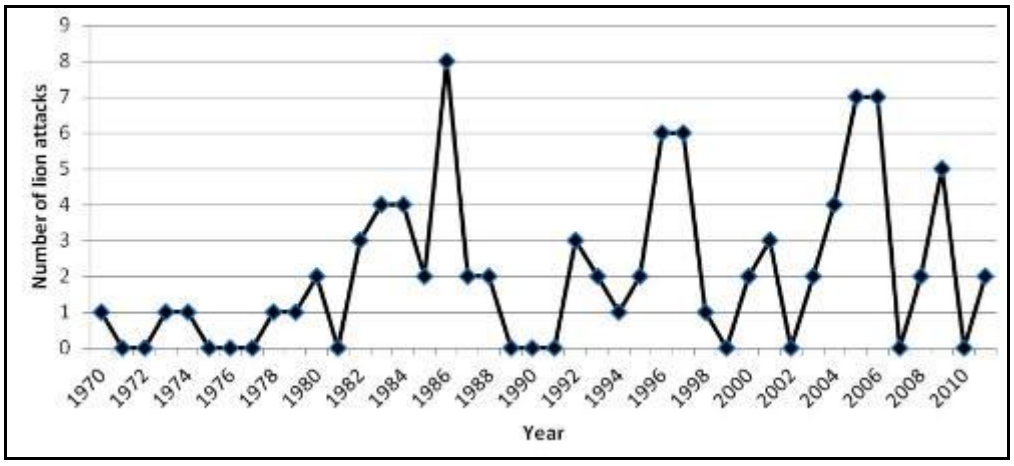


Fig 23: Lion attacks (injuries and fatalities) on people over time in NNR between 1970 and 2010.

Lion attacks are horrific events that affect a family for many years thereafter. It is usually possible to obtain detailed information on the attack, season, and victim's names from attacks that occurred more than 30 years ago. Reports are verified as the same name of victims and circumstance of the attack are often repeated by multiple reporters. We are therefore confident that these data represent the majority of the attacks that have occurred. In general the victims are from villages within NNR (25 villages; Fig, 24) with two attacks on Tanzanians. It is likely that attacks on outsiders may not be reported and are less likely to be remembered as the family members are not living in NNR and these attacks may be under estimated.

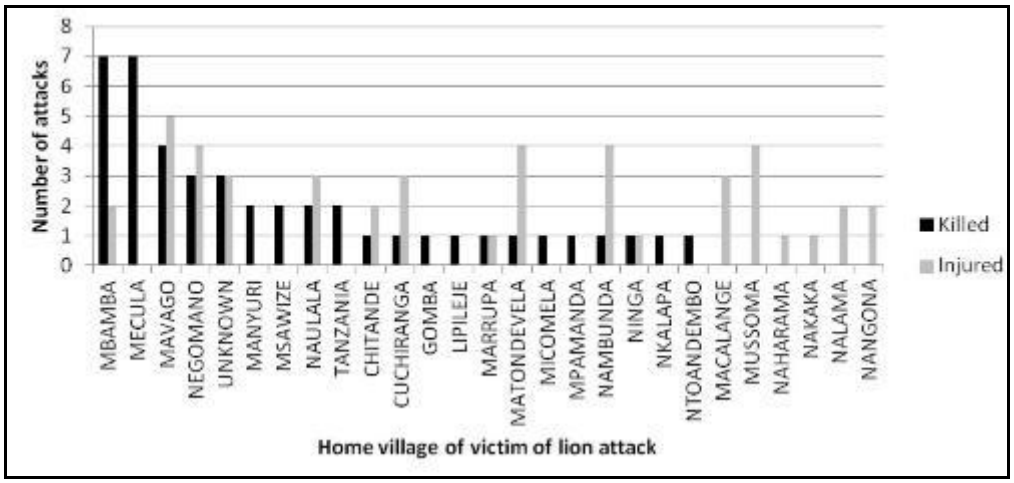


Fig 24: Home village of victims of lion attacks in the past 40 years (since 1970).

Overall, where the sex and age of the victims was known (n=78), 86 % were male and 85% were older than 45 years. Less than 5% of the victims were children (0-7 years) or youths (8-15 years). The majority of attacks occurred in the village itself or in the village fields (76% in total) with only 23% of attacks occurring in the bush. Five of the 13 bush attacks were related to illegal hunting activities where either a hunter was attacked while hunting lion or people were attacked at poaching camps where there was substantial meat. There have been surprisingly few attacks of people in the bush given the large numbers of pedestrians and fishermen moving and living in the bush during the dry season.

Data from NNR and elsewhere show that lions generally avoid contact with people (Chapter 2). However, during the wet season prey is hard to catch in the long grass with abundant water and lions are attracted into villages and fields due to high prey "catchability". Large number of potential prey species are in the fields at this time feeding on crops (crop pests) particularly bushpig and warthog (Kushnir *et al* 2010). Where data were available on the month of the attack, the records show that majority of people were killed by lion (67%) during the wet season (December to April). While communities are remarkably fatalistic about lion attacks and on many occasions believe that attacks in the village or fields are the work of "spirit lions" not bush lions, the data clearly shows that certain behaviours increase the risk of attack. Half the attacks (50%) occur when people sleep outside or in shelters that do not have roofs and a door (Fig 25). Other risky behaviours are sitting around a fire at night in the open (12.5% of attacks), and walking alone both at night to the toilet and during the day (22%).

