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ISBN 978-82-326-2558-1 (printed ver.)
ISBN 978-82-326-2559-8 (electronic ver.)
ISSN 1503-8181

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IMT-report 2017:243

Doctoral theses at NTNU, 2017:243

Printed by NTNU Grafisk senter

Preface

I would like to thank many people for their assistance and contributions to the success of my studies and research towards my Ph.D. I would like to start with a very large thank you to Professor Audax Mabulla from the University of Dar es Salaam for his assistance, primarily for facilitation of my application to full admission to the University of Dar es Salaam in 2001. Furthermore, I extend my appreciation to my academic supervisor Professor Eivin Røskaft for his tireless support and supervision, for his endless patience and always being available and for providing the correct advice whenever it was required. Professor Eivin Røskaft, I further appreciate your visits, on more than one occasion, to Serengeti and Arusha for the supervision of my Ph.D. research and thesis. I thank the Norwegian University of Science and Technology (NTNU) for their patience and for providing me the opportunity to undertake my Ph.D. studies. Thanks to Mr. Emmanuel H. Masenga, the project manager for the Serengeti African Wild Dogs Conservation Project, because without his assistance, interest and dedication, I would not have had the opportunity to conduct research on this fascinating and endangered animal. I thank Dr. Robert Fyumagwa, the current Director of the Serengeti Wildlife Research Centre (SWRC), for providing much needed logistical support during the field component of this research.

Additionally, my Ph.D. studies would not have been possible without the help from different projects and institutions that provided both financial and logistical support for my research in the Eastern Serengeti, such as the IPBES Projects and the Norwegian University of Science and Technology (NTNU) through the Quota program. The finalization of my thesis was possible with a grant from EU-Horizon 2020 through Grant Agreement 641918 (AfricanBioServices).

Furthermore, the management of TAWIRI is thanked for granting me study leave and for assisting me logistically during the period of my data collection. The Department of Biology at NTNU is also thanked for hosting me as a student during the entire period of my studies. I must also remember the other staff members in the Department of Biology who were always available when I required any type of assistance: Dr. Craig Jackson and Dr. Bård Stokke offered invaluable advice and input in the writing of some of my manuscripts.

I am grateful to the Serengeti Wildlife Research Centre staff members who are all acknowledged for their cooperation and support. All village leaders in the Loliondo Game Controlled Area (LGCA) are acknowledged for their valuable support. Moreover, special thanks go to my enumerators who assisted me in data collection in the area. Mr. Franco Mbise, Ms. Anne Cathrine Strande Straube and Ms. Ane Maria Guttu are all thanked for their valuable support and cooperation during the entire period of my data collection in the field and thereafter in writing the manuscripts. I also acknowledge Mr. Machoke Mwita who is thanked for his assistance in drawing maps for our study area. I also appreciated the good times with my fellow students at NTNU and Dr. Angela Mwakatobe, Ms. Rosemary Mramba, Dr. Wilfred Marealle and other Tanzanians for their academic and social companionship.

Apart from the academic life, during our stays in Norway, we sometimes enjoyed social gatherings that always were organized in the house of Eivin Røskaft. Therefore, 'Mama' Berit Røskaft is thanked for her valuable time devoted to preparing Tanzanian food for us. We really enjoyed that and I say "ASANTE SANA MAMA".

Last but by no means least, I also extend my acknowledgments to my beloved late father Daniel and mother Bertha, my beloved wife Lucy, daughter Maureen and son Daniel and to my brother and sisters Emmanuel, Caroline, Brenda and Glory who continued to pray for me during my entire study period. I hope I have mentioned and thanked all that assisted me in one way or another in making my dream becoming true, but to anyone who I might have forgotten, I say to you "THANK YOU VERY MUCH - ASANTENI SANA-TUSEN TAKK".

Richard D. Lyamuya

Trondheim

September 2017

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Summary

Globally, wild carnivore populations outside protected areas are at threat from retaliatory killings triggered by livestock depredation. Monitoring of livestock depredation in specific areas is essential to formulate conflict management strategies that can address the root causes of human-carnivore conflicts and promote wild carnivore conservation. Livestock depredation is associated with several factors, such as the increase in human population and eventual increase in land conversion for agriculture and human settlements, which reduce ecosystem services and increase losses of natural habitats for wild carnivores. Moreover, increased hunting of wild herbivore species by humans for subsistence, sport or trophies has led to the depletion of prey species required by wild carnivores. Additionally, the large home ranges required by many wild carnivores force them to overlap with human activities outside of protected areas, increasing conflicts with farmers. As wide-ranging species, carnivores generally roam beyond the boundaries of protected area from which they disperse into unprotected lands, making them more vulnerable to anthropogenic threats linked to higher human densities and more likely to cause damage by coming into contact with livestock. These conflicts occur in the eastern Serengeti ecosystem and involve most of the wild carnivores. From 2000 onwards, incidences of livestock depredation caused by African wild dogs (*Lycaon pictus*) increased in the area. Researchers were stimulated to investigate whether this depredation was actually occurring, because during the early 1990s, African wild dogs had disappeared from Serengeti National Park. The results of this study showed that problems with African wild dogs did occur and that wild dogs were common predators in the area to the east of Serengeti National Park for several decades. The species primarily preyed on sheep (*Ovis aries*) and goats (*Capra aegagrushircus*) in the evening when they were grazing in the fields.

We were challenged by this finding to investigate why more incidences of livestock depredation occurred in the evening when livestock continued to graze in the fields. Did this predation occur because livestock were left unattended in the field or because society had abandoned traditional animal husbandry practices? Therefore, another study was conducted to acquire information to answer this question, and the results revealed that a single herder attended all predator-visited livestock herds. Additionally, more attacks occurred when the herders were young females. Carrying defensive equipment (e.g., knives and spears) reduced the number of successful carnivore

attacks. Therefore, improving traditional livestock practices, particularly the use of more adult male herders, might assist in reducing the depredation problem in the area.

We further investigated whether conflict with African wild dogs developed in recent years or has existed since the Maasai pastoralists were evicted from Serengeti National Park in 1959. The results revealed that conflicts occurred before 1959, but that the numbers of conflicts were low. Conflicts decreased during the 1990s, but increased again beginning in 2000. This increase was attributed to increases in the human population and livestock numbers as well as increases in wild dog populations in the area.

Then, we tested two approaches that could help to either reduce or eliminate the problem in the area. The first approach assessed the attitudes of the Maasai pastoralists towards the conservation of wild carnivores in their area because the conservation of wild carnivores primarily relies on the acceptance of local people. For most Maasai pastoralists, particularly females, negative attitudes were expressed towards the conservation of wild carnivores in their area. However, Maasai pastoralists who had been to school, primarily males, expressed more positive attitudes towards the conservation of wild carnivores. Therefore, to achieve the conservation goals for the species, more conservation interventions should be directed towards females.

We finally tested whether a wildlife education program could increase knowledge of wild carnivores in the area and thereby change the attitudes of local people, focusing in particular on schoolchildren. The results showed that knowledge of wild carnivore identification increased among the school children involved in our education program. This increase in knowledge was important, in general, for the conservation of wild carnivores and, in particular, for attitudes towards African wild dogs because the post-test results showed that most school children considered wild dogs to be an important part of the ecosystem.

Therefore, to foster coexistence, the recommendations of this study are that the continued increase in livestock density must cease and that wild prey populations should be protected in the area. Additionally, improving the herding intensity by increasing the number of adult male herders per livestock herd is required at all times, particularly during the afternoon and evening as well as during seasonally sensitive periods. In our study area, female Maasai pastoralists must be more involved in tourist activities operating in their area, schooled and, when possible, be allowed to

access natural resources in protected areas during times of hardship to change their attitudes and gain their support for the conservation of wild carnivores in their area. Additionally, implementation of a wildlife education program and performance payments for the conservation of carnivores and zoning to reduce livestock loss are highly recommended for the area. Furthermore, the involvement of local residents in conflict management and introduction of grass and fodder species could be helpful in mitigating the problem in the area. From the results of this study, future experimental research is required that focuses on using guard dogs to deter wild carnivores from predating on livestock as they graze in the field.

List of papers

The Ph.D. thesis consists of the following five papers:

Richard D. Lyamuya, Emmanuel H. Masenga, Robert D. Fyumagwa, Machoke N. Mwita & Eivin Røskaft (2014). Human–carnivore conflict over livestock in the eastern part of the Serengeti ecosystem, with a particular focus on the African wild dog (*Lycaon pictus*). *Oryx, Fauna & Flora International*, 48(3), 378–384. doi: 10.1017/S0030605312001706.

Richard D. Lyamuya, Emmanuel H. Masenga, Robert D. Fyumagwa, Machoke N. Mwita, Craig R. Jackson & Eivin Røskaft (2016). A historical perspective of the Maasai - African wild dog conflict in the Serengeti Ecosystem. *Environment and Natural Resources Research*, 6(2), 42-50. doi:10.5539/enrr.v6n2pxx

Richard D. Lyamuya, Emmanuel H. Masenga, Robert D. Fyumagwa, Machoke N. Mwita & Eivin Røskaft (2016). Pastoralist herding efficiency in dealing with carnivore-livestock conflicts in the eastern Serengeti, Tanzania. *International Journal of Biodiversity Science, Ecosystem Services & Management*. 12(3), 202-2011. doi:10.1080/21513732.2016.1163735.

Richard D. Lyamuya, Emmanuel H. Masenga, Franco Peniel Mbise, Robert D. Fyumagwa, Machoke N. Mwita & Eivin Røskaft (2014). Attitudes of Maasai pastoralists towards the conservation of large carnivores in the Loliondo Game Controlled Area of northern Tanzania. *International Journal of Biodiversity and Conservation*, 6(11), 797-805. doi:10.5897/IJBC2014.0769.

Richard D. Lyamuya, Anne Cathrine Strande Straube, Ane M. Guttu, Emmanuel H. Masenga, Franco P. Mbise, Robert D. Fyumagwa, Bård G. Stokke, Craig R. Jackson & Eivin Røskaft (2016). Can enhanced awareness change local schoolchildren's knowledge of carnivores in northern Tanzania? *Human Dimensions of Wildlife*, 21(5), 403-413. doi:10.1080/10871209.2016.1180566

1.0 Introduction

1.1 Background of the Human-carnivore conflict (HCC)

The large-bodied mammals of the order Carnivora (hereafter referred to as large carnivores) include approximately 226 species (Treves and Karanth 2003a) and are culturally important to humans; their body parts are used in ceremonies and traditional medicine and they are featured in storytelling, mythology and witchcraft (Williams et al. 2016). Large carnivores are depicted in artworks, on currencies, on coats of arms and on the kits of sport teams (Williams et al. 2016). These carnivores provide important ecosystem services, such as helping to maintain wildlife abundance and richness (Treves and Karanth 2003a, Atwood and Breck 2012) and increasing carbon storage (Williams et al. 2016). They can generate large revenues through tourism and hunting but they can also be a financial burden because of predation on livestock; which is frequently termed a human-carnivore conflict (HCC) (Williams et al. 2016). HCC represents the most common negative form of interaction between humans and wildlife and is defined as the carnivore-related threats to human life, economic security, or recreation (Treves and Karanth 2003a) or any action by humans or wildlife that adversely affects the other (Conover 2001, Treves and Karanth 2003a, Atwood and Breck 2012, Dejene et al. 2016). Such interactions can be predation of livestock (Holmern et al. 2007, Nyahongo 2007, Ikanda and Packer 2008, Røskaft et al. 2013, Lyamuya et al. 2014, Dejene et al. 2016) or retaliatory killing of wild carnivores (Ogada et al. 2003, Holmern et al. 2007, Ikanda and Packer 2008, Masenga et al. 2013, Dejene et al. 2016). These conflicts have existed since humans domesticated wild ungulates (Datiko and Bekele 2013). HCC results in economic losses to farmers in different parts of the world because of lost or injured and stressed livestock (Mishra 1997, Holmern et al. 2007, Nyahongo 2007, Røskaft et al. 2013, Dejene et al. 2016). The economic effect on the individual farmer varies substantially among different locations and predator species (Häggmark et al. 2015) but is a threat to both wild species and human livelihoods (Dejene et al. 2016). Large depredation costs may reduce the tolerance of people for carnivores, which can jeopardize carnivore conservation efforts. Historically, conflicts between carnivores and human activities have led to low carnivore population levels in more densely populated regions as a result of the retaliatory killings of predators (Ogada et al. 2003, Holmern et al. 2007, Ikanda and Packer 2008, Masenga et al. 2013, Dejene et al. 2016). Therefore,

HCC is a serious management issue because of the threat the problem poses to the survival of many endangered species in the world and because of the opposition, it often causes towards carnivore conservation efforts (Woodroffe et al. 2005, Holmern et al. 2007, Ikanda and Packer 2008). This is exemplified by the endangered African wild dogs (*Lycaon pictus*) throughout their range (Mishra 1997, Masenga et al. 2013). Although the elements of HCC are interconnected, most of them have been studied as separate components elsewhere (Spira 2014).

In Africa, several wild carnivore species are implicated in the HCC problem, including the lion (*Panthera leo*), leopard (*Panthera pardus*), spotted hyena (*Crocuta crocuta*), cheetah (*Acinonyx jubatus*), African wild dog, caracal (*Caracal caracal*) and black-backed jackal (*Canis mesomelas*) (Butler 2000, Patterson et al. 2004, Kolowski and Holekamp 2006, Holmern et al. 2007, Van Bommel et al. 2007). Based on previous studies, livestock predation often follows a seasonal pattern (Butler 2000, Patterson et al. 2004, Kolowski and Holekamp 2006) and is influenced by environmental conditions and husbandry practices (Ogada et al. 2003, Kolowski and Holekamp 2006). Most studies of predation on livestock in Africa have focused on east and southern Africa, with few studies from west and central Africa (Van Bommel et al. 2007). This geographic bias is attributed to the low herbivore biomass that characterizes West Africa (East 1984, Fritz 1997) and fragmented wildlife populations primarily confined to small, unfenced protected areas that are surrounded by human settlements.

The few published studies from Africa report that <1 to 10% of livestock holdings are lost annually to wild carnivores (Mizutani 1999, Rasmussen 1999, Butler 2000, Woodroffe et al. 2005). However, the cost of livestock damage by wild carnivores is often unevenly distributed (Dejene et al. 2016). Other studies reveal that the true numbers of livestock lost to predators may not be as important as the perception of livestock owners of the severity of damage, with actual damage often lower than the perceived damage; however, it is the perceived damage that most influences public opinion (Rodriguez 2007). Therefore, more often than not, the solution to conflict with predators results in retributive killing via guns, spears or poisons (Rodriguez 2007).

Of the several reasons for HCC, most occurrences are due to the considerable expansion and growth of human populations in the last few decades (Woodroffe 2000, Rodriguez 2007, Dejene et al. 2016), which have had a significant negative effect on biodiversity (Treves and Karanth 2003a, Datiko and Bekele 2013, Dejene et al. 2016). The growth has resulted in the degradation

of wildlife habitats due to increased human activities (Jackson et al. 1996, Mladenoff et al. 1997, Naughton-Treves et al. 2003, Dejene et al. 2016) which has eventually forced wild animals, in particular the carnivores, to live increasingly close to humans (Treves and Karanth 2003a, Dejene et al. 2016). The results of the increased contact are normally conflicts, death and ultimately, a decline in the population of wild carnivores (Rodriguez 2007, Datiko and Bekele 2013, Dejene et al. 2016). Additionally, previous studies reveal that the highest intensity conflicts tend to occur in areas in which humans live adjacent to protected areas (Mishra 1997, Røskaft et al. 2013). HCCs also occur because of the protein-rich diet of wild carnivores and their large home range requirements, which draw them into recurrent competition with humans, with somewhat similar requirements (Treves and Karanth 2003a, Dejene et al. 2016). Moreover, the increase in carnivore conservation initiatives has resulted in the recovery and expansion of carnivore populations, which also escalates the problem (Jackson et al. 1996, Karanth and Chellam 2009). Additionally, increasing livestock populations (Dejene et al. 2016) and competitive exclusion of wild herbivores has escalated the problem outside many protected areas (Datiko and Bekele 2013). These growing densities of livestock populations can create an overlap in diets and forage competition with wild herbivores, which results in overgrazing and a decline or local extinction in wild herbivore populations (Mishra et al. 2003, Dejene et al. 2016). Furthermore, the creation of protected areas (which serve as refuges from which predators can populate the surrounding area) escalates the problem in most adjacent areas (Jackson et al. 1996).

Indeed, although many wild carnivores are specialized on wild prey species, when opportunities are presented, they will prey on livestock (Treves and Karanth 2003a, Dejene et al. 2016). This use of alternate prey is consistent with previous findings, which indicate that the depletion of wild prey as the result of human activities has forced some predators to switch to livestock as their food source (Jackson et al. 1996, Treves and Karanth 2003a, Rodriguez 2007, Dejene et al. 2016). Examples are reported from Kenya and northern Botswana (Datiko and Bekele 2013) and Ethiopia (Dejene et al. 2016). According to previous studies, although the essential diet of carnivores is based on wild prey species; diets can be expanded to livestock species when wild prey availability is low (Patterson et al. 2004, Spira 2014, Dejene et al. 2016) because prey selection depends on the availability of potential prey (Datiko and Bekele 2013, Dejene et al. 2016). Moreover, morphological, behavioural and physiological adaptations of carnivores allow individual predators to locate, capture, ingest and digest a variety of prey taxa (Datiko and Bekele 2013). Therefore,

livestock depredation can be particularly frequent in areas in which domesticated stock have replaced native wildlife (Jackson et al. 1996, Patterson et al. 2004, Rodriguez 2007, Spira 2014, Dejene et al. 2016) or in which the ratio between livestock and wild prey abundance is low, although this ratio does not necessarily lead to higher depredation rates (Woodroffe et al. 2005, Spira 2014, Dejene et al. 2016). The depredation occurs because domestic livestock have evolved only weak anti-predatory strategies; hence, they are easily killed with little effort by the predator (Datiko and Bekele 2013). Moreover, domestic animals are particularly vulnerable to wild carnivore depredation because of the long-term decreased risk of predation in human-mediated environments has caused the anti-predatory abilities of domestic livestock degenerated (Madhusudan and Mishra 2003). Livestock depredation is a worldwide problem (Treves and Karanth 2003a, Dejene et al. 2016)(Paper I), with the highest intensities occurring in areas in which humans live adjacent to protected areas (Mishra 1997, Holmern et al. 2007, Datiko and Bekele 2013, Røskaft et al. 2013). Thus, when humans and carnivores coexist, competition for shared resources, such as prey species or livestock, often results in conflicts (Rodriguez 2007, Atwood and Breck 2012, Dejene et al. 2016). Although livestock predation usually follows seasonal patterns, exceptions are noted (Jackson et al. 1996, Holmern et al. 2007, Datiko and Bekele 2013). However, studies show that tolerance of people towards predators depends on the extent of the predation on their livestock (Rodriguez 2007, Datiko and Bekele 2013, Dejene et al. 2016). Moreover, in most places in which HCCs occur, the problem is escalated by careless livestock herding practices (Jackson et al. 1996, Ikanda and Packer 2008)(Paper III).

The consequences of HCCs affect both people and wildlife. Indeed, depredation events cost the keepers of livestock income with losses in livestock and time and money spent in preventing depredation attacks (Rodriguez 2007, Spira 2014, Dejene et al. 2016). As a result, livestock keepers tend to form negative attitudes towards the carnivores that they consider a threat to human livelihoods and may respond to conflicts by killing the culprits in revenge by trapping, snaring, poisoning, shooting or spearing (Rodriguez 2007, Spira 2014, Dejene et al. 2016). This response occurs particularly when predation costs are enormous and persistent and when losses are uncompensated by the state or conservation agencies. Furthermore, the problem persists when there is no interest or capacity for government agencies to control, prevent or fully compensate damages and losses incurred. Ultimately, instead of enlisting their support, participation and collaboration, many local people are set against conservation initiatives (Rodriguez 2007). This

situation has now become one of the biggest impediments to the conservation of wildlife and wildlife habitats across many countries of Africa (Rodriguez 2007, Dejene et al. 2016). HCC also entrenches rural poverty, particularly when losses are not controlled, contained or fully compensated, because the cost and burden of conservation is transferred to local communities, although they may not specifically be the largest beneficiaries of wildlife-related benefits (such as tourism revenue and ecosystem services). Furthermore, HCCs undermine human health and safety and increase social costs (Dejene et al. 2016) because in most cases, humans are exposed to zoonotic diseases and the transmission of domestic animal diseases. Such diseases include foot and mouth disease, in addition to physical injury or even death caused by wild carnivore attacks, which have high financial costs for individuals and society in the form of medical treatments to cure and prevent infections transmitted from animals. Negative social effects on humans include missed school and work, additional labour costs, loss of sleep, fear, restriction of travel and loss of pets.

Similarly, the consequences to wildlife are serious, and the threats they face from humans may be direct or indirect (Dejene et al. 2016). Direct consequences include killing large carnivores by spearing and poisoning to retaliate for the losses incurred (Ogada et al. 2003, Holmern et al. 2007, Ikanda and Packer 2008, Masenga et al. 2013, Spira 2014, Dejene et al. 2016). Additionally, reduced tolerance to wildlife results in illegal activities, such as bush-meat hunting to reduce wildlife numbers and the associated damages. The indirect consequences of negative human interactions include destruction of critical wildlife habitats, encroachment into wildlife space, conversion of that space to alternative land uses, and general insularization (Dejene et al. 2016). Collectively, the effect of indirect and direct consequences is to reduce carnivore populations, leading to local extinctions and their confinement in protected areas (Dejene et al. 2016). In Africa, for example, large carnivore populations have been declining over the last decades, primarily because of conflicts with humans (Spira 2014, Dejene et al. 2016). In Tanzania, particularly in the Serengeti ecosystem, HCCs are widespread across the area and possibly threaten the viability of large carnivore populations, with those ranging outside protected areas most at risk from human-caused mortality (Holmern et al. 2007, Ikanda and Packer 2008, Masenga et al. 2013). Among the carnivore species of conservation concern, leopards (near-threatened), spotted hyenas (near-threatened), lions (vulnerable), cheetahs (vulnerable) and African wild dogs (endangered), all have experienced local extinctions and contractions of their ranges in the last century (Spira 2014).

One of the most pressing and intractable concerns in conservation is mitigating conflicts between humans and large carnivores (Atwood and Breck 2012). Therefore, the management of HCCs has become an important part of carnivore conservation and safeguarding human welfare and livelihoods (Dejene et al. 2016). According to Spira (2014), the effectiveness of the methods used to prevent and mitigate livestock depredation depends upon their social acceptability and technical feasibility. Moreover, the study by Dejene et al. (2016) revealed that assessing HCCs and quantifying the associated effects are fundamental to implement appropriate conflict mitigation techniques to minimize domestic animal loss and safeguard the conservation of the species. Faced with these issues, resolving conflicts between people and wild carnivores is fundamentally important to develop effective conservation strategies for large carnivores (Atwood and Breck 2012, Dejene et al. 2016). Furthermore, HCCs are one of the most persistent and very emotive aspects of conservation that must be managed for humans to co-exist with wildlife, particularly in poor, rural third world countries (Dejene et al. 2016). Therefore, carnivore conservation and conflict mitigation must be based on a sound understanding of carnivore behaviour and ecology. Some of the recommendations for mitigation of HCCs are presented in the following paragraphs.

1.1.1 Improving Traditional Husbandry Practices

In previous studies, the methods used to protect livestock from depredation differed significantly based on the distance from the protected area (Røskaft et al. 2013). However, in most cases, livestock owners elsewhere and in particular the Serengeti ecosystem use herders to look after their livestock to reduce the likelihood of livestock predation (Dejene et al. 2016)(Paper III), because when herdsmen are present, the predation rate is generally lower than that in free-ranging herds (Breitenmoser 1998, Datiko and Bekele 2013, Dejene et al. 2016). Additionally, Datiko & Betele (2013) suggest that the likelihood of livestock predation increases for unattended livestock, particularly goats and sheep, during daylight hours. However, small children used as herders did not reduce predation on livestock (Ikanda and Packer 2008, Datiko and Bekele 2013, Dejene et al. 2016).

1.1.2 Compensation Schemes

The economic costs to humans caused by HCCs are significant, and compensation is a measure that aims to alleviate conflict by reimbursing people for their losses. Compensation systems provide monetary payments or licenses to exploit natural resources that allow the hunting of game or the collection of fuel wood, timber and fodder from inside protected areas. Of the two methods, financial compensation is a very contentious issue and the least popular because of the inefficiency and low rate of reimbursement (Mishra 1997, Madhusudan 2003). The difficulty with financial compensation is a reality in many developing countries, which face budget constraints and usually pay on an irregular basis and to a limited extent (Rodriguez 2007). The second compensation scheme, also known as the "settlement of rights" to use natural resources, is apparently a more practical solution.

1.1.3 Translocation

Translocation is one way to mitigate HCC by moving wild carnivores out of areas in which they are at high risk (Davies and Du Toit 2004). Translocation, which is the intentional transport and release of animals to re-establish, augment or introduce a population in the wild, is frequently used to restore extirpated carnivore populations and primarily involves moving a certain number of animals to a new site for conservation purposes (Davies and Du Toit 2004). Although translocation may appear the least sensible of the solutions listed above and risks exporting the problem to another site, it may be a practical and acceptable approach in some cases and in which a suitable habitat is available with territorial vacancies (Davies and Du Toit 2004). Translocation works well when isolated individuals are unable to survive or reproduce because they are too distant from the main population and must be moved back to their own group and also when the carnivore density is high (Treves and Karanth 2003a). However, translocations can be ineffective in reducing depredation primarily because problematic individuals are simply placed elsewhere and also cause high rates of mortality post-translocation, which are counter to conservation goals (Spira 2014). Therefore, understanding the factors that influence translocation success is important because carnivore translocations are time-consuming, expensive, and controversial. According to Davies

& du Toit (2004), several wild dog translocations and reintroductions have been conducted, with varying degrees of success. For example, one such translocation occurred in Zimbabwe in mid-1997 in response to demands from cattle ranchers in the Nyamandhlovu region of Matebeleland. Approximately 11 to 14 dogs in the targeted pack were captured and immediately transported by road to an enclosure on Fothergill Island in Lake Kariba, part of Matusadona National Park, and were later released into the main part of the park. A combination of post-release radio-collar failures and dispersal of individuals from the park prevented long-term monitoring of the released individuals. However, none of the released individuals was observed within the study area subsequent to the 1998 breeding season, and although the outcome of the translocation is unknown, it is unlikely that it was a success (Davies and Du Toit 2004).

1.1.4 Conservation Education

Several studies demonstrate that conservation education can be used to increase the awareness of local people about wild carnivores and their importance to nature and thereby improve their attitudes and behaviours towards carnivores (Archer 2002, Prokop and Tunnicliffe 2008, Spira 2014)(Paper V). Different levels of conservation education and training activities, for example, in schools or in adult education arenas, such as farmer field schools, could have the objectives of disseminating innovative techniques, building local capacity in conflict resolution and increasing public understanding of HCCs (Prokop and Tunnicliffe 2008)(Paper V).

1.1.5 Zoning

When human settlements expand into habitats used by endangered wild carnivore species, the application of zoning is one way to minimize HCC (Treves and Karanth 2003a). Existing protected areas that prevent human activities are a form of zoning. With zoning, HCCs are addressed by reducing "the spatial overlap between large carnivores and unmitigated sources of conflicts" (Treves and Karanth 2003b, a, Spira 2014). By creating different management zones across the landscape in which either people or large carnivores are given the priority at various levels, the dual goal of conserving carnivores and reducing their effect on people's livelihoods may be met (Karanth and Chellam 2009, Spira 2014). However, zoning does not necessarily prevent livestock

depredation in areas in which people and wildlife continue to share the landscape (Treves and Karanth 2003a, Spira 2014).

1.2 An overview of HCCs in the Serengeti Ecosystem

Wildlife protected areas outside Serengeti National Park support various forms of land use, such as agriculture, livestock grazing, human settlements, infrastructure development and minor collection of forest produce (Mishra 1997). Livestock grazing in those areas is particularly widespread, and livestock holdings form an important component of the local pastoral and agricultural economy (Mishra 1997). Therefore, the loss of livestock in any of these local pastoral societies has a significant effect (Nyahongo 2007, Ikanda and Packer 2008, Masenga et al. 2013)(Holmen et al., 2007;). HCCs are a serious management issue that often cause opposition towards conservation efforts (Woodroffe et al. 2005, Holmern et al. 2007, Nyahongo 2007, Ikanda and Packer 2008) and therefore hinder the conservation of globally threatened species throughout their ranges (Mishra 1997). Previous studies in the northwestern Serengeti ecosystem found that HCCs in the area were caused primarily by spotted hyenas, leopards, baboons (*Papio cynocephalus*), lions and lastly by black-backed jackals (Holmern et al. 2007, Nyahongo 2007, Røskaft et al. 2013). As a result, local people had low tolerance to the problem and showed a negative attitude towards the conservation of wild carnivores in their communal lands (Holmern et al. 2007). In another study from the southern eastern Serengeti ecosystem in which the Ngorongoro Conservation Area is located, the Maasai pastoralists co-exist with large migratory herbivores and associated carnivores (Ikanda and Packer 2008) although lions, leopards and spotted hyenas prey on their livestock. As revenge, the Maasai pastoralists kill those carnivore species that prey upon their livestock (Holmern et al. 2007, Ikanda and Packer 2008, Masenga et al. 2013). Lions prey more on cattle and mostly commonly in grazing herds tended solely by children (rather than by warriors) and in large herds tended by a few herders (Ikanda and Packer 2008).

In the eastern Serengeti ecosystem in which the Loliondo Game Controlled Area (LGCA) is located, similar findings were obtained (Maddox 2003)(Paper I). According to Maddox (2003), lions, leopards, spotted hyenas and cheetahs were the primary predators causing livestock losses in the area. However, the local people did not report African wild dogs as a problem in the area

(Maddox 2003, Ikanda and Packer 2008). Notably, in our paper, African wild dogs were the primary predator causing livestock losses in the area. The other carnivore species reportedly causing the same problem were lions, leopards, spotted hyenas, cheetahs and baboons. African wild dogs attacked livestock primarily during the day and in the evening when livestock herds were grazing in the field (Paper I). Generally, in the Serengeti ecosystem, HCCs occur in the highest frequencies in the villages nearest the park boundary (Holmern et al. 2007, Røskaft et al. 2013). However, in the study by Nyahongo (2007), livestock depredation, primarily by spotted hyenas, was higher in the villages far from the park boundary. This result can be explained by the ability of certain carnivore species, such as spotted hyenas, to commute up to 80 km and forage, even in villages located far from the park boundary (Nyahongo 2007). Among all the carnivores involved, the spotted hyena was the most common destructive wild carnivore species in the area (Maddox 2003, Holmern et al. 2007, Nyahongo 2007, Ikanda and Packer 2008, Røskaft et al. 2013)(Paper I).

1.3 African wild dog

The African wild dog is one of the rarest species in Africa and one of the most endangered carnivores in the world (Woodroffe et al. 2005, Woodroffe 2011). Wild dogs represent a challenge for modern conservation because viable populations require vast areas to persist; however, the increasing human population in Africa results in increasingly smaller areas for wildlife conservation in most regions (Woodroffe et al. 2005, Woodroffe 2011, Ngongolo et al. 2015). African wild dogs are cursorial predators and can occupy a range of habitats from montane forest to semi-desert and were formerly distributed throughout sub-Saharan Africa, absent only from the lowland forests of the Congo basin (Fanshawe et al. 1991). Wild dogs are intensely social, hunting, breeding and even dispersing in close cooperation with other pack members (Malcolm and Marten 1982, McNutt 1995, Creel and Creel 2002). Thus, packs, rather than individuals, are arguably the most appropriate measure by which to count wild dog populations (Woodroffe 2011). Usually, the dominant or alpha male and female in a pack reproduce. The alpha female is usually the oldest in the group, and she gives birth in a den after three months (Woodroffe 2011). When adulthood is reached, the new pups may choose to remain with their natal pack or disperse (Ngongolo et al.

2015). Wild dogs generally disperse in single sex groups, and these groups either make contact and join another pack or meet another set of opposite sex dogs and form a new pack (McNutt 1995, Ngongolo et al. 2015). They are old enough to reproduce after two years but rarely do so until they have achieved sufficient status in the dominance hierarchy. Wild dogs are active at dawn and dusk (Woodroffe et al. 2005, Ngongolo et al. 2015).

Populations of wild dogs are declining rapidly regardless of the many conservation efforts to protect the species (Masenga et al. 2013, Ngongolo et al. 2015). The decline is occurring because of habitat destruction and fragmentation due to human encroachment, deliberate killing by game and livestock farmers, and accidental capture in snares, vehicle collisions and infectious disease (Woodroffe 2011). In many African countries, the species is considered extinct, whereas in others, few remain (Woodroffe 2011, Ngongolo et al. 2015). For example, in Benin, Burkina Faso, Ghana and Niger, the species is thought to be extinct because of their long-time disappearance. By contrast, Tanzania is among the African countries with a good population of wild dogs (Fanshawe et al. 1991, Ngongolo et al. 2015). Although social cooperation helps them survive severe living conditions, the African wild dog is now one of the most endangered animals in Africa (Woodroffe et al. 2005, Ngongolo et al. 2015).

The conservation challenges for wild dogs are based on habitat loss/degradation/fragmentation as the result of human activities, including development activities, agriculture, industrialization, mining (Ngongolo et al. 2015) and retaliatory killing due to depredation behaviour (Woodroffe et al. 2005, Masenga et al. 2013). Therefore, proper mitigation measures are required to rescue the species from disappearance.

2. Aims of the Thesis

In this thesis, the conflicts between humans and large carnivores were assessed with a special focus on African wild dogs in the Eastern Serengeti Ecosystem, Tanzania, as a case study. Although local people did not report African wild dogs as a problem in the area in 1990s (Maddox 2003), since 2000, reports of livestock depredation by wild dogs have increased (Masenga and Mentzel 2005). To address the problem of this depredation, the first part of this thesis focused on the conflict over livestock depredation and attempted to answer the following questions:

Is the African wild dog the only wild carnivore species causing livestock depredation in the area?

Is this problem recent or was there a problem before the Maasai were evicted from the Serengeti in 1959?

Have traditional husbandry methods been abandoned in the area?

The answers to these questions are provided in Papers I-III.

The second part of this thesis focused on how to promote the coexistence of humans and large carnivores in this area and attempted to answer the following questions:

What attitudes do the Maasai pastoralists have towards the conservation of large carnivores in their area?

Can conservation education assist in changing the level of local people's knowledge and therefore improve the conservation of large carnivores in the area?

The answers to these questions are provided in Papers IV and V.

3. Summaries of Papers

3.1 Paper I

Human-carnivore conflict over livestock in the eastern part of the Serengeti ecosystem with a particular focus on African wild dogs (*Lycaon pictus*).

African wild dogs were formerly distributed throughout sub-Saharan Africa (Woodroffe et al. 1997, Woodroffe et al. 2004, Masenga 2011) but are now one of the most threatened and endangered carnivores in the world (Woodroffe et al. 2004, Lyamuya et al. 2014). Currently, they have disappeared from much of their former range, with 25 of 39 countries no longer inhabited by the species (Fanshawe et al. 1991, Lyamuya et al. 2014).