To investigate this further, data were collected on the activities of people that might make them vulnerable to attack in the Mbamba village fields during the 2008 wet season. During this four month period (Dec– March) 62% of interviewees had heard or seen signs of lion

and there were 15 visual sightings. Ten of the visual sightings were at night when respondents were chasing warthogs and bushpigs out of fields and the lion group sizes varied from 1-6 individuals. Radio tracking data from this same period showed that on at least seven occasions radio collared lions were moving inside the fields and village (see Annual report 2008 for details). During the wet season the majority of people (80%) walked alone at night to chase off warthogs (which forage at night here perhaps due to human presence) and bushpigs out of the fields without lights. Only 20% used some sort of light, either a torch or a *chenje* (bamboo flare). The majority of people slept in the fields in temporary shelters with their wives and all children under the age of 5-6 years (80%). People slept under a wide variety of shelters with only 24% of the people interviewed sleeping in shelters potentially safe from lion or leopard attacks (i.e. had strong walls, a roof and a door, or on stilts, with walls and roof). The safest shelters were "*Sanja"* (7%; house on stilts with walls), "*injinjili"* (4%; thatch house on ground with thick logs as walls and a door) and *Uyimbo* (13%, proper thatch house with door and walls made from clay and branches. The majority slept under a simple "*Chilindu"*, a completely open thatch shelter, or a "Kango" a similar structure with bamboo or grass walls but no door. In Mbamba village it was the young men who built the worst shelters. Two elderly men who remembered the lion attacks in the village in the 1990s had both constructed substantial shelters that were safe for their families.

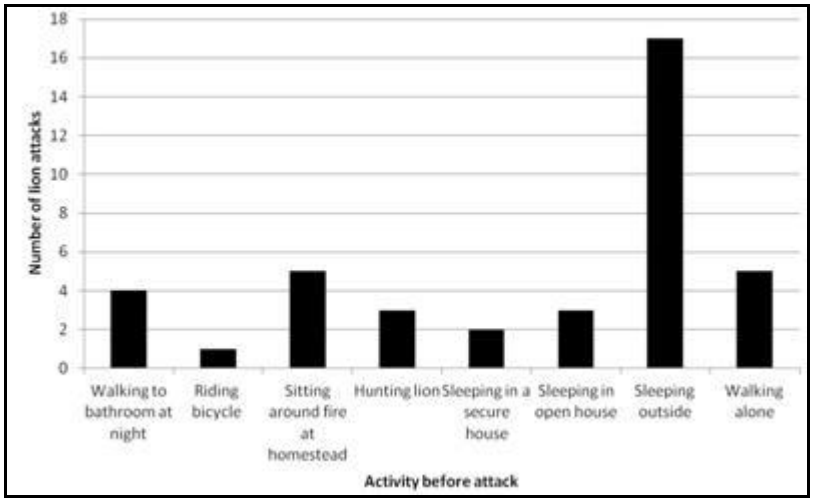


Fig 25: Activity of people before they were attacked showing the risk of sleeping outside in a house with no walls or a roof.

The data clearly show that there are certain risky behaviours that increase the chance of lion (or leopard, and spotted hyena attack). The result of the Negomano interviews suggest that after the lion attacks in 2006 people changed their behaviour with regards to lions and this resulted in no further attacks (Jorge *et al* 2009). In some cases people abandoned isolated fields and started farming closer to other fields or inside the village itself. Other people build stronger houses in the fields, built fences around homesteads or decided to sleep in the village rather than the fields. A few people immigrated to Tanzania. Unfortunately these changes in behaviour came after attacks had already occurred. Education and outreach is essential. NCP has initiated education materials through the Safe behaviours poster, conservation storybook, theatre in Mbamba village and constant extension work.

In addition decreasing the contact between people and lions will reduce the potential for lion attacks to occur. Fences are known to be effective at reducing bushpig and warthog damage in fields (Kushnir *et al*., 2010, Human-Lion Toolkit 2011, Annual Report 2009) The Living fences initiative (*Commiphora africana* hedge) aims to reduce the incursions of

bushpigs and warthogs in fields, which will therefore reduce the attraction of lions into fields and reduce the need for people to walk around at night protecting fields. In time this is expected to reduce lion attacks as contact between lions and people in the fields will be minimized. To date we have planted 2 experimental fences in Mbamba fields as well as a portion of the boundary fence. In collaboration with SRN fences have also been planted in 4 other villages. These activities are a good example of the way in which targeted simple research can result in the identification and implementation of simple solutions.

CHAPTER 5: SPORT HUNTING OF LIONS IN NNR: THE EFFECT OF THE NIASSA LION POINT SYSTEM.

INTRODUCTION AND OVERVIEW

Lions have been hunted in NNR for many years, both by local hunters for skins and sport hunters for trophies. One is illegal while the other is legal, but in both lions are killed and the mortality is additive to the total mortality of lions in NNR. As with all other forms of human mediated mortality of lions in NNR (snaring, retaliatory killing, problem animal control and disease), it is essential that sport hunting is sustainable and monitored. Sport hunting of lions is frequently elevated above other forms of off-take because it is legally sanctioned, automatically assumed to be sustainable due to quota setting and because of the large revenues that flow to management authorities for conservation management. It has been assumed that sport hunting is good for conservation and justifiable because of the benefits. Recent studies across the region have shown that this assumption is unjustified and in several places sport hunting of lions has been proven to be instrumental in the decline of lion populations (Packer *et al* 2009, Brink 2010; Loveridge et al 2007). Recent research in Tanzania has shown that sport hunting is the only statistically significant variable that has contributed to declining lion off-takes in Tanzania, not habitat loss and not retaliatory killing (Packer *et al* 2009). In addition sport hunting of underage lions is a **scientifically proven threat** due to infanticide (Pusey & Packer 1994; Whitman *et al.* 2004, Loveridge *et al* 2007). Sport hunting of lions therefore cannot automatically be assumed to be benign or even a positive force for conservation. It must be monitored and managed.
However, in most areas it is poorly monitored and managed. Not only are quotas seldom based on data on actual lion densities, but actual off-take in not well monitored and managers frequently using inappropriate measures of trophy quality to assess the sustainability of sport hunting. For many species these measures have no bearing on ecological sustainability and should not be used to assess hunting success and sustainability. For lions, trophy quality is frequently assessed using SCI (Safari Club International) and Roland Ward skull measures. For lions in particular, the SCI skull measure (width of skull +length of length in inches) has no bearing on the age of the lions once the lion is adult (over 4 years).

Sport hunting of lions is a controversial topic and even more controversial when it occurs in a protected area. It is becoming increasingly difficult to justify killing lions for sport or fun given the declines in lion populations across their range and the effort and funding that is going in to minimize the killing of lions by other means. For local communities in particular, it remains difficult to explain why it is illegal to kill a lion to sell its skin if you are a local resident but legal to kill a lion for its skin and trophy if you are a foreigner, particularly when the revenues from lion hunts seldom go to communities directly and certainly do not go to the specific local hunter that would have made the revenue from the sale of the skin. In Niassa Reserve the substantial revenues provided by sport hunting do provide funds for conservation management in terms of concession and trophy fees and according to national

law 20% of these revenues must be paid to communities in these areas (although this has implementation difficulties). However, it remains unclear whether there is a clear enough link between these revenues and specific species to increase tolerance for lions by communities or whether these revenues are commensurate with losses experienced by households. These issues are also true for leopard hunting in NNR (Jorge et al , in prep). We cannot address the sport hunting of lions in a protected area like Niassa Reserve without bearing in mind the larger context of the sport hunting and lion conservation debate that is currently raging. It is imperative that transparent, and rigorous monitoring of sport hunting of lions and other carnivores in NNR continues. Given the level of the threat of bushmeat snaring to lions in NNR, it would seem prudent to stop the sport hunting of lions in NNR (which adds to this mortality) until the snaring can be brought under control. However, it has been suggested that lion hunting is very important to the business model of the sport hunting operators in NNR (9 operators) and removing lion as a trophy will cause hunting operation in Niassa to collapse (Lindzey et al 2012). This is not in the interests of conservation in NNR as the funds generated from the sport hunting concession in terms of trophy fees and concession fees are essential to generate revenue for conservation management. Sport hunting revenues currently generate 30% of NNRs annual operating budget of the conservation area (Jorge et al 2012, in prep). At this point the only pragmatic option is to ensure the sport hunting off takes are low and sustainable, transparent and well managed.

In 2003, we highlighted sport hunting as a concern in NNR in the initial carnivore survey (Begg & Begg 2004). We initiated trophy monitoring of lion and leopard trophies in 2004 and there was clearly a problem with 75% of the trophies clearly younger than 6 years of age. Operators were suggesting that NNR lions had no manes, that quotas needed to be increased yet there was little information on lion densities and other than a quota no aging on monitoring of trophy quality. SRN proved to be a leader in lion conservation when it instituted the SRN lion regulations in 2006, along with the points system, which assigned quotas based on trophy quality and enforced the 6 year minimum age limit through independent trophy monitoring. The six year age minimum is not only supported by lion researchers, but is also supported by sport hunting associations - Conservation Force, Hunting Report, SCI Chapters and has become a regional standard in Tanzania, Zimbabwe, Botswana, Zambia. As a result SRN received and continues to receive recognition for its efforts (Markhor Award, CIC Recommendation on the long-term conservation of the African Lion – May 2009, Hunting Report, Conservation Force, and various peer reviewed scientific papers currently in press). The point system was also unanimously supported by all NNR hunting operators at the 2006 Operators meeting. Variations of the points system are being integrated into a quota system for leopard in Botswana. (Funston pers. com, 2009), and Zimbabwe lion hunting regulations (Z. Davidson, pers. com 2009). NCP initiated monitoring of lion and leopard trophies in 2004.

Through the partnership between SRN, NCP and NNR sport hunting operators we believe that sport hunting of lions in NNR is currently sustainable and well managed. NNR remains one of the only conservation areas where the six year age minimum is monitored and enforced and has been since the SRN lion regulations were implemented in 2006 based on a proposal from NCP. The aim of this chapter is simply to summarise the results of the lion trophy monitoring and effects of the Niassa lion regulations and points system. Detailed analyses of trophy quality, visual aging cues, lion hunts etc have been produced on an ongoing basis and will not be repeated here. Annual sport hunting reports were produced in 2004, 2006, 2007, 2008, and 2009 with summaries in the NCP annual reports. In addition a detailed sport hunting memo was produced in January 2010, and a pamphlet (A visual guide

to Aging Niassa Lions) was produced in 2009 and distributed to all sport hunting operators and SRN.