The population of wild dogs is currently estimated at approximately 6,600 adults in 39 subpopulations, with only 1,400 mature individuals (Jones et al. 2016) and continues to decrease (McNutt 1995). This decrease is primarily due to lethal control measures implemented by humans

as the result of wild dog depredation behaviour (Woodroffe et al. 2005, Masenga et al. 2013, Lyamuya et al. 2014).

In Serengeti National Park, African wild dogs were declared locally extinct in 1991 (Creel et al. 1997, Stearns et al. 2000, Carbone et al. 2005). However, eight packs of wild dogs were reported in the eastern Serengeti ecosystem during 2008–2009. These packs, with fewer than 100 adults in total, inhabited the north-eastern part of the ecosystem (Masenga 2011). Attacks on livestock by wild dogs have increased in that area since 2000, when packs began to reappear in the area (Masenga and Mentzel 2005).

In this paper, we assessed the patterns of attack related to such conflicts and their magnitude in the area. We focused on the African wild dog and for comparison, on other large carnivore species in the area (lions, leopards, spotted hyenas, striped hyenas (*Hyaena hyaena*) and cheetahs). We found that wild dogs were the only common predator of the herds of the Maasai and Sonjo tribes and attacked mostly sheep and goats in the afternoon and evening, whereas the other carnivores generally attacked livestock at night. These findings demonstrated that conflicts occurred in the area, and therefore, to ensure the coexistence and persistence of wild dogs, the conflicts must be resolved.

3.2 Paper II

A historical perspective of the Maasai-African wild dog conflict in the Serengeti Ecosystem.

The Maasai pastoralists have inhabited the Serengeti since the end of the eighteenth century, arriving from the north and displacing other tribes in the Serengeti area (e.g., Sukuma, Ikoma and Ndorobo) (Neumann 1995). They became the dominant ethnic group in the Serengeti by the late 1800s (Homewood et al. 2004). Since then, the Maasai pastoralists in the Serengeti area have lived alongside wild animals, including African wild dogs, with low levels of conflict. In 1959, they were evicted from Serengeti National Park (SNP) and displaced to the Loliondo Game Controlled Area (LGCA) and Ngorongoro Conservation Area (NCA) (Neumann 1995).

Before the the Maasai pastoralists were evicted from the Serengeti, the African wild dog population was most likely high, yet the wild dogs were declared locally extinct in SNP in 1991 (Gascoyne et al. 1993, Stearns et al. 2000, Carbone et al. 2005). However, according to previous studies, although the packs inside the national park disappeared, the population never went extinct and most likely survived in adjoining areas (Burrows et al. 1994, Marsden et al. 2012).

In this paper, we investigated whether the Maasai pastoralists endured any conflict with African wild dogs over livestock during their stay in SNP before 1959 and whether conflicts had escalated in recent years. We found that male Maasai pastoralists had a greater awareness of local wild dog presence and livestock-derived conflict than that of females because in Maasai culture, males perform most of the outdoor activities, such as herding of livestock in the bush, and thereby acquire more information. Conflicts occurred before 1959 but at a low level, then decreased during the 1990s, but then increased again beginning in 2000. The increase that started in 2000 was attributed to the increase in human, livestock and wild dog populations in the area. Insights into the conflict have the potential to aid conservation management of the threatened carnivore.

3.3 Paper III

Pastoralist herding efficiency dealing with carnivore-livestock conflicts in the Eastern Serengeti, Tanzania.

Recent studies in the Eastern Serengeti in northern Tanzania demonstrated that livestock depredation occurs and that the African wild dog is the most common wild carnivore species involved in such conflicts (Masenga et al. 2013, Røskaft et al. 2013, Lyamuya et al. 2014). Similar depredations have been reported elsewhere in Tanzania and Africa (Woodroffe et al. 1997, Rasmussen 1999, Maddox 2003, Swarner 2004, Wang and Macdonald 2006, Mwebi 2007, Nyahongo 2007, Ikanda and Packer 2008).

To promote coexistence between humans and wild carnivore species, incidences of livestock depredation must be either reduced or prevented (Kaczensky 2003, Mwebi 2007, Woodroffe et al. 2007). Previous studies recommend improving livestock husbandry methods that deter livestock

predation to prevent carnivores from developing a taste for livestock (Mwebi 2007). Among the recommended methods for this problem are improvements in traditional livestock herding practices (Mwebi 2007, Woodroffe et al. 2007).

In this paper, the reasons African wild dogs prey more frequently on livestock during the day, as described in a previous study (Lyamuya et al. 2014), were investigated. We hypothesized that adult male herders are more efficient in caring for livestock than females in both the Maasai and Sonjo tribes. Our hypothesis was supported, and we found that female herders experienced more attacks than male herders did. This difference between the sexes was likely because in both tribal cultures only males receive general training that involves fighting against dangerous wild animals and other enemies before they become "Morans" (warriors) (Mwebi 2007). We further hypothesized that the use of equipment, such as spears and knives, reduces carnivore depredation in the area. This hypothesis was also supported, and we found that carrying defensive equipment (e.g., knives and spears) reduced the number of successful carnivore attacks in the area. In this regard, the simple analysis used to assess pastoralists herding efficiency dealing with carnivore-livestock conflicts may be useful in promoting the coexistence of humans and wild dogs in the area.

3.4 Paper IV

Attitudes of Maasai pastoralists towards conservation of large carnivores in the Loliondo Game Controlled Area of northern Tanzania.

Human–carnivore coexistence requires a better understanding of human attitudes, particularly of people who must bear the consequences of large carnivores in their vicinity (Jackson et al. 2003, Lagendijk and Gusset 2008, Gusset et al. 2009, Carter et al. 2014). Therefore, in many parts of the world, human attitudes rather than natural conditions determine the size and distribution of large carnivore populations (Jackson et al. 2003, Treves and Karanth 2003a, Mannelqvist 2010, Yirga et al. 2011). Thus, positive attitudes among the public and local communities may influence levels of tolerance towards wildlife.

According to previous studies, when local people coexist with large carnivores, in most cases, they hold negative attitudes towards their conservation because large carnivores either kill their livestock or attack people (Løe and Røskaft 2004, Gusset et al. 2009, Carter et al. 2014, Lyamuya et al. 2014). Hence, local people frequently respond by killing (Kissui 2008, Yirga et al. 2011, Masenga et al. 2013). Such killing is reducing the numbers of carnivores both at a population level and for entire species (Lindsey et al. 2005, Woodroffe et al. 2005, Lucherini and Merino 2008, Yirga et al. 2011, Jhamvar-Shingote and Schuett 2013, Carter et al. 2014). A similar situation occurs among the Maasai pastoralists inhabiting the Loliondo Game Controlled Area in northern Tanzania in which the local people frequently kill troublesome carnivores (Ikanda and Packer 2008, Lyamuya 2011, Masenga et al. 2013, Lyamuya et al. 2014). Our findings showed clearly in which areas and how conservation interventions should be focused (i.e., gender and education) to improve the coexistence of Maasai pastoralists with large carnivores in an area. These results are consistent with those of previous studies that found that the assessment of attitudes towards large carnivores is frequently the first stage for determining proper conservation strategies (Jackson et al. 2003, Kaczensky 2003, Lindsey et al. 2005, Gusset et al. 2009, Carter et al. 2014).

3.5 Paper V

Can enhanced awareness change local schoolchildren's knowledge of carnivores in northern Tanzania?

Using educational tools as a medium to promote changes in human feelings and behaviour, conservation education aims to increase awareness and knowledge of wildlife and other natural resources through systematic methods, programs and activities (Williams 2002, Mulder et al. 2009). Increasing awareness and knowledge is currently of critical importance because of increased anthropogenic pressures on our natural environment (Mutisya et al. 2013). Based on previous studies, education is required to inform people on how and why natural resources should be used with care (Lagendijk and Gusset 2008, Gusset et al. 2009, van Dalum 2013).

Currently, wildlife education programs are used as a tool to increase the coexistence between humans and carnivores, and as a result, the further continual decline of large carnivore populations

worldwide has been reduced (Ernst and Theimer 2011, van Dalum 2013). Children are more suitable for these programs because their level of knowledge has been successfully increased, and thereafter, children positively influence the attitudes and behaviour of their parents (Williams 2002). Furthermore, several studies found that becoming familiar with animals via wildlife education programs usually promotes their coexistence (Bogner 2002, Tal 2010, van Dalum 2013). We hypothesized that the educational program would increase the general knowledge on large carnivore identification among the schoolchildren that participated, specifically for the African wild dog, and therefore would most likely enhance their coexistence in the area. Our results supported this hypothesis, and we found an increase in knowledge among the school children involved in our education program on large carnivore identification. Additionally, the increase in knowledge was important to large carnivore conservation, in particular that for the African wild dogs because the post-test results showed that most schoolchildren considered wild dogs to be an important part of the ecosystem.

4.0 General Discussion

Conflicts between pastoralism and carnivore conservation over livestock depredation pose a serious challenge to endangered carnivores worldwide and have become an important concern for local livelihoods, often causing opposition towards efforts for carnivore conservation (Mishra 1997, Woodroffe et al. 2005, Holmern et al. 2007, Ikanda and Packer 2008). The conflicts usually occur in communities living close to protected areas (Holmern et al. 2007, Røskaft et al. 2013). In the Serengeti ecosystem, HCC is escalating because of an increasing human population, loss of natural habitats, and in some regions, decreasing wildlife populations because of human activities (Holmern et al. 2007). Therefore, alleviating HCC is central to large carnivore conservation and is often of economic importance in areas in which people must coexist with carnivores (Li et al. 2013). In particular, for the Maasai and Sonjo tribes to coexist with wild carnivores in their area, HCC must be alleviated because livestock grazing in both tribes is widespread and livestock holdings form an important component of their economy (Mishra 1997). Therefore, livestock losses in any of these local pastoral societies have a significant effect. However, we found that African wild dogs were the only common predator encountered by both tribes and attacked mostly

sheep and goats in the afternoon and evening (Paper I), which were results consistent with those of previous studies elsewhere in the area (Holmern et al. 2007, Nyahongo 2007, Ikanda and Packer 2008, Røskaft et al. 2013). In many instances of livestock depredation, the Maasai pastoralists retaliated by killing those carnivore species that preyed upon their livestock, thereby leading to declines in their populations (Ikanda and Packer 2008, Masenga et al. 2013). Male Maasai pastoralists better understood the HCC problem because of their traditional role in guarding livestock. HCC were reported before 1959 but occurrences were initially low, with the problem decreasing further during the 1990s, but HCC increased beginning in 2000 because of the increases in human, livestock and wild dog populations in the area (Paper II).

To prevent further depredation in their areas, both tribes used herders to guard their livestock when grazing in the field (Paper III). However, our results showed that more attacks occurred when herders were females. As a likely explanation, in both tribal cultures, only males receive general training, which involves fighting against dangerous wild animals and other enemies, before they become "Morans" (warriors) (Paper III). Furthermore, our results revealed that the use of equipment, such as spears and knives, helped to reduce carnivore depredation in the area. Additionally, in previous studies, domestic dogs were used to guard livestock from depredation (Davies and Du Toit 2004, Datiko and Bekele 2013) although domestic dogs were not used in our study (Paper III). Guard dogs are reportedly efficient against serval (*Leptailurus serval*) and baboon attacks but not against those of a lion or caracal (Datiko and Bekele 2013). Usually, in the absence of herders, baboons also attack dogs. Caracals also prefer dogs. Similar cases are reported from Serengeti National Park in which hyenas kill dogs (Holmern et al. 2007, Datiko and Bekele 2013). However, guard dogs have been successful elsewhere (Davies and Du Toit 2004, Datiko and Bekele 2013). Furthermore, livestock are kraaled by most livestock keepers at night (Ogada et al. 2003, Treves and Karanth 2003a, Davies and Du Toit 2004, Rodriguez 2007, Dejene et al. 2016) because predation rates are reduced with livestock in kraals at night (Treves and Karanth 2003a, Rodriguez 2007, Datiko and Bekele 2013). Most of the households visited had at least one thorn bush kraal or 'boma' to enclose livestock during the night. However, kraal quality was often poor and improvements could help reduce livestock depredation because in previous studies, good kraal construction is associated with reduced losses to large carnivores (Ogada et al. 2003, Davies and Du Toit 2004, Rodriguez 2007, Datiko and Bekele 2013). For night-time protection, numerous studies recommend using predator-proof housing as an alternative (Rodriguez 2007). Therefore,

improving livestock husbandry techniques can greatly affect predation on livestock (Treves and Karanth 2003a, Davies and Du Toit 2004, Holmern et al. 2007, Rodriguez 2007, Datiko and Bekele 2013, Dejene et al. 2016).

Based on our previous findings, female pastoralists held a more negative attitude towards the conservation of large carnivores in their area (Paper IV). Therefore, based on these findings, the conflict that occurred in the area must be resolved to ensure the coexistence of humans and large carnivores. To ensure this coexistence, in our study, a wildlife conservation education program was used to increase awareness and knowledge of wildlife and other natural resources in school children through systematic methods, programs and activities using educational tools as a medium to promote changes in their feelings and behaviour (Williams 2002, Mulder et al. 2009)(Paper V). Educating rural villagers in practical skills can help them to address dangerous wild carnivore species and to acquire and develop new tools for defending their livestock (Paper V). Over time, education can change the behaviour amongst local populations, which would contribute to reduced risks, improvements in local livelihoods and reduced vulnerability (Archer 2002, Prokop and Tunnicliffe 2008)(Paper V). In an optimistic scenario, wildlife conservation education and training would promote a commitment towards conservation and increase the awareness of the essential role of wildlife in ecosystem function, in addition to increasing understanding of the economic and recreational value and the ethical and aesthetic importance of wildlife (Archer 2002, Prokop and Tunnicliffe 2008)(Paper V). With such education, the tolerance of local people will ultimately increase towards wild carnivores and increase support for conservation efforts (Prokop and Tunnicliffe 2008)(Paper V). In our study, knowledge increased among the schoolchildren involved in our education program on the identification of large carnivores, and based on post-test results, most schoolchildren considered wild dogs to be an important part of the ecosystem. Thus, the increase in knowledge likely benefitted the conservation of large carnivores, particularly that of African wild dogs (Paper V).

In some studies, a compensation scheme was used to enhance human-carnivore coexistence in a particular area because such schemes contribute to an increase in the tolerance of livestock keepers towards carnivores and therefore avert retaliatory killings (Rodriguez 2007, Spira 2014). However, in practice, establishing a compensation scheme remains challenging, particularly in developing countries in which institutional capacity might be inadequate for managing such a scheme (Spira

2014). As an unintentional result, livestock owners may expend little effort to prevent depredation by improving husbandry practices associated with livestock security (Rodriguez 2007, Spira 2014). A good example is that of the Predator Compensation Fund on Mbirikani Group Ranch, a communally owned area in southern Kenya's Maasailand, which is one of the relatively few that operates in the world (Rodriguez 2007). This fund compensated owners for livestock attacked/killed by wild carnivores and as a result, increased tolerance levels for carnivores (Rodriguez 2007). Although most people indicated a desire for the project to continue, they also felt the project was unfair and inequitable (Rodriguez 2007). Indeed, for compensation schemes to be successful, some elements must be established, including quick and accurate verification of damage, fair payment, a plan for sufficient and sustainable funds, shared project ownership, clear rules, guidelines and measures of success (Rodriguez 2007). Therefore, most compensation schemes require more frequent and extensive education efforts delivered to all community members, in addition to the timely dissemination of project information to increase the transparency of the project (Rodriguez 2007).

5.0 Conclusions, Recommendations and Management Implications

Conflict between humans and African wild dogs and other carnivore species over livestock predation in our study area was prevalent, but generally relatively low. As one of the primary findings, predators killed very few livestock annually. However, from a human perspective, each animal owned by the Maasai or Sonjo tribe has sentimental and economic value, and therefore predation results in a significant outburst. Attacks by wild dogs were mostly on sheep and goats and occurred more frequently in the evening. Other carnivore species, such as lions, spotted hyenas, cheetahs and leopards, also caused similar problems, however, to a lesser extent, most likely because of their smaller population sizes. Adult males had a greater awareness of the local wild dogs and livestock-derived conflicts than did females, and men more frequently chased and killed wild dogs that attacked their livestock. Finally, this conflict has persisted for several decades and existed before 1959. Although conflicts apparently decreased during the 1990s, they increased again beginning in 2000. This increase was most likely due to the increase in the human population and number of livestock as well as an increase in the area's wild dog population.

Although conflicts continue in the area, our results demonstrated that both tribes spent considerable time caring for their livestock when they were grazing in the fields, because all visited livestock herds were attended by at least one herder. The use of herders worked well in reducing livestock predation. However, in our study, most of the livestock losses were higher when females were herders and when herders lacked weapons to protect their livestock from attacking carnivores. Moreover, our findings revealed that when herders were carrying defensive equipment (e.g., knife/spear) carnivore attacks were reduced dramatically; therefore, using good defensive equipment in the future is crucial.

Furthermore, because females experienced more conflicts than males, females generally expressed negative attitudes towards the conservation of all five large carnivore species in the study area. More males had been to school and were more likely to visit wilderness areas than females, which were other factors for the difference in attitudes. Therefore, men more frequently encountered large carnivores when they were out in the bush and received more benefits from having wild carnivores in their area.

In our study, schoolchildren's knowledge of large carnivore identification increased during a short and intense education program of less than one week. In particular, these students improved their identification of the African wild dog in the Loliondo Area, although we are unsure how long this change will persist.

Therefore, to foster the coexistence between African wild dogs and other carnivores and humans in the area, the following recommendations are proposed:

1) African wild dogs prefer to prey on wild prey species rather than livestock when such wild species are in sufficient supply. Therefore, to reduce livestock depredation in the area, the continued increase in livestock density must cease, and the wild prey populations should be protected.