METHODS

Based on numerous conversations with Niassa sport hunting operators, professional hunters (particularly D. Littleton)and on trophy monitoring information collected by NCP (2004 and 2005), the Niassa Points system for determining lion quotas was developed by NCP and proposed to SRN in 2006 (Begg & Begg 2006b). The aims of the point system were reduce the number of underage lions taken as trophies and to provide incentives and disincentives for sustainable hunting.. The SRN Lion Regulations were unanimously accepted by sport hunting operators and SRN in 2006 (with an enforced 6 year age minimum). The points system was used to assign the quotas from the 2007 hunting season onwards based on the previous year's trophy age.

In October to November of each year (2004-2011; 8 years), all lion and leopard trophies taken by sport hunting operators are aged and measured in situ before they leave NNR by NCP. Each lion trophy is independently aged based on tooth wear, closure of the pulp cavity, mane development, nose pigmentation and general body condition, using criteria developed specifically for Niassa lions since 2004 and from other research (see Begg & Begg 2007), and placed in one of three age categories: < 4 years of age, 4-6 years and older than 6 years.2008 Quotas for each hunting concession were then calculated according the SRN Niassa Points System and SRN lion regulations.

In addition a hunt datasheet is provided to each operator for each lion and leopard hunt at the start of every sport hunting season. Information to be filled in by the relevant professional hunter includes the location where trophies were taken, time to kill, number of baits, and condition of animal. Photographs must be provided for each trophy, including a full face picture showing the nose pigmentation and mane development. All data are entered into an access database and analysed.

Lions are aged according to teeth wear which is correlated with nose pigmentation (noses get darker with age, reaching 50% black at 5-6 years; Whitman et al 2004) and mane development. GIS analysis of nose pigmentation and chipping of the enamel ridge (surface and line) was completed for all images of lions up until 2010 in collaboration with Kathy Zeller (Panthera; Fig 26; Fig 27). Data analysis is ongoing and is currently being prepared for publication in a peer reviewed scientific journal in 2012. Data presented here includes 2011 data for off take and aging but does not include 2011 for trophy analysis (nose pigmentation, X-rays of pulp cavities etc) which have not yet been completed.

Fig 26: GIS analysis of nose pigmentation to determine percentage pigmentation, analysed by K. Zeller (Panthera)

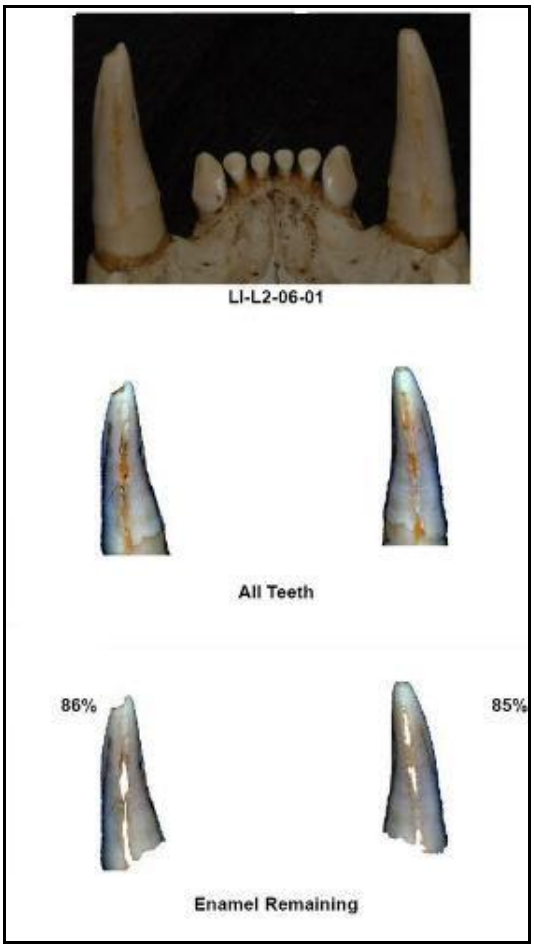


Fig 27: Example of the GIS analysis of the percentage chipping of the canine area and enamel ridge. Analysis done by K. Zeller (Panthera).

RESULTS AND DISCUSSION

Effect of the SRN Points System

The results show conclusively that the Points System for assigning quotas and Niassa lion regulations have been successful at reducing the number of underage lions taken as trophies (Fig 28, Table 14). In 2007, NCPs conservation goal was to reduce the number of underage trophies taken to less that 20% of the off-take by 2010. This was achieved in 2011 when only 1 trophy (12.5%) was under the age of 6 years. In 2004 when trophy monitoring began, 75% of the lion trophies see were under the age of 6, with only 2 of the 8 trophies six years of age or older (Table 14) and 3 of the lions taken as trophies were under 4 years of age. Since 2007, no lions under the age of four have been taken as trophies.

In 2008, off-take dropped markedly as only 4 lions were taken as trophies (25% of the assigned quota) yet all these lions were over the age of 6. This was a direct response to decreasing the quotas in two concessions in previous years and extension and education. Professional hunters were increasingly cautious, turned down many of the lions they saw as too young and only 36% of hunts were successful. Concern about the drop in off-take and the increasing number of unsuccessful lion hunts resulted in a loss of confidence and undermining of the Points system by some operators and the SRN tourism advisor. In 2009, quotas were not assigned according to the Points System by SRN and MITUR , which further eroded confidence. Several operators felt the regulations were not being followed. As a result, the number of underage lions shot as trophies increased from zero in 2008 to 50% in 2009. In 2010, quotas were again assigned according to the SRN regulations, and one concessionaire received a decrease in quota and the situation stabilized. In the past two years, off-take has remained stable at 40% (8 lions) and the number of underage lions shot as trophies has continued to decline. The number of lion trophies six years and older remained constant at 3-4 lions / year between 2005 and 2009, with an increase in 2010 and 2011 that is likely to reflect the opening of new areas as hunting concessions.

While the points system has been successful constant monitoring and independent auditing of lion trophies remains essential to ensure the regulations are followed. There are indications that several of the NNR operators would revert to shooting underage lions if the Points system wws not strictly enforced and supported by the Management authority.

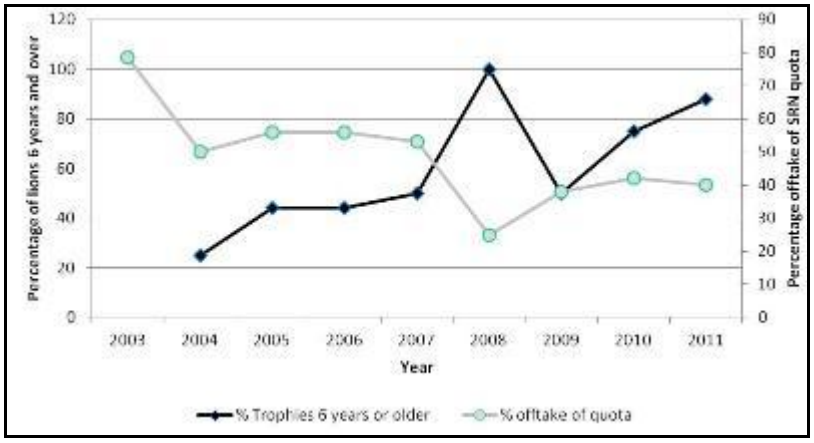


Fig 28: Effects of the Niassa Points System showing changes in off take and number of acceptable lion trophies between 2003 and 2011. Note trophy monitoring was initiated in 2004, and the Points system was first used to determine lion quotas in 2007.

Table 14: Age and off-take of sport hunted lion trophies between 2004 and 2011. Note that trophy monitoring by NCP was only initiated in 2004. The SRN lion regulations and points system for assigned quotas based on trophy age was instituted in 2006 but only affected quotas in 2007.

Parameter	No monitoring		Pre points system			Post points system				
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Off take	3	11	8	9	9	8	4	6	8	8
% off take of SRN quota		78.57	50.00	56.25	56.25	53.33	25.00	37.50	42.11	40.00
% quota underage (<6)			37.50	31.25	31.25	26.67	0.00	19.00	10.53	5.00
% off take underage			75.00	55.56	55.56	50.00	0.00	50.00	25.00	12.50
No. of lions suitable 6 and older			2	4	4	4	4	3	6	7
% off take suitable			25.00	44.44	44.44	50.00	100.00	50.00	75.00	87.50
Proportion of safaris successful					0.53	0.67	0.36	0.46	0.73	0.73

In many areas, trophy off-take as a percentage of the quota is used as an indication of the status of lions. When off-take declines it is said to reflect a declining lion population. However, this is only true if effort remains constant. Many operators do not sell all their lion hunts for a variety of reason including the global economic downturn, poor marketing and lack of effort. The number of lion hunts conducted as a percentage of the SRN quota has declined between 2006 and 2011 (Fig. 29) perhaps representing the economic downturn. However the proportion of successful lion hunts has increased. The argument that the six year age minimum is resulting in too many unsuccessful hunts which hurts business is clearly not true. The decline in off-take is more likely to be due to the economic downturn than the SRN lion regulations. It is a pity that no data is available on lion hunts prior to 2006. The number of days to a lion kill, and the proportion of the safari completed before a kills is have not changed significantly between 2006 and 2011, but pre 2006 (pre Points System) data are not available (Table 15).