2) Additionally, although most incidences of livestock depredation occurred in the afternoon and evening, improving herding intensity is required at all times, but particularly during the afternoon and evening and during seasonally sensitive periods. The number of adult male herders per livestock herd should also be increased during the sensitive periods, particularly during the evening.

3) Female Maasai pastoralists must be more involved in tourist activities in their areas and must attend school. When possible, they should be allowed to access natural resources in the protected areas during times of hardship to increase positive attitudes and to gain their support for the conservation of wild carnivores in their area. This support can be achieved with the involvement of females in carnivore conservation in their areas as "carnivore guardians."

4) To ensure that wild carnivores, particularly African wild dogs, are well conserved in the area, the implementation of a wildlife education program with the aim to educate local people about wildlife conservation is very important. This study indicated that conservation education is a continuous learning process that must be included in primary and secondary school curricula as early as possible to favour mutual coexistence between large carnivores (in particular, the African wild dog) and humans. Therefore, one of the most important strategies to ensure sustainable conservation of such species in a human dominated landscape, particularly faced with the current, rapid human population growth, is to increase the knowledge about large carnivores and their biology. Moreover, increased support for wildlife education among schoolchildren and improved support for wildlife clubs will benefit large carnivores. Therefore, through its outreach program, Tanzania National Parks (TANAPA) should support and develop such a program in the future.

5) When possible, conservation performance payments for carnivores should be institutionalized to reward those who conserve wild carnivores in their areas.

6) The problem of livestock depredation during the night is caused by other carnivore species, and our findings indicated that improvements and increased maintenance of thorn bush kraal or 'boma' and preferably the use of predator-proof bomas, which are traditional livestock husbandry practices, can reduce carnivore attacks at night.

7) Our findings revealed that even the loss of a single livestock by wild carnivores resulted in a large outburst from livestock owners; therefore, compensation schemes for livestock depredation must be institutionalized to improve the tolerance of local people to wild carnivores in the area.

8) For the African wild dogs and other carnivores that are found in human dominated landscapes, an institutionalized zoning scheme is required to reduce the frequencies of carnivore contacts with humans and livestock.

9) Finally, involving local residents in conflict management will provide incentives to maintain and relocate corrals, and introducing grass and fodder species can be helpful in mitigating the problem in the area.

5.1 Future Research Needs

In the future, an experimental approach is required to investigate the use of specially bred guard dogs, which have been used elsewhere with success to deter wild carnivores from preying on foraging livestock. Currently, the use of such guard dogs has not been attempted in the area, except for using common domestic dogs, which failed to reduce the problem in our study.

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Paper I

Is not included due to copyright

Paper II

Environment and Natural Resources Research; Vol. 6, No. 2; 2016
ISSN 1927-0488 E-ISSN 1927-0496
Published by Canadian Center of Science and Education

A Historical Perspective of the Maasai - African Wild Dog Conflict in the Serengeti Ecosystem

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Received: March 2, 2016 Accepted: March16, 2016 Online Published: March 23, 2016

doi:10.5539/enrr.v6n2p42 URL: http://dx.doi.org/10.5539/enrr.v6n2p42

Abstract

This study discusses the conflict between Maasai pastoralists and African wild dogs (*Lycaon pictus)* over livestock before and after the Maasai were evicted from the Serengeti National Park (SNP) in 1959. We surveyed 181 randomly selected households from six villages in the eastern Serengeti ecosystem. A semi-structured questionnaire was used to acquire the required information from the respondents. We found that males had a greater awareness of local wild dog presence and livestock-derived conflict than females, and reported more frequently to have chased and killed wild dogs that attacked their livestock. Moreover, the conflict existed before 1959, decreased during the 1990s, but increased from 2000 onwards. This increase is attributed to the growth in human, livestock and wild dog populations in the area. This study recommends that to foster their coexistence, the continued escalation in livestock numbers needs to cease while simultaneously protecting the region's wild prey populations.

Keywords: African wild dogs, predation, livestock, gender, conflict

1. Introduction

Human-carnivore conflict over livestock presents one of the most complex challenges facing wildlife management and conservation. This global problem (Ciucci & Boitani, 1998; Rodney & Rinchen, 2004; Røskaft, Bjerke, Kaltenborn, Linnell, & Andersen, 2003; Røskaft, Händel, Bjerke, & Kaltenborn, 2007; Treves & Karanth, 2003; Woodroffe, Lindsey, Romanach, Stein, & ole Ranah, 2005) is also a significant problem in the Serengeti ecosystem in northern Tanzania (Ikanda & Packer, 2008; Jackson, Ahlborn, Gurung, & Ale, 1996; Kaczensky, 1999; Larson, 2008). The most important driving factors include increasing human populations, loss of natural habitats and, in some regions, growing wildlife populations resulting from successful conservation programs (Wang & Macdonald, 2006). The endangered African wild dog (*Lycaon pictus)* has disappeared from much of its former range, due mostly to conflict with humans (Ogada, Woodroffe, Oguge, & Frank, 2003; Rasmussen, 1999; Treves & Karanth, 2003) which has led to their population decline (Swarner, 2004; Woodroffe et al., 2005). This endangered species has been reported to prey on livestock wherever it comes into contact with domestic animals (Lyamuya, Masenga, Fyumagwa, & Røskaft, 2014; Rasmussen, 1999; Swarner, 2004; Woodroffe et al., 2005). The Maasai pastoralists in the eastern Serengeti ecosystem are among those suffering livestock losses to wild dogs (Lyamuya et al., 2014; Masenga, 2011). The Maasai pastoralists have inhabited the Serengeti and Ngorongoro areas until the end of the eighteenth century, arriving from the north and displacing other tribes in the Serengeti area (e.g., Sukuma, Ikoma and Ndorobo) (Neumann, 1995). They became the dominant ethnic group in the Serengeti by the late 1800s (Homewood & Rodgers, 1991). Since then, the Maasai pastoralists in the Serengeti area have lived alongside wild animals, including the African wild dogs, up to 1959 when they were evicted from the Serengeti National Park and displaced to the Loliondo Game Controlled Area (LGCA) and Ngorongoro Conservation Area (NCA) (Neumann, 1995). Before that, the African wild dog population was most likely high, yet the wild dogs were declared locally extinct in the Serengeti National Park (SNP) in 1991 (Carbone et al., 2005; Gascoyne, Laurenson, Lelo, & Borner, 1993; Stearns & Stearns, 1999). A recent genetic study, however, has indicated that while the packs inside the national park disappeared, the population never went extinct and most probably survived in adjoining areas (Marsden, Wayne, & Mable, 2012).

Wild dogs currently inhabiting LGCA and NCA are genetically similar to those previously inhabiting the Serengeti plains, ruling out the possibility that this population has recolonized the area from elsewhere (Marsden et al., 2012). The LGCA and NCA support the only wild dog population in the area since the population has failed to naturally recolonize the Serengeti National Park (Masenga, 2011).

Therefore, there is little information on the historical distribution of wild dogs in the ecosystem, especially as to where the population successfully survived the supposed local extinction. There is also a lack of information as to whether the Maasai pastoralists had any conflict with the wild dogs over their livestock during their stay in the SNP before 1959, and whether this has escalated in recent years. Information on the status of the conflict will thus provide a much needed overview of the historical distribution of wild dogs and temporal trends in the conflict in the area. Insights into the conflict will aid conservation management of the threatened carnivore.

We tested three hypotheses in this study. The first hypothesis was that the wild dogs have continuously inhabited the LGCA, even directly after the reported extinction. The second hypothesis is that male Maasai pastoralists have a greater awareness of local wild dog presence and the livestock-derived conflict in their area. The third hypothesis is that the conflict between the Maasai pastoralists and wild dogs has increased in recent years due to human and livestock population growth and an increase in the wild dog population in the area.

2. Materials and Methods

The study was conducted in six villages in the LGCA in the eastern Serengeti ecosystem (Figure 1). LGCA borders the Maasai Mara National Reserve along the Kenyan border and the SNP in Tanzania between 2°5'00''–2°2'60''S and 35°61'67''–35°37'00''E (Masenga, 2011). The region is one of the most wildlife-rich areas in the world (Maddox, 2003). Hundreds of thousands of wildebeest (*Connochaetes taurinus)*, zebra (*Equus burchelli)* and other ungulates pass through the communities during their annual migration from the Maasai Mara to the Serengeti Plains (Holdo et al., 2010). Large predators remain remarkably widespread throughout the LGCA compared with nominally unprotected areas in other parts of Tanzania and neighbouring countries. Maddox (2003) described a significant cheetah (*Acinonyx jubatus)* population in the LGCA and noted the large numbers of lions (*Panthera leo)*, spotted hyenas (*Crocuta crocuta)*, and jackals (*Canis mesomelas)* in the area. The Maasai pastoralists mostly inhabit the area closest to the SNP boundary, covering approximately 4500 km^2 (Lyamuya, Masenga, Fyumagwa, & Røskaft, 2014). The dominant form of land use and livelihood in the area is trans-human pastoralism (Homewood & Rodgers, 1991), which utilizes wet and dry season livestock grazing pastures according to traditional patterns of movement. Rangelands are managed communally but are not considered to be open access lands.

The data for this study were collected in January 2013 and encompassed 181 households chosen randomly from the six Maasai villages living in the eastern Serengeti ecosystem (Figure 1). The method used for data collection and sample size determination followed the same methods previously employed in other studies (Fa, Peres, & Meeuwig, 2002; Sancheti & Kapoor, 2003). No prior notice was given to the interviewees, although the village chairman was first consulted about the study and asked for permission to carry out interviews in his/her area. A purposive sampling strategy was used, with respondents chosen according to availability based on their age and gender. A semi-structured interview was administered through a questionnaire translated into "Swahili" language with the help of Maasai translators to acquire information related to their perspectives on the history of human-wild dog conflict in the area. The information collected included basic information such as the respondent's age, GPS location, tribe (only Maasai), educational level (e.g., had been to school, had not been to school) and occupation (e.g., livestock keeper, housewife, employee). Respondents were then asked if they were born before or after the Maasai eviction from the SNP. After that, respondents were asked the following questions regarding their coexistence with wild dogs: (1) "Have you ever seen wild dogs?" (2) "How often do you see wild dogs in your area?" (3) "How is the general population trend of wild dogs in your area?" (4) "Have you ever seen wild dogs preying on your livestock?" (5) "How often do you see wild dogs preying on your livestock?" (6) "How did you react when you observed wild dogs attacking your livestock?; (7) "If you compare the present situation on livestock attacks by wild dogs to those days when you were young, is it increasing, decreasing or does it remain stable?"

During the survey, we collected village centre GPS locations which assisted us in drawing our study area map in Arc View 9.0 (Environmental Systems Research Institute, Redlands, CA, USA). Statistical Package for Social Science (SPSS) Statistics 21.0 for Windows (http://www.spss.com) was used to perform all statistical analyses (Kirkpatrick & Feeney, 2010). We used both logistic and linear regression analyses to test different independent variables that could explain the variations existing among dependent variables in our data. Because most of our data were nominal, we primarily used non-parametric Chi-square tests (Fowler, Cohen, & Jarvis, 2009) to determine frequency differences among different variables; hence, in all tests, $P \leq 0.05$ was considered statistically significant.

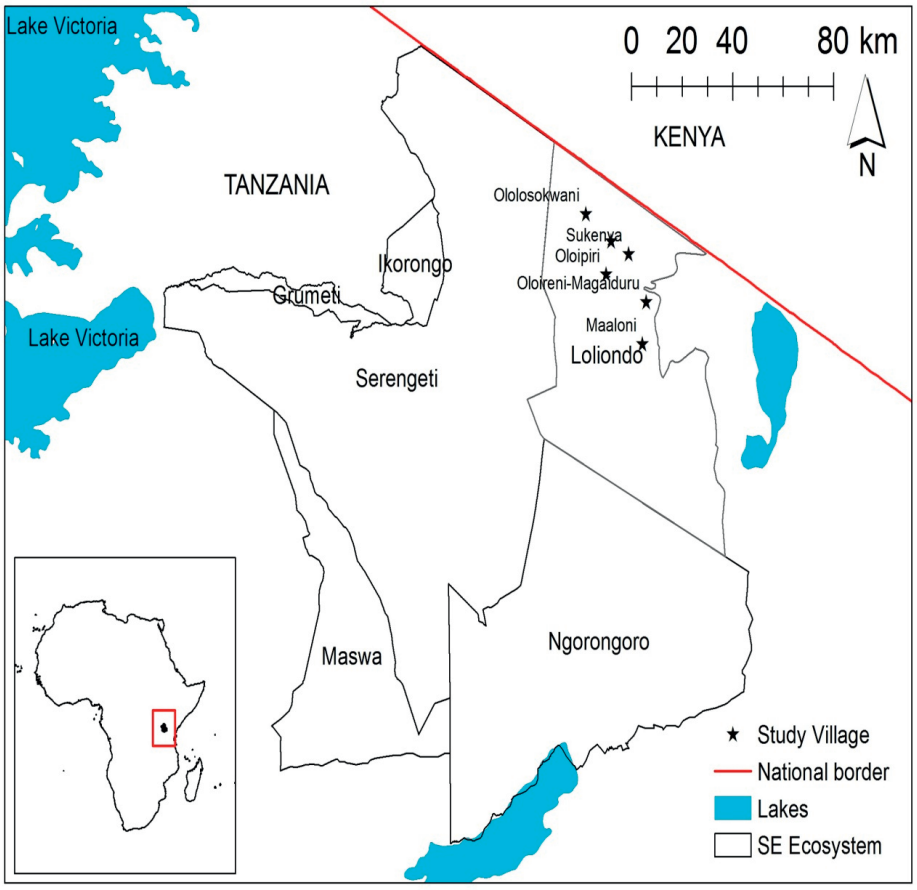

Figure 1. A map of the Serengeti ecosystem showing the study area with the surveyed villages marked with stars

3. Results

Male Maasai pastoralists (98 %, n = 123) reported more frequently to have seen wild dogs in their area than did females (66 %, n = 58; $\chi^2_1 = 36.5$, P = 0.001). Those who had been to school had more frequently (95 %, n = 74) seen wild dogs in the area than those who had never been to school (82 %, n = 107; $\chi^2_1 = 6.02$, P = 0.014). However, no difference in this respect was found between those born before or after the eviction from SNP (1959) (χ^2_1= 0.479, P = 0.359).

A logistic regression analysis with response to the question "Have you ever seen wild dogs? (yes/no)" as a dependent variable, and gender, education level and born before or after eviction from the SNP (1959) as independent variables indicated that gender (B = 2.7, Wald = 15.8, P ≤ 0.001) was the only factor explaining whether wild dogs had been seen in their area (Wald χ^2_3 = 32.7, P ≤ 0.001, Nagelkerke r^2 = 0.328). The other factors such as born before or after the Maasai eviction from the SNP and education level were not found to be significant in explaining the variation in the observations (yes/no) of wild dogs in the area.

Males more frequently reported seeing wild dogs on a daily or weekly basis compared to females (χ^2_1= 39.2, P ≤ 0.001, Table 1). Furthermore, the frequency on how often Maasai pastoralist had observed wild dogs varied with education level (χ^2_1= 17.1, P = 0.002, Table 1) and whether they were born before or after the eviction from SNP (χ^2_1= 33.6, P ≤ 0.001, Table 1). Those who not had been to school observed wild dogs more frequent than those who had been to school, while those born before eviction from the SNP (1959) also observed wild dogs more common than those born after eviction.

Table 1. Responses to the question "How often do you see African wild dogs in your area?" in relation to gender, education level or whether born before or after the eviction from Serengeti National Park (1959)

Frequency		Daily	Weekly	Monthly	Rarely	Never	*n*
		%	%	%	%	%	
Gender	Males	24	27	12	35	2	123
	Females	14	10	9	33	35	58
Education	No school	27	18	8	30	18	107
	Been to school	11	27	16	41	5	74
Born	Before	35	28	11	15	10	79
	After	9	17	11	49	15	102

Furthermore, a linear regression analysis with how often Maasai pastoralist have observed wild dogs in their area as a dependent variable and with gender, education level and born before/after eviction as independent variables was significant ($F_{3,177} = 23.3$, $r^2 = 0.283$, $P < 0.001$). Here both born before/after eviction ($B = 1.11$, $t_1 = 6.07$, $P \leq 0.001$) and gender ($B = 1.09$, $t_1 = 5.64$, $P \leq 0.001$) explained the variation significantly, while education level did not.

Most males (55 %, n = 123) reported that the wild dog population was decreasing in the area while most females (45 %, n = 58), indicated that the population was increasing ($\chi^2_1 = 32.7$, $P \leq 0.001$). The assessment of the wild dog population trend also differed between the two groups with different education levels ($\chi^2_1 = 15.3$, $P = 0.002$). Most of those who had been to school (46 %) thought the population was increasing while a majority of those who had never been to school (23 %) had no opinion. No difference in this assessment of the current population trend was found between those born before or after eviction from the SNP ($\chi^2_1 = 5.37$, $P = 0.15$). A linear regression analysis with assessment of the population trend as a dependent variable and with gender, education level and born before or after the eviction from SNP as independent variables was significant ($F_{3, 177} = 2.84$, Nagelkerker$^2 = 0.046$, $P = 0.039$), however, only gender ($B = 0.297$, $t_1 = 1.74$, $P = 0.083$) explained some of this variation, while education level and born before or after the eviction from SNP did not.

Males (81 %, n =123) reported more frequently than females (50 %, n = 58) having seen wild dogs preying on their livestock ($\chi^2_1 = 18.9$, $P \leq 0.001$). Furthermore, those who had been to school more frequently (81 %, n = 74) reported to have seen wild dogs preying on their livestock than those who had never been to school (65 %, n = 107; $\chi^2_1 = 5.9$, $P = 0.015$). However, no difference in this respect was found between those born before or after eviction ($\chi^2_1 = 0.58$, $P = 0.445$). Logistic regression with wild dogs preying on livestock as a dependent variable and with gender, education level and born before or after eviction as independent variables were significant (Wald $\chi^2_3 = 30.6$, $P \leq 0.001$, Nagelkerke $r^2 = 0.156$). Gender ($B = 1.38$, Wald $\chi^2_1 = 13.7$, $P \leq 0.001$) was, however, the only factor explaining whether wild dogs had been seen preying on their livestock in their area while education level and born before or after the eviction from SNP was non-significant.