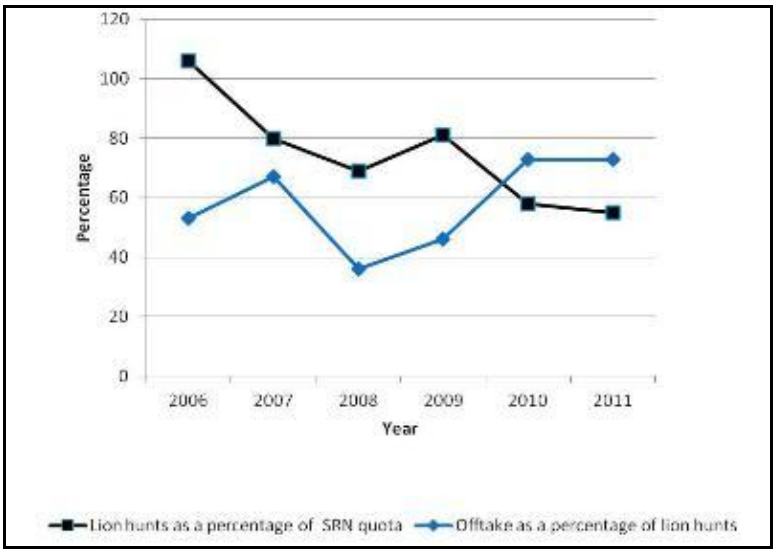


Fig 29: The change in the number of lion hunts conducted over time as a percentage of the assigned SRN quota and the percentage of successful lion hunts.

Table 15: Indices of lion hunt effort from 2006 to 2010.

Category	2006	2007	2008	2009	2010
Proportion of safari to kill	0.63 (0.15; 7)	0.46 (0.36; 5)	0.54 (0.28; 4)	0.57 (0.28; 5)	0.53 (0.31; 6)
Number of days to kill	11 (3.42; 8)	11.6 (7.74; 7)	15.6 (5.41; 12)	15.3 (4.71; 12)	12.8 (6.56; 9)
Average number of baits	5.4	4.1	5.8	8.5	5.8

Trophy aging

Between 2004 and 2010, 68 lions were aged according to tooth wear and this was correlated with nose pigmentation and mane development. Details of aging cues are provided in annual reports and not repeated here. When individual lions are ranked according to the SCI rating (skull size) and coded for age category based on teeth wear (Fig 30), it can be seen that there is no relationship between SCI rating and age. Two of the youngest animals had the biggest skulls. Lion body size is therefore not an accurate way to age lions in NNR or elsewhere.

Nose pigmentation has been shown to be clearly related to age in lions in Tanzania and this has been validated in NNR (Fig. 31; Whitman et al 2004). Few known age lions are available in NNR due to high mortality and turnover and low densities in the intensive study area (Chapter 2). However, GIS analysis of nose pigmentation clearly shows that lions can be placed in an age category on the basis of nose pigmentation (Fig. 32) with significant differences in the mean nose pigmentation of lions in different age categories (Kruskal Wallis; $H=10.94$, $p< 0.05$). The percentage of nose pigmentation is significantly positively correlated with the percentage chipping of the enamel ridge (Spearman's rank; CC: 0.58, $p < 0.01$; Fig. 33)

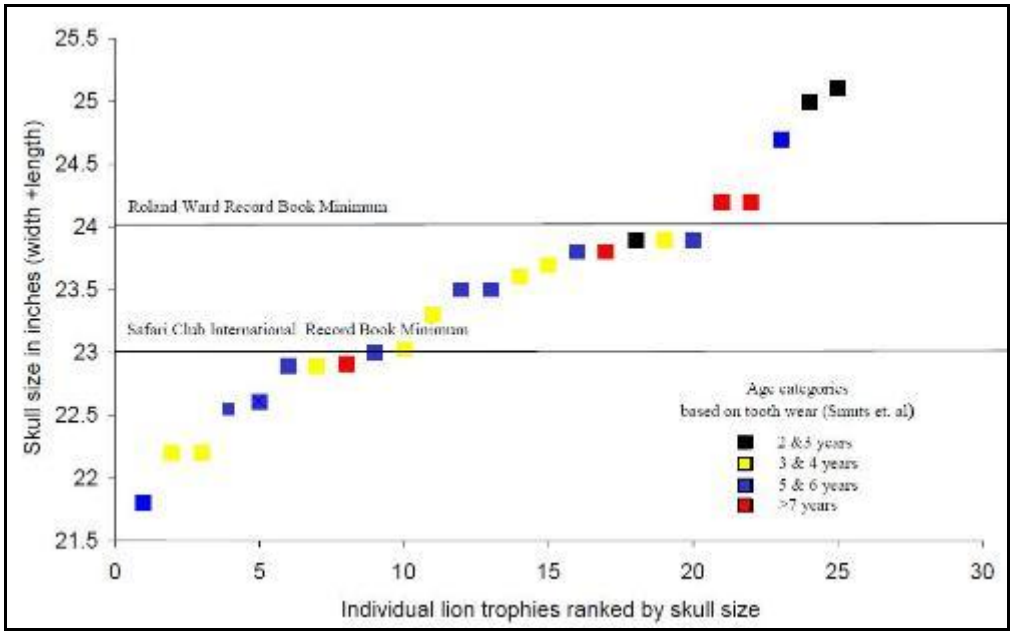


Fig. 30: Individual lions ranked according to SCI rating (Skull size) and coded for age category showing the lack of a relationship between SCI sport hunting index and trophy age.

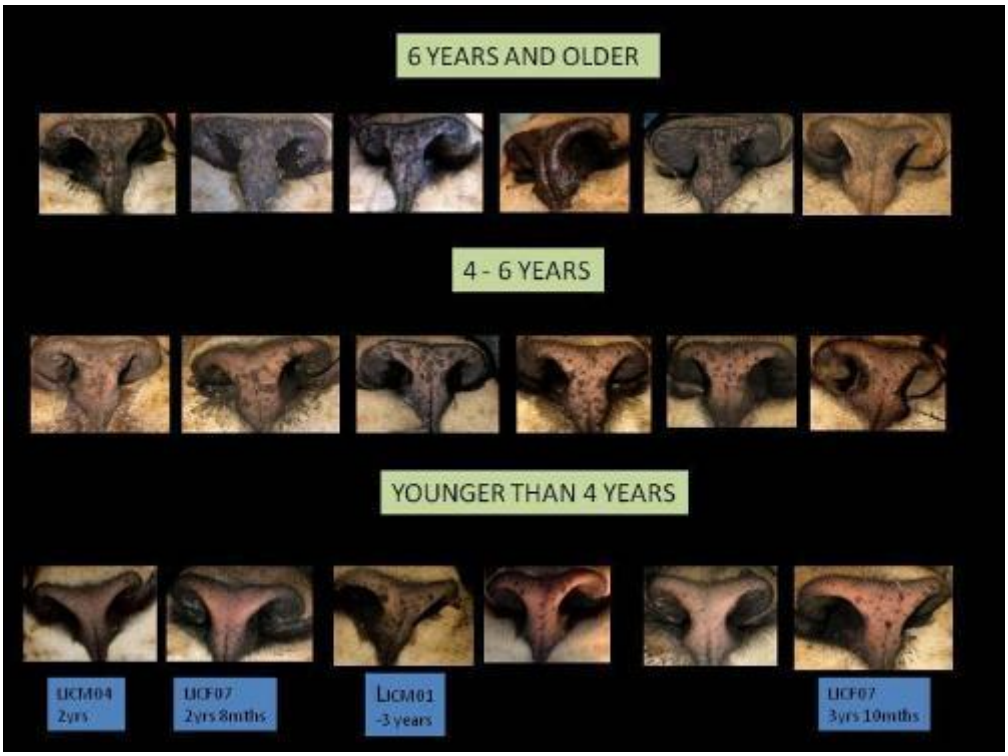


Fig. 31: Nose pigmentation of captured lions placed into age categories based on tooth wear clearly showing how lion noses go darker with age.

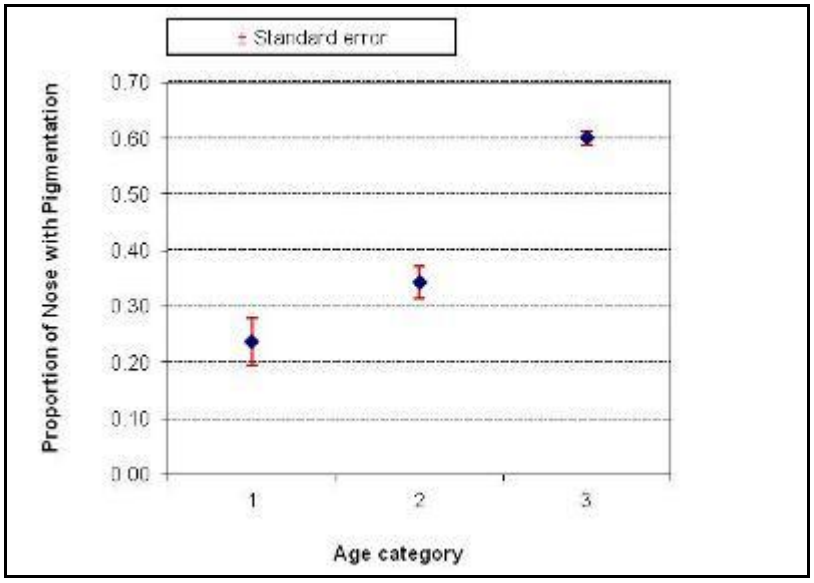


Fig. 32: Mean nose pigmentation for captured lions placed in age categories based on teeth wear, where 1 = less than 4 years old; 2 = 4-6 years and 3 =6 years and older.

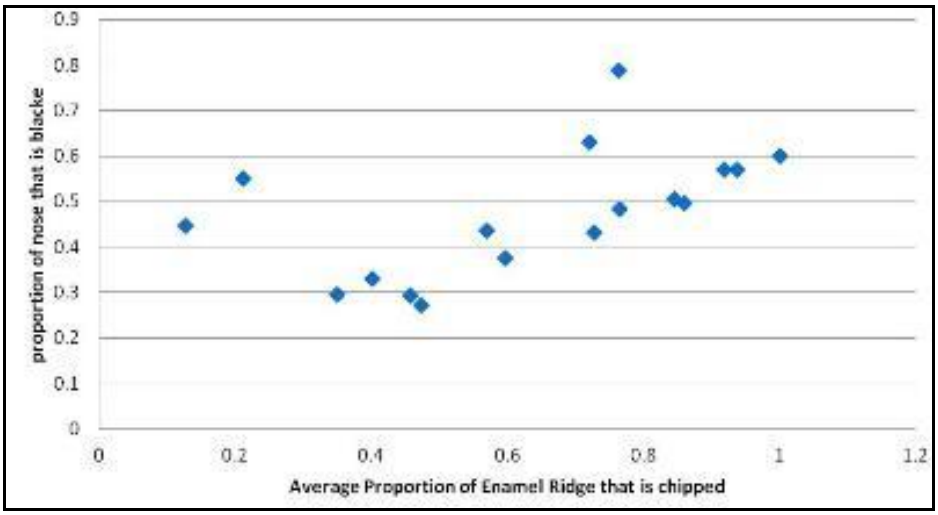


Fig.33: Relationship between the proportion of the nose that is black and the proportion of the enamel ridge that is chipped, based on GIS analysis conducted by Kathy Zeller (Panthera).