Although most respondents had seen wild dogs preying on their livestock rarely in their area the frequencies differed between the two gender ($\chi^2_1 = 23.9$, $P \leq 0.001$), the two education groups ($\chi^2_1 = 10.7$, $P = 0.015$), but not in relation to whether they were born before or after the eviction from SNP ($\chi^2_1 = 3.52$, $P = 0.32$). A linear regression analysis how often do you see wild dogs preying on your livestock as a dependent variable and with gender, education level and born before or after the eviction from SNP as independent variables was significant ($F_{3, 177} = 6.81$, $P = 0.039$), however, only gender ($B = 0.406$, $t_1 = 3.61$, $P = 0.001$) explained some of the variation, while education level and born before or after the eviction from SNP did not.

Males reported more frequently chasing or killing wild dogs when they saw them attacking their livestock than did females ($\chi^2_1 = 10.8$, $P = 0.005$, Table 2). However, no differences in this reaction patterns were found concerning education level ($P = 0.32$) or between those born before or after the eviction from SNP ($P = 0.23$).

More males (71 %) than females (50 %) claimed that the present situation recording wild dog attacks is increasing compared to previous days ($\chi^2_3 = 12.7$, $P = 0.005$, Table 3), similarly 75 % among those born before the eviction from SNP claimed the wild dog attacks on livestock is increasing while only 56 % of those born after the eviction claimed so ($\chi^2_3 = 13.6$, $P = 0.004$, Table 3). No difference in this respect was found between those with or without education ($P = 0.85$).

A linear regression analysis with "If you compare the present situation on livestock attacks by wild dogs to those days when you were young, is it increasing, decreasing or does it remain stable?" as a dependent variable and with gender, education level and born before or after the eviction from SNP as independent variables was significant ($F_{3, 177} = 8.89$, $P \leq 0.001$). Born before or after the eviction from SNP ($B = 0.656$, $t_1 = 3.82$, $P \leq 0.001$) and gender ($B = 0.621$, $t_1 = 3.31$, $P \leq 0.001$) significantly explained this variation, while education level did not.

Table 2: Responses to the question "How did you react when you observed African wild dogs attacking your livestock?" in relation to gender

Gender	I chase them away or kill them	I try to find help or do nothing	Wild dogs flee when they see people	*n*
	%	%	%	
Males	57	19	24	112
Females	32	18	50	44

Table 3. Responses to the question "If you compare the present situation on livestock attacks by wild dogs to those days when you were young, is it increasing, decreasing or remains stable?" in relation to gender (only those born before 1959)

		Elder males	Elder females	*n*
Increasing	%	74	26	42
Stable	%	25	75	4
Decreasing	%	83	17	6
No opinion	%	50	50	2
TOTAL	%	70	30	54

4. Discussion

Our results reveal that male Maasai pastoralists more frequently reported having seen wild dogs in their area than did females. This finding supports our hypothesis that male Maasai pastoralists have a greater awareness of local wild dog presence in their area. This is because male Maasai normally follow the livestock out into the bush (Mmassy & Røskaft, 2013) and therefore, acquire more information. Also, this finding indicates that wild dogs were present in the LGCA long before and even after the Maasai were evicted from the SNP in 1959. Therefore, our results support our hypothesis that the wild dogs have continuously inhabited the LGCA, even directly after the reported extinction as from the results of the genetic study conducted by Marsden et al. (2012), indicated that the Serengeti population of African wild dogs did not go extinct in the region as previously reported (Stearns & Stearns, 1999). While Marsden et al. (2012) did postulate that the population may have survived unrecorded in the Loliondo region, our results confirm this and that the population has persisted there subsequently.

Furthermore, our results show that wild dogs were sighted more often by Male pastoralists on a daily or weekly basis compared to females, which supports our hypothesis that male Maasai pastoralists have a greater awareness of local wild dog presence in their area. Moreover, those born before eviction from the SNP (1959) also observed wild dogs more frequent than those born after eviction, because before 1959, the population of the African wild dogs in the area was most likely high (Carbone et al., 2005; Frame, Malcolm, Frame, & Vanlawick, 1979) and thus, those born before eviction from SNP were able to see more often than those born after eviction. Also, those born after eviction experienced more of the reported decline of African wild dogs in the SNP during the 1990s (Carbone et al., 2005; Stearns & Stearns, 1999) which reduced their chances to see wild dogs more frequently in the area. However, since 2000 onwards, the African wild dogs have been reported to be sighted more frequently in the LGCAand has increased to some extent their chances of being sighted in the area (H. E. Masenga & Mentzel, 2005).

In explaining the general population trend of wild dogs in the area, it was found that most males reported that wild dog population was decreasing while most females reported it was increasing. The reported decrease in wild dog population by males was probably because its population observed before 1990 was most likely high, but despite

their initially high numbers, African wild dogs were declared locally extinct in the Serengeti National Park (SNP) in 1991 (Carbone et al., 2005; Gascoyne et al., 1993; Stearns & Stearns, 1999). Due to the division of labour within the Maasai pastoralist society (FAO, 2013; Mmassy & Røskaft, 2013), males were expected to observe and be more aware of changes in the wild dog population.

Our results also supported the hypothesis that male Maasai pastoralists were more concious of the conflict over livestock with wild dogs in their area since male Maasai pastoralists reported more frequently than females to have seen wild dogs, especially those preying on livestock. This finding may be attributed to the existing division of labour within the Maasai pastoralist society which favours males doing outdoor activities such as daily livestock herding (FAO, 2013; Mmassy & Røskaft, 2013), whereas females mostly do domestic work such as caring for children, cooking, milking livestock, fetching water and firewood collection (Mwebi, 2007). Our findings further indicate that the Maasai conflict with African wild dogs existed before their eviction from the SNP in 1959, but conflict occurred at a low level.

Males reported more frequently than females that they had seen wild dogs preying on their livestock, albeit rarely, which is in support of our hypothesis that male Maasai pastoralists are more aware of the conflict over livestock with wild dogs in their area than female Maasai. The rarity of sighting livestock depredation incidences by males Maasai is attributed to the abundant wild prey species reported to be found in the area (Grzimek & Grzimek, 1960; Thirgood et al., 2004) and also because previous studies have found no difference in terms of species diversity and density of both ungulates and carnivores between the SNP and its surrounding areas (Campbell & Borner, 1995; Maddox, 2003). Wild dogs have been found to prefer to prey on wild prey species rather than livestock wherever wild prey species are more abundant (Hayward, O'Brien, Hofmeyr, & Kerley, 2006; Rasmussen, 1999).

According to our results, males more frequently reported that they chased and killed wild dogs when they saw them preying on livestock. Therefore, our findings support previous studies showing that most livestock keepers do retaliate by killing problem animals following livestock losses (Bangs & Shivik, 2001; Gese, 2003; Ikanda & Packer, 2008; Kissui, 2008; Maddox, 2003; E. H. Masenga et al., 2013), which have brought some carnivore species close to local extinction (Rasmussen, 1999; Woodroffe et al., 2005), the African wild dog being one such species (Swarner, 2004; Woodroffe et al., 2005).

Our findings concur with the previous studies as more males and those born before the eviction from SNP claimed that the present situation on livestock attacks by wild dogs is increasing, supporting our hypothesis that this conflict has risen in recent years due to human population growth and an increase in the wild dog population in the area. The human population at the time of eviction was small, comprising around 1000 Maasai pastoralists (Neumann, 1998), whereas recent settlements in the Ngorongoro district number more than 180,000 Maasai pastoralists (Homewood & Rodgers, 1991). This increase in number of livestock in the area has probably increased the rate of wild dogs encounters (Lyamuya et al., 2014; E. H. Masenga et al., 2013; H. E. Masenga & Mentzel, 2005). Our findings support what previous studies indicating that the endangered African wild dog population posed no significant problem to the Maasai pastoralists in the Serengeti Ecosystem (Ikanda & Packer, 2008; Maddox, 2003). This was perhaps because of the reported extinction of the African wild dogs in 1991 (Carbone et al., 2005; Creel, Creel, & Monfort, 1997; Gascoyne et al., 1993; Stearns & Stearns, 1999) that reflected a reduction in their numbers to a such extent that wild dogs were not easily detected (Marsden et al., 2012). Therefore, this conflict was considered to decrease during that period (Ikanda & Packer, 2008; Maddox, 2003) and then increased again from 2000 onwards (H. E. Masenga & Mentzel, 2005). Given wild dogs' wide-ranging behaviour, attacks on livestock would most likely have been low when the human and livestock population was small. The increase in the wild dog, human and livestock populations thus intensifies the probability of encounter and attacks.

5. Conclusion

This study confirms that male Maasai pastoralists have a greater awareness of local wild dog presence and the livestock-derived conflict in their area. Moreover, the conflict between the Maasai pastoralists and African wild dogs over livestock existed before 1959 and has continued to present days. Furthermore, wild dogs did not go completely extinct from the Serengeti ecosystem in 1991 and managed to survive in other areas including the LGCA (Burrows, Hofer, & East Marion, 1994; Marsden et al., 2012). Conflict decreased in 1990s and has increased in recent years. This study suggests that for the Maasai pastoralists to coexist better with African wild dogs, the continuing rise in livestock density needs to cease while wild prey population should be protected.

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Vol. 6(11), pp. 797-805, November, 2014
DOI: 10.5897/IJBC2014.0769
Article Number: C83085B48647
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Attitudes of Maasai pastoralists towards the conservation of large carnivores in the Loliondo Game Controlled Area of Northern Tanzania

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Received 30 September, 2014; Accepted 3 November, 2014

Attitudes towards the conservation of lions, leopards, cheetah, spotted hyenas and African wild dogs were assessed in the Loliondo Game Controlled Area of northern Tanzania in January 2013. Our survey encompassed 181 individuals each representing onehousehold, of which 30 were chosen randomly from six Maasai pastoralist villages. A semi-structured questionnaire was used to acquire the required information from the respondents. We found that the majority of the Maasai pastoralists, particularly females, expressed negative attitudes towards the conservation of large carnivores. The reasons given for disliking carnivores differed between the sexes, but the most common reasons were that the carnivores attacked the respondents' livestock at night and also purposefully and frequently attacked people. The Maasai pastoralists who had been to school, mostly males, expressed more positive attitudes than those who had not been to school. Those who liked at least two carnivore species had received greater benefits from conservation programs than those who liked only one or disliked all carnivore species. Therefore, to support the conservation of wild dogs and other large carnivores at large, we recommend that where possible, female Maasai should be allowed to access Protected Areas (PAs) resources during the time of hard ship or drought to improve their livelihood. In addition, they should be empowered by being involved in conserving large carnivores as "carnivore guardians", exposed to ecotourism activities and be educated. Furthermore, conservation performance payments for carnivores should be institutionalized in the area.

Key words: Large carnivores, conservation, human attitudes, Loliondo Game Controlled Area.

INTRODUCTION

Worldwide, previous studies have found that about 95% of the total range of all carnivore species, occurs outside protected areas (Crooks et al., 2011). Only small numbers are able to survive in human-dominated landscapes

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(Woodroffe, 2000; Dolrenry, 2013; Hazzah et al., 2013). Previous studies have furthermore, pointed out that human attitudes which normally predict human behaviour from their behavioural beliefs as explained by the theory of reasoned action (Ajzen and Fishbein, 1980), or planned behaviour (Marchini and Macdonald, 2012), could be performed at any time towards the presence of large carnivores in their vicinity (Marchini and Macdonald, 2012). Such attitudes rather than natural conditions have been the main reasons for the decrease of large carnivores (Jackson et al., 2003; Treves and Karanth, 2003; Mannelqvist, 2010; Yirga et al., 2011). The assessment of such attitudes is frequently the first stage of proper conservation strategies (Jackson et al., 2003; Kaczensky et al., 2003; Lindsey et al., 2005; Lagendijk and Gusset, 2008; Mannelqvist, 2010; Carter et al., 2014). In most cases, it has been found that, wherever humans perform negative attitudes because large carnivores kill their livestock or attack people (Løe and Røskaft, 2004; Lagendijk and Gusset, 2008; Yirga et al., 2011; Carter et al., 2014; Lyamuya et al., 2014), or had experienced Protected Areas (PAs) policy during times of hardship (for example, access policies to grazing inside PA during drought) (Hazzah et al., 2013), as well as socio-economic factors (Hazzah et al., 2009); large carnivores are the ones to suffer as the consequence of such attitudes which undermine their management and conservation efforts (Ikanda and Packer, 2008; Kissui, 2008; Yirga et al., 2011; Carter et al., 2014; Masenga et al., 2013). Usually, humans have been found to be intolerable to loss by wild carnivores and thus retaliate by killing those problem carnivores which eventually reduce their numbers at both the population and species levels (Lindsey et al., 2005; Woodroffe et al., 2005; Lucherini and Merino, 2008; Shingote, 2011; Yirga et al., 2011; Carter et al., 2014).

A similar situation has been observed to occur among the Maasai pastoralists who inhabit the Loliondo Game Controlled Area and Ngorongoro Conservation Area in northern Tanzania, where the local people frequently retaliate by killing troublesome carnivores in their areas (Ikanda and Packer, 2008; Masenga et al., 2013) as well as in other pastoral areas in Africa (Kissui, 2008; Hazzah et al., 2009; Miner, 2011). Therefore, currently there is a global challenge in facilitating human-carnivore coexistence in human-dominated landscapes since it requires to first understand factors that influence human attitudes, particularly humans who have to bear the consequences of the presence of large carnivores in their vicinity (Jackson et al., 2003; Lagendijk and Gusset, 2008; Carter et al., 2014). On the other hand, there is a need to propose proper and conducive management measures that would enhance coexistence between humans and large carnivores in an area as previous studies have proposed and proved to be successful (Kissui, 2008; Zabel and Holm-Muller, 2008; Hazzah et al., 2009; Miner, 2011; Hazzah et al., 2014; McManus et al., 2014).

This study aimed at determining the main factors that cause negative attitudes among Maasai pastoralists towards the conservation of large carnivores such as lions (*Pantheraleo*), leopards (*Pantherapardus*), cheetah (*Acinonyxjubatus*), spotted hyenas (*Crocutacrocuta*) and African wild dogs (*Lycaonpictus*) in the Loliondo Game Controlled Area (LGCA), northern Tanzania. We made the following hypotheses: 1) Because education helps in the development of positive attitudes (Røskaft et al., 2007; Dalum, 2013), the Maasai pastoralists who have been to school will express more positive attitudes towards large carnivores than those who have never been to school; 2) male Maasai pastoralists will express more positive attitudes towards the conservation of large carnivores than females because their culture favours men in terms of the right to speak; 3) the pastoralists who receive many benefits of having large carnivores in their vicinity (for example, being part of vaccination programs, having access policies for grazing, firewood collection and water fetching in PAs during times of hardship, or acquiring the benefits of tourism for example, employ-ment and income generation) will exhibit more positive attitudes towards these species than those who receive few benefits. Because wild dogs are the main predators of livestock in our study area, we paid this species special attention.

MATERIALS AND METHODS

Study area

The study was conducted in the eastern Serengeti ecosystem in the Loliondo Game Controlled Area (LGCA; Figure 1). The LGCA is located in the Maasai ancestral land in the northern part of Tanzania and covers approximately 4500 km^2 (Lyamuya et al., 2014). The Maasai are nomadic pastoralists with a very low proportion of agro-pastoralists (Masenga and Mentzel, 2005; Masenga, 2010; Lyamuya et al., 2014). The Maasai depends entirely on livestock for their economic survival. The LGCA exhibits a bi-modal rainfall pattern with peaks that occur in December and April and a total yearly precipitation of 400-1200 mm precipitation per annum (Jaeger, 1982; Maddox, 2003; Masenga and Mentzel, 2005). The LGCA is dominated by open woodland and grassland. The open woodland is found primarily in the northern region on rolling hills that are interspersed with rocky outcrops. In the central region, there are mountains with steep slopes and densely vegetated gullies. The open areas in the lowlands are either cultivated or open woodlands. The southern portion of the area gives way to short grassland (Masenga and Mentzel, 2005).

Data collection

The data for this study were collected in January 2013. Our survey encompassed 181 individuals, each representing one household chosen randomly from six Maasai villages adjacent to the eastern Serengeti ecosystem. The methods used for data collection and sample size determination followed those that have been used in previous studies (Sancheti and Kapoor, 2003). No prior notice was given to the interviewees, although the village chairman was first consulted about the study and asked for permission to perform the interviews in his/her area. The sampling strategy was opportunistic, and the interviewees were chosen according to availability based on their age and gender. A semi-structured questionnaire was administered by two researchers. They asked questions in Swahili

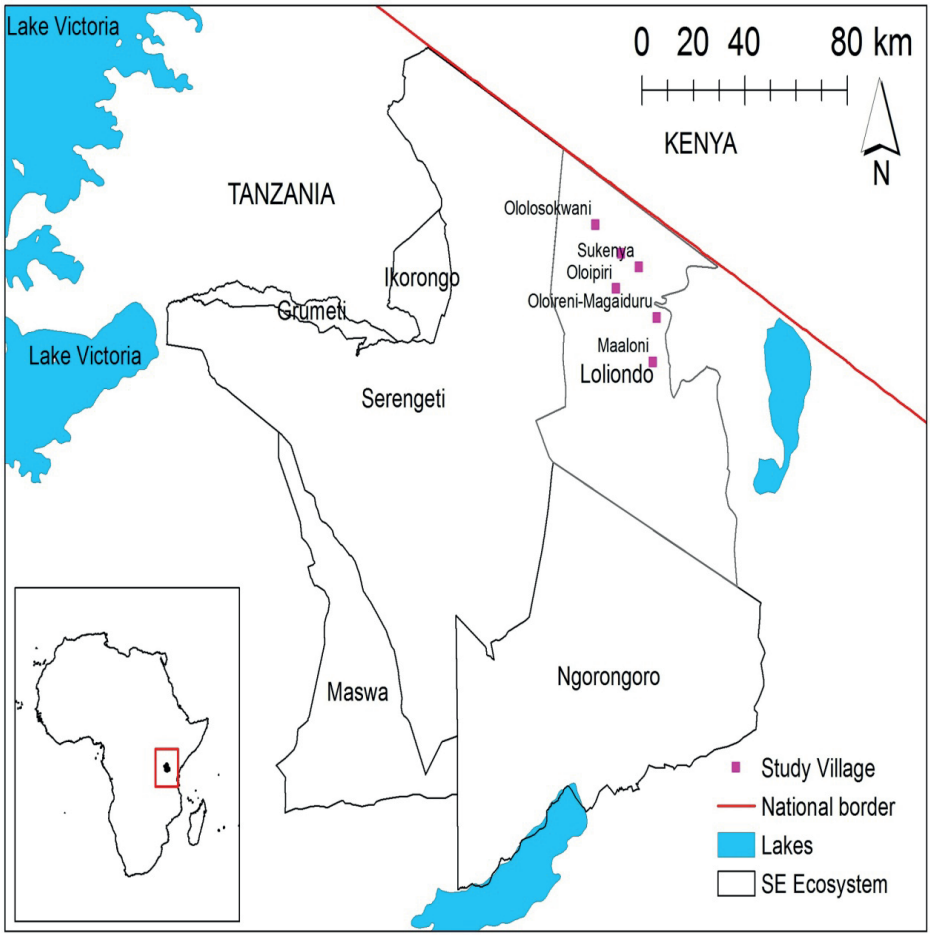

Figure 1. A map of the Serengeti ecosystem showing the study area of the Loliondo Game Controlled Area in northern Tanzania. The studied villages are indicated in purple.

which were then translated to the Maasai language with the help of Maasai translators. With this method, the researchers were able to record information on the attitudes of the Maasai pastoralists in relation to the conservation of large carnivores in their area. The data collected included basic information about the participant's age, age class (youths, adults and elders; however, rather than using these age classes in our analyses, we classified the participants into two age groups: those born before (n = 77) and those born after (n = 104) 1959), gender (males n = 123; females = 58), village centre GPS location, tribe (Maasai), and educational level (had been to school (n =74), never been to school (n = 107)).

Next, we asked the participants whether they were aged between 54 - 100 years (e.g. old- born before the eviction from SNP) or between 30 - 53 years (e.g. young- born after the eviction from the Serengeti National Park (1959)). Thereafter, these participants were asked questions related to their attitudes toward the conservation of large carnivores, e.g., 1) "What carnivore species (lion, leopard, spotted hyena, cheetah and wild dog) do you like/dislike in your area?", 2) "Why do you like/dislike the carnivores?", 3) "Do you think wild dogs have a right to stay in your area?",4) "Do you receive any benefits (e.g., being part of vaccination programs, having access policies for grazing, firewood collection and water fetching in PAs during times of hardship or acquiring the benefits of tourism e.g employment and income generation) from the presence of wild dogs in your area?" and 5) "What do you think should be done to conserve wild dogs?"

Data analyses

All analyses were performed using Statistical Package for Social Science (SPSS) Statistics version 17.0 for Windows. Because most of the data were nominal, we primarily used non-parametric Chi-

Table 1. Percentages of the Maasai respondents who exhibited different attitudes based on gender, age class and educational level.

Number of carnivore species liked		≥2	1	0	Total
		N (%)	N (%)	N (%)	N (%)
Gender	Males	26 (21.1)	65 (52.8)	32 (26.0)	123 (100)
	Females	2 (3.4)	24 (41.4)	32 (55.2)	58 (100)
Age group	After 1959 (30-53 years)	19 (18.4)	52(50.5)	32 (31.1)	103 (100)
	Before 1959 (54-100 years)	9 (11.7)	36(46.8)	32 (41.6)	77
Education	Been to school	16 (21.6)	40 (54.1)	18 (24.3)	78 (100)
	No education	12 (11.2)	49 25.8)	46 (43.0)	107 (100)

Table 2. The different reasons given by the respondents of each gender why they liked or disliked the carnivores.

Reasons	Males	Females	Total
Dislike	N (%)	N (%)	N (%)
They purposely attack livestock at night	62 (50.4)	24 (41.4)	86 (47.5)
They are enemies of people	3 (2.4)	5 (8.6)	8 (4.4)
They attack livestock and people	16 (13.0)	19 (32.8)	35 (19.3)
Like			
They are easy to chase	21 (17.1)	6 (10.3)	27 (14.9)
They attract tourists and are source of income	7 (5.7)	1 (1.7)	8 (4.4)
They cause no problems	14 (11.4)	3 (5.2)	17 (9.4)
Total	123 (100)	58 (100)	181 (100)

square tests (Fowler et al., 2009; Zar, 2010) to determine the differences in the frequencies among different variables. Additionally, descriptive statistics were used to determine the frequencies of the respondents who reported liking or disliking the conservation of the different large carnivores in their area. Very few respondents liked the carnivores, and the patterns were similar for all four species; therefore, we pooled these categories. As a first step, we analysed the frequencies with which the participants' liked or disliked each of the four carnivores and produced five categories (liked zero species (N = 64), liked one carnivore species (N = 89), or liked two, three or four of the species (N = 28)). We then pooled the last three categories into one category termed like at least two (2-4) of the carnivores (lion, leopard, cheetah, spotted hyena; n = 28), and the other two categories were termed like one carnivore (n = 89) and dislike all carnivores (n = 64). We used these three categories of attitudes in the analyses. All statistical tests were two tailed, and the significance level was set at $P \leq 0.05$.

RESULTS

Our results revealed that out of the 181 respondents, males represented 67.6% while females represented 31.9%. About 59.1% of the respondents had never been to school which represent mostly females (82.8%) while 52.0% of males had never been to school ($\chi^2 = 19.7$, df = 1, $P<0.001$). Most of those who were born after their eviction from the Serengeti National Park (1959) had been to school (51.0%), while most of those born before that period had never been to school (74.0%) ($\chi^2 = 12.6$, df = 2, P = 0.002).

To test Maasai pastoralists' attitudes toward conservation of large carnivores respondents' answers of like at least two species were taken to express positive attitudes, like one species as an indicator of an intermediate attitude and "dislike all species" as an expression of the most negative attitudes. From this, females expressed significantly more negative attitudes than the males ($\chi^2 = 18.5$, df = 2, $P<0.001$, Table 1). The negative attitudes of the females were related to the different reasons given by the two sexes regarding why they liked or disliked the carnivores ($\chi^2 = 16.2$, df = 5, P = 0.006, Table 2).

Furthermore, those who had never been to school (71.9%) expressed significantly more negative attitudes toward large carnivores than did those who had been to school (28.1%) ($\chi^2 = 7.9$, df = 2, P = 0.018). However, no significant difference in attitudes was found between those born before and after eviction ($\chi^2 = 2.78$, df = 2, P

= 0.249). A linear regression analysis using carnivore attitudes (likes ≥2, 1, 0) as the dependent variable and gender, born before or after eviction and education level as independent variables was statistically significant (r^2 = 0.120, F = 7.971, df = 3, P< 0.001). However, only gender significantly explained this variation (t = 3.73, P< 0.001). The other two variables (born before or after eviction and education) did not explain any significant additionally variation.

Generally, most of the Maasai pastoralists expressed negative attitudes towards the conservation of wild dogs (like = 34.1% and dislike = 65.4%). To further investigate the attitudes toward the conservation of wild dogs we used the following question: “Do you think wild dogs have a right to stay in your area”? Answers of “yes” express positive attitudes and “no” express a negative attitude”. Generally, the male pastoralists expressed significantly more positive attitudes (56.1%) than the females (30.4 %) (χ^2 = 10.2, df = 1, P = 0.001). A logistic regression analysis with “Do you think wild dogs have a right to stay in your area”? as a dependent variable with gender, age class and education level as independent variables, was statistically significant (Cox and Snell r^2 = 0.107, Nagelkerker^2 = 0.143,χ^2 = 20.327, df = 3, P< 0.001). All independent variables explained some of the variation statistically significant (education level, Wald = 7.53, P = 0.006; age class, Wald = 5.27, P = 0.022; gender, Wald = 4.43, P = 0.035). This was due to the fact that males (52.0%,) were more educated than females (17.2%) (χ^2 = 19.7, df = 1, P< 0.001).

Furthermore, those who liked at least two carnivore species (39.3 %) were significantly more likely to have been benefited by having wild dogs in their area as compared to those that liked one (11.2%) or disliked all carnivores (4.7%) (χ^2 = 20.8, df = 2, P< 0.001). Those who had never been to school expressed more negative attitudes (60.7%) towards the rights of the wild dogs to stay in their area as compared to those who had been to school (38.3%, n = 41) (χ^2 = 9.2, df = 2, P = 0.010). A logistic regression analysis using the answers to the question “Do you receive any benefit from the presence of wild dogs in your area?” (yes, no) as a dependent variable and gender, education level and born before or after eviction as independent variables proved to be statistically significant (Cox and Snell r^2 = 0.074, Nagelkerke r^2 = 0.136, χ^2 = 13.802, df = 3, P = 0.003). However, only gender (Wald = 5.47, df = 1, P =0.019) significantly explained the variation in receiving benefits; that is, the males generally received more benefits than the females. Education level and born before or after eviction did not significantly contribute in explaining the variation.

The results of a linear regression analysis using the “like none, one or ≥2 carnivores species’’ as the dependable variable and do you receive any benefit from having wild dogs in your area? and gender as indepen- dent variables proved that both of these factors significantly explained the attitudes of the Maasai pastoralists (r^2 = 0.172, F = 9.09, P< 0.001). Both gender (t = 3.079, P = 0.002) and do you receive any benefit from having wild dogs in your area? (t = 3.330, P = 0.001) explained significantly the variation, but education level and born before or after eviction did not significantly explain any additional variation.

There were significant differences in the advice given by male and female Maasaire garding the proper strategies for wild dogs conservation in their area; the males (76.4 %) advised that local people should be involved in their conservation, while the majority of the females offered no advice (51.7 %; χ^2 = 20.1, df = 3, P< 0.001; Table 3). Additionally, most of those who had been to school (82.4 %) advised that local people should be involved in wild dog conservation, while those who had not been to school (42.0 %) were more likely to offer no advice (χ^2 = 14.2, df = 3, P = 0.003; Table 3). There was also a statistically significant difference between those born before and after eviction; those born after were more eager to express opinions regarding conservation (χ^2 = 20.1, df = 3, P< 0.001; Table 3).

DISCUSSION

Overall, the attitudes of the Maasai pastoralists are important tools that should be considered regarding the value of conserving large carnivores in the Loliondo Game Controlled Area, northern Tanzania (Maddox, 2003; Ikanda and Packer, 2008; Kissui, 2008; Masenga et al., 2013) and other areas of Africa (Hazzah et al., 2009; 2013, 2014). Our findings support the hypothesis that females generally express more negative attitudes toward the conservation of large carnivores than males. These negative attitudes might be related on one hand to their behavioural beliefs as the result of not receiving any benefits from the presence of large carnivores in their area due to their denied access to PA resources (such as grazing their livestock, firewood collection and fetching water) during time of hardship or drought (Hazzah et al., 2013). While on the other hand, by reasons given by both of them that include the notion that carnivores cause livestock losses due to their predatory behaviour (Maddox, 2003; Lyamuya et al., 2014). Hazzah et al. (2013) found that when people are given access to PAs resources during the times of hardship they usually perform positive attitudes towards wildlife as seen near Tsavo and Nairobi national parks in Kenya. According to theory of reasoned action developed by Ajzen and Fishbein (1980) and that of planned behaviour by Marchini and Macdonald (2012), the behavioural beliefs usually determine the attitude of a person whether positive or negative towards an object. This eventually generates his or her behavioural intention as well as moral behaviour. Despite the fact that females in the Maasai culture are neglected from their right to speak, they still have negative attitudes towards large carnivores, which is of conservation concern as they might through their behavioural intention and moral

Table 3. Different reasons given by the respondents regarding the types of conservation strategies that the Maasai pastoralists would like to see implemented in relation to wild dogs.

Variable	Reason	Local people should be involved in wild dog conservation	Compensation schemes should be established	Wild dog should be taken away from people	No advice
		N (%)	N (%)	N (%)	N (%)
Gender	Males	31 (25.2)	12 (9.8)	51 (41.5)	29 (23.6)
	Females	3 (5.2)	2 (3.4)	23 (39.7)	30 (51.7)
Age group	After 1959	19 (18.4)	9 (8.7)	51 (49.5)	24 (23.3)
	Before 1959	15 (19.5)	5 (6.5)	22 (28.6)	35 (45.5)
Education	Been to school	19 (25.7)	8 (10.8)	34 (45.9)	13 (17.6)
	No education	15 (14.0)	6 (5.6)	40 (37.4)	46 (43.0)

behaviour influence their children and husbands to dislike such animals, hence they hinder conservation efforts (Ikanda and Packer, 2008; Kissui, 2008; Yirga et al., 2011; Carter et al., 2014; Masenga et al., 2013). To overcome this problem, it is required that females be empowered by being involved in the conservation of large carnivores as e.g. guardians. Previous studies have shown that guardians of large carnivores have been successful where it has been applied. A good example is the Maasai land in Kenya (Hazzah et al., 2014). Moreover, since most of the females have never been to school it is predicted that they are more likely to work and entirely depend on livestock keeping for their survival. Thus they suffer from losses to wild carnivores, and become more negative than males. It has previously been found that people who have not been to school or have low levels of education hold more negative attitudes toward the conservation of large carnivores in their areas (Lindsey et al., 2005; Røskaft et al., 2007; Lucherini and Merino, 2008; Li et al., 2010; Mannelqvist, 2010; Carter et al., 2014; Dalum, 2013). Previous studies indicate that if female Maasai pastoralists were to be taken to school to improve their understanding and knowledge, this would in most cases shape their attitudes in a positive way towards large carnivores and thus enhance their coexistence (Røskaft et al., 2007; Li et al., 2010; Carter et al., 2014).

Interestingly, the strongest effects in our study were the difference in attitudes between the two genders. According to Dalum (2013) factors such as age, gender and general education level cause variation in attitudes toward wildlife conservation. Moreover, factors such as culture, economy, social status and exposure to an event have also been found to influence attitudes (Røskaft et al., 2003; Yirga et al., 2011). Thus, in our case, gender was found to be the most significant factor in explaining the negative attitudes of the Maasai pastoralists (Røskaft et al., 2007; Mannelqvist, 2010). This is because females Maasai are less educated and do less outdoor activities than males reducing their chances of encountering species that are in conflict with them which might be the reason for the increase in negativity towards such carnivores (de Pinho et al., 2014). According to Pinho et al. (2014) facilitation for local residents, in our case female Maasai, visiting PAs increases their familiarity with species that are rarely seen or most frequently seen in conflict with their interests and hence increases their tolerance and positive attitudes towards them. The males' more positive attitudes may be explained by the preference of male to wild animals and education level (Li et al., 2010).

Furthermore, positive attitudes were related to the income generating activities of the tourist industry, and the males were more frequently involved in these activities than the females. Moreover, previous studies have indicated that older people might continue to be influenced by the potentially negative attitude that was prevalent during their childhood (Røskaft et al., 2007).

Generally, most Maasai pastoralists expressed negative attitudes towards the conservation of wild dogs in their area. These negative attitudes were associated with the participants' beliefs (Ajzen and Fishbein, 1980; Marchini and Macdonald, 2012) that the wild dogs prey on their livestock and cause economic losses. Similar reasons have been reported in previous studies (Lindsey et al., 2005; Lucherini and Merino, 2008; Mannelqvist, 2010; Dalum, 2013). We found that the males expressed more positive attitudes towards the conservation of wild dogs than the females because the males frequently see them and received more benefits from their presence than the females. The males benefited from tourism activities more frequently and generated more income than the females. The importance of such benefits in shaping positive attitudes has also been found elsewhere (Røskaft et al., 2007; Lagendijk and Gusset, 2008; Mannelqvist, 2010).

CONCLUSION AND MANAGEMENT IMPLICATIONS

We conclude that female Maasai pastoralists generally expressed more negative attitudes toward the conservation

of all five large carnivore species in their area as compared to the males. Additionally, the males who mostly had been to school were more likely to visit wilderness and more frequently observe large carnivores and receive benefits from having them in their area than females.

Therefore, to support the conservation of wild dogs and other large carnivores at large, we recommend that where possible, female Maasai should be allowed to access PAs resources during the time of hardship or drought to improve their livelihood. In addition, they should be empowered by being involved in conserving large carnivores as "carnivore guardians". Moreover, frequent visits to PAs should be increased on the side of females Maasai to increase their chances of encountering the rarely seen conflicting large carnivores in their area. In addition, females should be taken to school to receive more education on the ecological importance of large carnivores in their area because environmental education has been a frequently used tool in attempts to foster positive attitudes towards wildlife conservation (Jackson et al., 2003; Dalum, 2013; Straube, 2013). Also, female Maasai pastoralists should be exposed to ecotourism activities in their areas. Such tourism activities are frequently attracted to local areas because of the presence of such carnivore species, which might help the female Maasai to increase their income and hence improve their livelihood and attitudes towards carnivores' conservation (Lucherini and Merino, 2008). Furthermore, conservation performance payments for carnivores (Zabel and Holm-Muller, 2008) should be institutionalised in the area.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This study would not have been possible without the help of different people and institutions. We are grateful to the Tanzania Wildlife Research Institute (TAWIRI) for both financial and logistical support in data collection. This project was supported by a The Intergovernmental Policy Platform on Biodiversity and Ecosystem Services (IPBES) grant from the Ministry of Foreign Affairs through the Norwegian Environment Agency to NTNU and TAWIRI. Finally, we would like to thank everyone not mentioned here who participated in making this study possible.