Niassa lions can clearly be placed in the age categories based on visual characteristics. This is shown both from the GIS analysis of nose pigmentation and from validation of mane characteristics for Niassa lions illustrated in the aging pamphlet produced in 2009. This is supported by the results which show an increase in the proportion of lions over the age of 6 taken as trophies and the consistent hunting of over 6 year old lions by some professional hunters. Sport hunting on its own is currently sustainable in NNR and is unlikely to be having any major effects on population dynamics due to the innovative SRN lion regulations and points system for assigning quotas. Sport hunting operators and SRN are commended for their efforts.

However, the reality is that sport hunting is not the only form of lion off take in NNR and the off-take from snaring is of serious concern and is additive to the sport hunting off take.. From a purely theoretical viewpoint it would certainly be justified to recommend that sport hunting of lions be stopped in NNR until poaching was under control. The reality however is that the revenues generated from sport hunting operators in NNR are essential for conservation management, and lions are an essential species in these businesses. This may do conservation more harm than good. A more pragmatic solution is to continue with the very carefully managed sport hunting of lions with the enforced 6 year age minimum but to improve the anti-poaching and community engagement efforts of all concessionaires. Off take in future can only be increased if the illegal off take is reduced. It has also become evident over the past eight years of monitoring trophies in NNR, that independent monitoring and oversight remains essential and will need to continue into the foreseeable future.

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APPENDIX 1: LIST OF NCP OUTPUTS (2004-2011)

Annual reports to SRN (provided by 28 February each year)

Begg, C.M. & Begg, K.S. 2004. *A survey of carnivores in Niassa Reserve, northern Mozambique: 2003 Survey.* Unpublished report prepared for SGDRN, Maputo.

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Posters, pamphlets , film etc

Begg, K.S. 2007. Reserva do Niassa: 16 minute promotional DVD for SRN & FFI. Portuguese

Begg, K.S. 2008. Badger Quest: Honey Hunters of Niassa: 52 Minute Documentary in Portuguese and English.

Kingdom, A. 2010. Lions, leopards, Mother Nature and one small girl. Commissioned and printed by NCP. Conservation storybook (1000 Portuguese copies)

NCP. 2006. Stop rabies, Save Live: Rabies poster (Portuguese, 600 printed in 2006, 300 in 2008)

NCP. 2009. Quick Guide to Lions of Niassa Reserve: Pamphlet for sport hunters (English).

NCP. 2010. Safe behaviours: Poster on keeping yourself safe from carnivores (Portuguese: in production).

NCP 2011: Human-lion conflict toolkit: Booklet for fieldworkers and management

Presentations, workshops

- 2004. SRN Biodiversity Meeting, Maputo
- 2004. SRN TAC Meeting, Maputo
- 2005. SRN Operators Meeting, Pemba
- 2005. Honey badger and carnivore research. Museum of Natural History, Maputo.
- 2006. SRN Operators Meeting, Maputo
- 2006. Research in Niassa Reserve, Museum of Natural History, Maputo
- 2006. Progress of Niassa Lion and Wild dog projects – future activities: end of Phase 1: Mbatamila, Niassa Reserve.
- 2007. SRN Operators Meeting, Lichinga
- 2007. Research and Monitoring in Niassa for Niassa Board (Dick Viets, Westley Logon, Mark Rose), Maputo.
- 2008. SRN Operators Meeting, Maputo
- 2008. September, WCN Wildlife Expo, San Francisco, USA (300 people)
- 2008. April, FFI-USA – Fair Play Foundation, Delaware, USA (100 people)
- 2008. April. FFI-USA Board, Delaware, USA (20 people)
- 2008. April. Wildlife Conservation Society, Bronx Zoo, New York (30 people).,
- 2009. Wildlife Conservation Network Expo, San Francisco, USA (450 people)

- 2009. Lion and leopard conservation and hunting for Hunting Report. Kambako Hunting Camp, Niassa.
- 2009. Niassa National Reserve. FFI donors in Nkuli Camp, Niassa.
- 2009: National meeting to develop National Lion Action Plan and Strategy, Maputo.
- 2009. SRN Operators Meeting, Pemba
- 2010. National Meeting to develop National Action Plan for African Wild Dog and Cheetah, Maputo.
- 2010. Resolving Human-lion Conflict -Niassa Carnivore Project. Workshop on human –lion conflict, Dar Es Salaam, Tanzania
- 2011: Niassa Points system and sport hunting: Meeting of lion sport hunting, Johannesburg
- 2011: SRN operators meeting, Maputo
- 2011; WCN Wildlife Expo: October San Francisco, US; 450 people)
- 2011: Genentech offsite postgraduates: Monterey, California: 100 people)
- 2011: Houston Zoo: Call of the wild series: Houston, Texas, 100 people