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Appendix I

Questionnaire survey on the historical perspective of human-wild dog conflict and local people attitudes towards large CARNIVORES in the north eastern part of the serengeti ecosystem

A. RESPONDENT'S GENERAL INFORMATION
1A. Respondent name:
B.Gender:
C. Age
D. Age class:
E. Education level:
F. Village name:
G.Occupation:
H.Tribe:
GPS location:
I. Place of residence:
J. Household numbers:
K. Livestock numbers:
L. Date:

B. HISTORICAL INFORMATION
1: Living information
a) Where you born before or after independence?
1. Before independence (<1960) 2.After independence (>1961)
b) Where you born in Loliondo game controlled area?
1. Yes 2. No
c) If not where were you born and when did you come to this area?
2: WILD DOGS INFORMATION
a) Since you were young, did you see any wild dogs in this area?1. Yes 2. No
b) If yes, how often do people in your village see them?1. Daily2.Weekly 3.Monthly 4. Rarely
c) What do you think about the population trend of wild dogs in your area when you compare your sightings today with those of previous days? 1. Increasing2.Stable 3.Decreasing 4.Don't know
d) Is there any reason for that?
e) Are the denning areas the same today as they used to be?1. Yes 2.No
f) If not, where did they den before compared to now?
e) Since you were born, have you ever herded livestock in your area?1. Yes 2. No
f) If yes, were you herding livestock when you were young or Moran?1. Young 2.Moran 3.Both
3. HUMAN-WILD DOG CONFLICT

a) Do you think wild dogs are a problem to you?1. Yes 2. No
b) If yes, what kind of problem do they cause to you?1. Killing livestock 2.Attack people 3. Spread diseases
c) Do you think this problemsaroserecently or has it existed since you were born?1. Arose recently 2. Existed since I was born 3. A m not sure
d) Since you were young, have you ever seen wild dogs preying on your livestock?1. Yes 2.No
e) How often do you see that?1. Very often 2.Often 3.Rarely
f) What domestic species are most frequently attacked?1. Cattle2.Goat\sheep 3.Donkeys 4.Domestic dogs
g) What did you do when you saw that happening?1. I chased them away2.I ran away to look for assistance 3.I killed them 4. I did nothing 5 Others
h) If you compare livestock attacks by wild dogs during old days and today, what do you think is the trend?1. Increasing 2. Stable 3.Decreasing 4.Don‘t know
i) Is there any reason for that?
4. PERCEPTIONS OF LOCAL PEOPLE
a) What carnivore species do you like most?

Species	Like them	Dislike them	Why?
Lions			
Leopards			
Spotted hyenas			
Wild dogs			
Cheetah			

b) Do you think wild dogs have a right to stay in your area?1. Yes 2. No 3. Don’t know
c) If yes or no, why?
d) What do you think should be done to conserve wild dogs?
e) Do you receive any benefits by having wild dogs in your area?1. Yes 2.No
f) If yes, what benefit do you receive?
g) If you compare with the old days, do you think you are currently benefiting more than during the old days by having wild dogs in your area?1. Yes 2. No 3. Don’t know
h) If yes or no why?
i) What is your advice to the future generations?

Paper V

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Doctoral theses in Biology
Norwegian University of Science and Technology
Department of Biology

Year	Name	Degree	Title
1974	Tor-Henning Iversen	Dr. philos Botany	The roles of statholiths, auxin transport, and auxin metabolism in root gravitropism
1978	Tore Slagsvold	Dr. philos Zoology	Breeding events of birds in relation to spring temperature and environmental phenology
1978	Egil Sakshaug	Dr. philos Botany	"The influence of environmental factors on the chemical composition of cultivated and natural populations of marine phytoplankton"
1980	Arnfinn Langeland	Dr. philos Zoology	Interaction between fish and zooplankton populations and their effects on the material utilization in a freshwater lake
1980	Helge Reinertsen	Dr. philos Botany	The effect of lake fertilization on the dynamics and stability of a limnetic ecosystem with special reference to the phytoplankton
1982	Gunn Mari Olsen	Dr. scient Botany	Gravitropism in roots of *Pisum sativum* and *Arabidopsis thaliana*
1982	Dag Dolmen	Dr. philos Zoology	Life aspects of two sympartic species of newts (*Triturus, Amphibia*) in Norway, with special emphasis on their ecological niche segregation
1984	Eivin Røskaft	Dr. philos Zoology	Sociobiological studies of the rook *Corvus frugilegus*
1984	Anne Margrethe Cameron	Dr. scient Botany	Effects of alcohol inhalation on levels of circulating testosterone, follicle stimulating hormone and luteinzing hormone in male mature rats
1984	Asbjørn Magne Nilsen	Dr. scient Botany	Alveolar macrophages from expectorates – Biological monitoring of workers exosed to occupational air pollution. An evaluation of the AM-test
1985	Jarle Mork	Dr. philos Zoology	Biochemical genetic studies in fish
1985	John Solem	Dr. philos Zoology	Taxonomy, distribution and ecology of caddisflies (*Trichoptera*) in the Dovrefjell mountains
1985	Randi E. Reinertsen	Dr. philos Zoology	Energy strategies in the cold: Metabolic and thermoregulatory adaptations in small northern birds
1986	Bernt-Erik Sæther	Dr. philos Zoology	Ecological and evolutionary basis for variation in reproductive traits of some vertebrates: A comparative approach
1986	Torleif Holthe	Dr. philos Zoology	Evolution, systematics, nomenclature, and zoogeography in the polychaete orders *Oweniimorpha* and *Terebellomorpha*, with special reference to the Arctic and Scandinavian fauna
1987	Helene Lampe	Dr. scient Zoology	The function of bird song in mate attraction and territorial defence, and the importance of song repertoires
1987	Olav Hogstad	Dr. philos Zoology	Winter survival strategies of the Willow tit *Parus montanus*
1987	Jarle Inge Holten	Dr. philos Botany	Autecological investigations along a coust-inland transect at Nord-Møre, Central Norway

1987	Rita Kumar	Dr. scient Botany	Somaclonal variation in plants regenerated from cell cultures of *Nicotiana sanderae* and *Chrysanthemum morifolium*
1987	Bjørn Åge Tømmerås	Dr. scient Zoology	Olfaction in bark beetle communities: Interspecific interactions in regulation of colonization density, predator - prey relationship and host attraction
1988	Hans Christian Pedersen	Dr. philos Zoology	Reproductive behaviour in willow ptarmigan with special emphasis on territoriality and parental care
1988	Tor G. Heggberget	Dr. philos Zoology	Reproduction in Atlantic Salmon (*Salmo salar*): Aspects of spawning, incubation, early life history and population structure
1988	Marianne V. Nielsen	Dr. scient Zoology	The effects of selected environmental factors on carbon allocation/growth of larval and juvenile mussels (*Mytilus edulis*)
1988	Ole Kristian Berg	Dr. scient Zoology	The formation of landlocked Atlantic salmon (*Salmo salar* L.)
1989	John W. Jensen	Dr. philos Zoology	Crustacean plankton and fish during the first decade of the manmade Nesjø reservoir, with special emphasis on the effects of gill nets and salmonid growth
1989	Helga J. Vivås	Dr. scient Zoology	Theoretical models of activity pattern and optimal foraging: Predictions for the Moose *Alces alces*
1989	Reidar Andersen	Dr. scient Zoology	Interactions between a generalist herbivore, the moose *Alces alces*, and its winter food resources: a study of behavioural variation
1989	Kurt Ingar Draget	Dr. scient Botany	Alginate gel media for plant tissue culture
1990	Bengt Finstad	Dr. scient Zoology	Osmotic and ionic regulation in Atlantic salmon, rainbow trout and Arctic charr: Effect of temperature, salinity and season
1990	Hege Johannesen	Dr. scient Zoology	Respiration and temperature regulation in birds with special emphasis on the oxygen extraction by the lung
1990	Åse Krøkje	Dr. scient Botany	The mutagenic load from air pollution at two work-places with PAH-exposure measured with Ames Salmonella/microsome test
1990	Arne Johan Jensen	Dr. philos Zoology	Effects of water temperature on early life history, juvenile growth and prespawning migrations of Atlantic salmion (*Salmo salar*) and brown trout (*Salmo trutta*): A summary of studies in Norwegian streams
1990	Tor Jørgen Almaas	Dr. scient Zoology	Pheromone reception in moths: Response characteristics of olfactory receptor neurons to intra- and interspecific chemical cues
1990	Magne Husby	Dr. scient Zoology	Breeding strategies in birds: Experiments with the Magpie *Pica pica*
1991	Tor Kvam	Dr. scient Zoology	Population biology of the European lynx (*Lynx lynx*) in Norway
1991	Jan Henning L'Abêe Lund	Dr. philos Zoology	Reproductive biology in freshwater fish, brown trout *Salmo trutta* and roach *Rutilus rutilus* in particular
1991	Asbjørn Moen	Dr. philos Botany	The plant cover of the boreal uplands of Central Norway. I. Vegetation ecology of Sølendet nature reserve; haymaking fens and birch woodlands
1991	Else Marie Løbersli	Dr. scient Botany	Soil acidification and metal uptake in plants
1991	Trond Nordtug	Dr. scient Zoology	Reflectometric studies of photomechanical adaptation in superposition eyes of arthropods

1991	Thyra Solem	Dr. scient Botany	Age, origin and development of blanket mires in Central Norway
1991	Odd Terje Sandlund	Dr. philos Zoology	The dynamics of habitat use in the salmonid genera *Coregonus* and *Salvelinus*: Ontogenic niche shifts and polymorphism
1991	Nina Jonsson	Dr. philos Zoology	Aspects of migration and spawning in salmonids
1991	Atle Bones	Dr. scient Botany	Compartmentation and molecular properties of thioglucoside glucohydrolase (myrosinase)
1992	Torgrim Breiehagen	Dr. scient Zoology	Mating behaviour and evolutionary aspects of the breeding system of two bird species: the Temminck's stint and the Pied flycatcher
1992	Anne Kjersti Bakken	Dr. scient Botany	The influence of photoperiod on nitrate assimilation and nitrogen status in timothy (*Phleum pratense* L.)
1992	Tycho Anker-Nilssen	Dr. scient Zoology	Food supply as a determinant of reproduction and population development in Norwegian Puffins *Fratercula arctica*
1992	Bjørn Munro Jenssen	Dr. philos Zoology	Thermoregulation in aquatic birds in air and water: With special emphasis on the effects of crude oil, chemically treated oil and cleaning on the thermal balance of ducks
1992	Arne Vollan Aarset	Dr. philos Zoology	The ecophysiology of under-ice fauna: Osmotic regulation, low temperature tolerance and metabolism in polar crustaceans.
1993	Geir Slupphaug	Dr. scient Botany	Regulation and expression of uracil-DNA glycosylase and O^6-methylguanine-DNA methyltransferase in mammalian cells
1993	Tor Fredrik Næsje	Dr. scient Zoology	Habitat shifts in coregonids.
1993	Yngvar Asbjørn Olsen	Dr. scient Zoology	Cortisol dynamics in Atlantic salmon, *Salmo salar* L.: Basal and stressor-induced variations in plasma levels ans some secondary effects.
1993	Bård Pedersen	Dr. scient Botany	Theoretical studies of life history evolution in modular and clonal organisms
1993	Ole Petter Thangstad	Dr. scient Botany	Molecular studies of myrosinase in Brassicaceae
1993	Thrine L. M. Heggberget	Dr. scient Zoology	Reproductive strategy and feeding ecology of the Eurasian otter *Lutra lutra*.
1993	Kjetil Bevanger	Dr. scient Zoology	Avian interactions with utility structures, a biological approach.
1993	Kåre Haugan	Dr. scient Botany	Mutations in the replication control gene trfA of the broad host-range plasmid RK2
1994	Peder Fiske	Dr. scient Zoology	Sexual selection in the lekking great snipe (*Gallinago media*): Male mating success and female behaviour at the lek
1994	Kjell Inge Reitan	Dr. scient Botany	Nutritional effects of algae in first-feeding of marine fish larvae
1994	Nils Røv	Dr. scient Zoology	Breeding distribution, population status and regulation of breeding numbers in the northeast-Atlantic Great Cormorant *Phalacrocorax carbo carbo*
1994	Annette-Susanne Hoepfner	Dr. scient Botany	Tissue culture techniques in propagation and breeding of Red Raspberry (*Rubus idaeus* L.)
1994	Inga Elise Bruteig	Dr. scient Botany	Distribution, ecology and biomonitoring studies of epiphytic lichens on conifers

1994	Geir Johnsen	Dr. scient Botany	Light harvesting and utilization in marine phytoplankton: Species-specific and photoadaptive responses
1994	Morten Bakken	Dr. scient Zoology	Infanticidal behaviour and reproductive performance in relation to competition capacity among farmed silver fox vixens, *Vulpes vulpes*
1994	Arne Moksnes	Dr. philos Zoology	Host adaptations towards brood parasitism by the Cockoo
1994	Solveig Bakken	Dr. scient Botany	Growth and nitrogen status in the moss *Dicranum majus* Sm. as influenced by nitrogen supply
1994	Torbjørn Forseth	Dr. scient Zoology	Bioenergetics in ecological and life history studies of fishes.
1995	Olav Vadstein	Dr. philos Botany	The role of heterotrophic planktonic bacteria in the cycling of phosphorus in lakes: Phosphorus requirement, competitive ability and food web interactions
1995	Hanne Christensen	Dr. scient Zoology	Determinants of Otter *Lutra lutra* distribution in Norway: Effects of harvest, polychlorinated biphenyls (PCBs), human population density and competition with mink *Mustela vision*
1995	Svein Håkon Lorentsen	Dr. scient Zoology	Reproductive effort in the Antarctic Petrel *Thalassoica antarctica*; the effect of parental body size and condition
1995	Chris Jørgen Jensen	Dr. scient Zoology	The surface electromyographic (EMG) amplitude as an estimate of upper trapezius muscle activity
1995	Martha Kold Bakkevig	Dr. scient Zoology	The impact of clothing textiles and construction in a clothing system on thermoregulatory responses, sweat accumulation and heat transport
1995	Vidar Moen	Dr. scient Zoology	Distribution patterns and adaptations to light in newly introduced populations of *Mysis relicta* and constraints on Cladoceran and Char populations
1995	Hans Haavardsholm Blom	Dr. philos Botany	A revision of the *Schistidium apocarpum* complex in Norway and Sweden
1996	Jorun Skjærmo	Dr. scient Botany	Microbial ecology of early stages of cultivated marine fish; inpact fish-bacterial interactions on growth and survival of larvae
1996	Ola Ugedal	Dr. scient Zoology	Radiocesium turnover in freshwater fishes
1996	Ingibjørg Einarsdottir	Dr. scient Zoology	Production of Atlantic salmon (*Salmo salar*) and Arctic charr (*Salvelinus alpinus*): A study of some physiological and immunological responses to rearing routines
1996	Christina M. S. Pereira	Dr. scient Zoology	Glucose metabolism in salmonids: Dietary effects and hormonal regulation
1996	Jan Fredrik Børseth	Dr. scient Zoology	The sodium energy gradients in muscle cells of *Mytilus edulis* and the effects of organic xenobiotics
1996	Gunnar Henriksen	Dr. scient Zoology	Status of Grey seal *Halichoerus grypus* and Harbour seal *Phoca vitulina* in the Barents sea region
1997	Gunvor Øie	Dr. scient Botany	Eevalution of rotifer *Brachionus plicatilis* quality in early first feeding of turbot *Scophtalmus maximus* L. larvae
1997	Håkon Holien	Dr. scient Botany	Studies of lichens in spurce forest of Central Norway. Diversity, old growth species and the relationship to site and stand parameters

1997	Ole Reitan	Dr. scient Zoology	Responses of birds to habitat disturbance due to damming
1997	Jon Arne Grøttum	Dr. scient Zoology	Physiological effects of reduced water quality on fish in aquaculture
1997	Per Gustav Thingstad	Dr. scient Zoology	Birds as indicators for studying natural and human-induced variations in the environment, with special emphasis on the suitability of the Pied Flycatcher
1997	Torgeir Nygård	Dr. scient Zoology	Temporal and spatial trends of pollutants in birds in Norway: Birds of prey and Willow Grouse used as
1997	Signe Nybø	Dr. scient Zoology	Impacts of long-range transported air pollution on birds with particular reference to the dipper *Cinclus cinclus* in southern Norway
1997	Atle Wibe	Dr. scient Zoology	Identification of conifer volatiles detected by receptor neurons in the pine weevil (*Hylobius abietis*), analysed by gas chromatography linked to electrophysiology and to mass spectrometry
1997	Rolv Lundheim	Dr. scient Zoology	Adaptive and incidental biological ice nucleators
1997	Arild Magne Landa	Dr. scient Zoology	Wolverines in Scandinavia: ecology, sheep depredation and conservation
1997	Kåre Magne Nielsen	Dr. scient Botany	An evolution of possible horizontal gene transfer from plants to sail bacteria by studies of natural transformation in *Acinetobacter calcoacetius*
1997	Jarle Tufto	Dr. scient Zoology	Gene flow and genetic drift in geographically structured populations: Ecological, population genetic, and statistical models
1997	Trygve Hesthagen	Dr. philos Zoology	Population responces of Arctic charr (*Salvelinus alpinus* (L.)) and brown trout (*Salmo trutta* L.) to acidification in Norwegian inland waters
1997	Trygve Sigholt	Dr. philos Zoology	Control of Parr-smolt transformation and seawater tolerance in farmed Atlantic Salmon (*Salmo salar*) Effects of photoperiod, temperature, gradual seawater acclimation, NaCl and betaine in the diet
1997	Jan Østnes	Dr. scient Zoology	Cold sensation in adult and neonate birds
1998	Seethaledsumy Visvalingam	Dr. scient Botany	Influence of environmental factors on myrosinases and myrosinase-binding proteins
1998	Thor Harald Ringsby	Dr. scient Zoology	Variation in space and time: The biology of a House sparrow metapopulation
1998	Erling Johan Solberg	Dr. scient Zoology	Variation in population dynamics and life history in a Norwegian moose (*Alces alces*) population: consequences of harvesting in a variable environment
1998	Sigurd Mjøen Saastad	Dr. scient Botany	Species delimitation and phylogenetic relationships between the Sphagnum recurvum complex (Bryophyta): genetic variation and phenotypic plasticity
1998	Bjarte Mortensen	Dr. scient Botany	Metabolism of volatile organic chemicals (VOCs) in a head liver S9 vial equilibration system in vitro
1998	Gunnar Austrheim	Dr. scient Botany	Plant biodiversity and land use in subalpine grasslands. – A conservtaion biological approach
1998	Bente Gunnveig Berg	Dr. scient Zoology	Encoding of pheromone information in two related moth species
1999	Kristian Overskaug	Dr. scient Zoology	Behavioural and morphological characteristics in Northern Tawny Owls *Strix aluco*: An intra- and interspecific comparative approach

1999	Hans Kristen Stenøien	Dr. scient Botany	Genetic studies of evolutionary processes in various populations of nonvascular plants (mosses, liverworts and hornworts)
1999	Trond Arnesen	Dr. scient Botany	Vegetation dynamics following trampling and burning in the outlying haylands at Sølendet, Central Norway
1999	Ingvar Stenberg	Dr. scient Zoology	Habitat selection, reproduction and survival in the White-backed Woodpecker *Dendrocopos leucotos*
1999	Stein Olle Johansen	Dr. scient Botany	A study of driftwood dispersal to the Nordic Seas by dendrochronology and wood anatomical analysis
1999	Trina Falck Galloway	Dr. scient Zoology	Muscle development and growth in early life stages of the Atlantic cod (*Gadus morhua* L.) and Halibut (*Hippoglossus hippoglossus* L.)
1999	Marianne Giæver	Dr. scient Zoology	Population genetic studies in three gadoid species: blue whiting (*Micromisistius poutassou*), haddock (*Melanogrammus aeglefinus*) and cod (*Gradus morhua*) in the North-East Atlantic
1999	Hans Martin Hanslin	Dr. scient Botany	The impact of environmental conditions of density dependent performance in the boreal forest bryophytes *Dicranum majus*, *Hylocomium splendens*, *Plagiochila asplenigides*, *Ptilium crista-castrensis* and *Rhytidiadelphus lokeus*
1999	Ingrid Bysveen Mjølnerød	Dr. scient Zoology	Aspects of population genetics, behaviour and performance of wild and farmed Atlantic salmon (*Salmo salar*) revealed by molecular genetic techniques
1999	Else Berit Skagen	Dr. scient Botany	The early regeneration process in protoplasts from *Brassica napus* hypocotyls cultivated under various g-forces
1999	Stein-Are Sæther	Dr. philos Zoology	Mate choice, competition for mates, and conflicts of interest in the Lekking Great Snipe
1999	Katrine Wangen Rustad	Dr. scient Zoology	Modulation of glutamatergic neurotransmission related to cognitive dysfunctions and Alzheimer's disease
1999	Per Terje Smiseth	Dr. scient Zoology	Social evolution in monogamous families:
1999	Gunnbjørn Bremset	Dr. scient Zoology	Young Atlantic salmon (*Salmo salar* L.) and Brown trout (*Salmo trutta* L.) inhabiting the deep pool habitat, with special reference to their habitat use, habitat preferences and competitive interactions
1999	Frode Ødegaard	Dr. scient Zoology	Host spesificity as parameter in estimates of arhrophod species richness
1999	Sonja Andersen	Dr. scient Zoology	Expressional and functional analyses of human, secretory phospholipase A2
2000	Ingrid Salvesen	Dr. scient Botany	Microbial ecology in early stages of marine fish: Development and evaluation of methods for microbial management in intensive larviculture
2000	Ingar Jostein Øien	Dr. scient Zoology	The Cuckoo (*Cuculus canorus*) and its host: adaptions and counteradaptions in a coevolutionary arms race
2000	Pavlos Makridis	Dr. scient Botany	Methods for the microbial econtrol of live food used for the rearing of marine fish larvae
2000	Sigbjørn Stokke	Dr. scient Zoology	Sexual segregation in the African elephant (*Loxodonta africana*)
2000	Odd A. Gulseth	Dr. philos Zoology	Seawater tolerance, migratory behaviour and growth of Charr, (*Salvelinus alpinus*), with emphasis on the high Arctic Dieset charr on Spitsbergen, Svalbard

2000	Pål A. Olsvik	Dr. scient Zoology	Biochemical impacts of Cd, Cu and Zn on brown trout (*Salmo trutta*) in two mining-contaminated rivers in Central Norway
2000	Sigurd Einum	Dr. scient Zoology	Maternal effects in fish: Implications for the evolution of breeding time and egg size
2001	Jan Ove Evjemo	Dr. scient Zoology	Production and nutritional adaptation of the brine shrimp *Artemia* sp. as live food organism for larvae of marine cold water fish species
2001	Olga Hilmo	Dr. scient Botany	Lichen response to environmental changes in the managed boreal forset systems
2001	Ingebrigt Uglem	Dr. scient Zoology	Male dimorphism and reproductive biology in corkwing wrasse (*Symphodus melops* L.)
2001	Bård Gunnar Stokke	Dr. scient Zoology	Coevolutionary adaptations in avian brood parasites and their hosts
2002	Ronny Aanes	Dr. scient Zoology	Spatio-temporal dynamics in Svalbard reindeer (*Rangifer tarandus platyrhynchus*)
2002	Mariann Sandsund	Dr. scient Zoology	Exercise- and cold-induced asthma. Respiratory and thermoregulatory responses
2002	Dag-Inge Øien	Dr. scient Botany	Dynamics of plant communities and populations in boreal vegetation influenced by scything at Sølendet, Central Norway
2002	Frank Rosell	Dr. scient Zoology	The function of scent marking in beaver (*Castor fiber*)
2002	Janne Østvang	Dr. scient Botany	The Role and Regulation of Phospholipase A_2 in Monocytes During Atherosclerosis Development
2002	Terje Thun	Dr. philos Biology	Dendrochronological constructions of Norwegian conifer chronologies providing dating of historical material
2002	Birgit Hafjeld Borgen	Dr. scient Biology	Functional analysis of plant idioblasts (Myrosin cells) and their role in defense, development and growth
2002	Bård Øyvind Solberg	Dr. scient Biology	Effects of climatic change on the growth of dominating tree species along major environmental gradients
2002	Per Winge	Dr. scient Biology	The evolution of small GTP binding proteins in cellular organisms. Studies of RAC GTPases in *Arabidopsis thaliana* and the Ral GTPase from *Drosophila melanogaster*
2002	Henrik Jensen	Dr. scient Biology	Causes and consequenses of individual variation in fitness-related traits in house sparrows
2003	Jens Rohloff	Dr. philos Biology	Cultivation of herbs and medicinal plants in Norway – Essential oil production and quality control
2003	Åsa Maria O. Espmark Wibe	Dr. scient Biology	Behavioural effects of environmental pollution in threespine stickleback *Gasterosteus aculeatur* L.
2003	Dagmar Hagen	Dr. scient Biology	Assisted recovery of disturbed arctic and alpine vegetation – an integrated approach
2003	Bjørn Dahle	Dr. scient Biology	Reproductive strategies in Scandinavian brown bears
2003	Cyril Lebogang Taolo	Dr. scient Biology	Population ecology, seasonal movement and habitat use of the African buffalo (*Syncerus caffer*) in Chobe National Park, Botswana
2003	Marit Stranden	Dr. scient Biology	Olfactory receptor neurones specified for the same odorants in three related Heliothine species (*Helicoverpa armigera, Helicoverpa assulta* and *Heliothis virescens*)
2003	Kristian Hassel	Dr. scient Biology	Life history characteristics and genetic variation in an expanding species, *Pogonatum dentatum*

2003	David Alexander Rae	Dr. scient Biology	Plant- and invertebrate-community responses to species interaction and microclimatic gradients in alpine and Artic environments
2003	Åsa A Borg	Dr. scient Biology	Sex roles and reproductive behaviour in gobies and guppies: a female perspective
2003	Eldar Åsgard Bendiksen	Dr. scient Biology	Environmental effects on lipid nutrition of farmed Atlantic salmon (*Salmo Salar* L.) parr and smolt
2004	Torkild Bakken	Dr. scient Biology	A revision of Nereidinae (Polychaeta, Nereididae)
2004	Ingar Pareliussen	Dr. scient Biology	Natural and Experimental Tree Establishment in a Fragmented Forest, Ambohitantely Forest Reserve, Madagascar
2004	Tore Brembu	Dr. scient Biology	Genetic, molecular and functional studies of RAC GTPases and the WAVE-like regulatory protein complex in *Arabidopsis thaliana*
2004	Liv S. Nilsen	Dr. scient Biology	Coastal heath vegetation on central Norway; recent past, present state and future possibilities
2004	Hanne T. Skiri	Dr. scient Biology	Olfactory coding and olfactory learning of plant odours in heliothine moths. An anatomical, physiological and behavioural study of three related species (*Heliothis virescens, Helicoverpa armigera* and *Helicoverpa assulta*)
2004	Lene Østby	Dr. scient Biology	Cytochrome P4501A (CYP1A) induction and DNA adducts as biomarkers for organic pollution in the natural environment
2004	Emmanuel J. Gerreta	Dr. philos Biology	The Importance of Water Quality and Quantity in the Tropical Ecosystems, Tanzania
2004	Linda Dalen	Dr. scient Biology	Dynamics of Mountain Birch Treelines in the Scandes Mountain Chain, and Effects of Climate Warming
2004	Lisbeth Mehli	Dr. scient Biology	Polygalacturonase-inhibiting protein (PGIP) in cultivated strawberry (*Fragaria* x *ananassa*): characterisation and induction of the gene following fruit infection by *Botrytis cinerea*
2004	Børge Moe	Dr. scient Biology	Energy-Allocation in Avian Nestlings Facing Short-Term Food Shortage
2005	Matilde Skogen Chauton	Dr. scient Biology	Metabolic profiling and species discrimination from High-Resolution Magic Angle Spinning NMR analysis of whole-cell samples
2005	Sten Karlsson	Dr. scient Biology	Dynamics of Genetic Polymorphisms
2005	Terje Bongard	Dr. scient Biology	Life History strategies, mate choice, and parental investment among Norwegians over a 300-year period
2005	Tonette Røstelien	PhD Biology	Functional characterisation of olfactory receptor neurone types in heliothine moths
2005	Erlend Kristiansen	Dr. scient Biology	Studies on antifreeze proteins
2005	Eugen G. Sørmo	Dr. scient Biology	Organochlorine pollutants in grey seal (*Halichoerus grypus*) pups and their impact on plasma thyrid hormone and vitamin A concentrations
2005	Christian Westad	Dr. scient Biology	Motor control of the upper trapezius
2005	Lasse Mork Olsen	PhD Biology	Interactions between marine osmo- and phagotrophs in different physicochemical environments
2005	Åslaug Viken	PhD Biology	Implications of mate choice for the management of small populations

2005	Ariaya Hymete Sahle Dingle	PhD Biology	Investigation of the biological activities and chemical constituents of selected *Echinops* spp. growing in Ethiopia
2005	Anders Gravbrøt Finstad	PhD Biology	Salmonid fishes in a changing climate: The winter challenge
2005	Shimane Washington Makabu	PhD Biology	Interactions between woody plants, elephants and other browsers in the Chobe Riverfront, Botswana
2005	Kjartan Østbye	Dr. scient Biology	The European whitefish *Coregonus lavaretus* (L.) species complex: historical contingency and adaptive radiation
2006	Kari Mette Murvoll	PhD Biology	Levels and effects of persistent organic pollutans (POPs) in seabirds, Retinoids and α-tocopherol – potential biomakers of POPs in birds?
2006	Ivar Herfindal	Dr. scient Biology	Life history consequences of environmental variation along ecological gradients in northern ungulates
2006	Nils Egil Tokle	PhD Biology	Are the ubiquitous marine copepods limited by food or predation? Experimental and field-based studies with main focus on *Calanus finmarchicus*
2006	Jan Ove Gjershaug	Dr. philos Biology	Taxonomy and conservation status of some booted eagles in south-east Asia
2006	Jon Kristian Skei	Dr. scient Biology	Conservation biology and acidification problems in the breeding habitat of amphibians in Norway
2006	Johanna Järnegren	PhD Biology	Acesta Oophaga and Acesta Excavata – a study of hidden biodiversity
2006	Bjørn Henrik Hansen	PhD Biology	Metal-mediated oxidative stress responses in brown trout (*Salmo trutta*) from mining contaminated rivers in Central Norway
2006	Vidar Grøtan	PhD Biology	Temporal and spatial effects of climate fluctuations on population dynamics of vertebrates
2006	Jafari R Kideghesho	PhD Biology	Wildlife conservation and local land use conflicts in western Serengeti, Corridor Tanzania
2006	Anna Maria Billing	PhD Biology	Reproductive decisions in the sex role reversed pipefish *Syngnathus typhle*: when and how to invest in reproduction
2006	Henrik Pärn	PhD Biology	Female ornaments and reproductive biology in the bluethroat
2006	Anders J. Fjellheim	PhD Biology	Selection and administration of probiotic bacteria to marine fish larvae
2006	P. Andreas Svensson	PhD Biology	Female coloration, egg carotenoids and reproductive success: gobies as a model system
2007	Sindre A. Pedersen	PhD Biology	Metal binding proteins and antifreeze proteins in the beetle *Tenebrio molitor* - a study on possible competition for the semi-essential amino acid cysteine
2007	Kasper Hancke	PhD Biology	Photosynthetic responses as a function of light and temperature: Field and laboratory studies on marine microalgae
2007	Tomas Holmern	PhD Biology	Bushmeat hunting in the western Serengeti: Implications for community-based conservation
2007	Kari Jørgensen	PhD Biology	Functional tracing of gustatory receptor neurons in the CNS and chemosensory learning in the moth *Heliothis virescens*
2007	Stig Ulland	PhD Biology	Functional Characterisation of Olfactory Receptor Neurons in the Cabbage Moth, (*Mamestra brassicae* L.) (Lepidoptera, Noctuidae). Gas Chromatography

			Linked to Single Cell Recordings and Mass Spectrometry
2007	Snorre Henriksen	PhD Biology	Spatial and temporal variation in herbivore resources at northern latitudes
2007	Roelof Frans May	PhD Biology	Spatial Ecology of Wolverines in Scandinavia
2007	Vedasto Gabriel Ndibalema	PhD Biology	Demographic variation, distribution and habitat use between wildebeest sub-populations in the Serengeti National Park, Tanzania
2007	Julius William Nyahongo	PhD Biology	Depredation of Livestock by wild Carnivores and Illegal Utilization of Natural Resources by Humans in the Western Serengeti, Tanzania
2007	Shombe Ntaraluka Hassan	PhD Biology	Effects of fire on large herbivores and their forage resources in Serengeti, Tanzania
2007	Per-Arvid Wold	PhD Biology	Functional development and response to dietary treatment in larval Atlantic cod *(Gadus morhua* L.) Focus on formulated diets and early weaning
2007	Anne Skjetne Mortensen	PhD Biology	Toxicogenomics of Aryl Hydrocarbon- and Estrogen Receptor Interactions in Fish: Mechanisms and Profiling of Gene Expression Patterns in Chemical Mixture Exposure Scenarios
2008	Brage Bremset Hansen	PhD Biology	The Svalbard reindeer (*Rangifer tarandus platyrhynchus*) and its food base: plant-herbivore interactions in a high-arctic ecosystem
2008	Jiska van Dijk	PhD Biology	Wolverine foraging strategies in a multiple-use landscape
2008	Flora John Magige	PhD Biology	The ecology and behaviour of the Masai Ostrich (Struthio camelus massaicus) in the Serengeti Ecosystem, Tanzania
2008	Bernt Rønning	PhD Biology	Sources of inter- and intra-individual variation in basal metabolic rate in the zebra finch, (*Taeniopygia guttata*)
2008	Sølvi Wehn	PhD Biology	Biodiversity dynamics in semi-natural mountain landscapes - A study of consequences of changed agricultural practices in Eastern Jotunheimen
2008	Trond Moxness Kortner	PhD Biology	"The Role of Androgens on previtellogenic oocyte growth in Atlantic cod (*Gadus morhua*): Identification and patterns of differentially expressed genes in relation to Stereological Evaluations"
2008	Katarina Mariann Jørgensen	Dr. scient Biology	The role of platelet activating factor in activation of growth arrested keratinocytes and re-epithelialisation
2008	Tommy Jørstad	PhD Biology	Statistical Modelling of Gene Expression Data
2008	Anna Kusnierczyk	PhD Biology	*Arabidopsis thaliana* Responses to Aphid Infestation
2008	Jussi Evertsen	PhD Biology	Herbivore sacoglossans with photosynthetic chloroplasts
2008	John Eilif Hermansen	PhD Biology	Mediating ecological interests between locals and globals by means of indicators. A study attributed to the asymmetry between stakeholders of tropical forest at Mt. Kilimanjaro, Tanzania
2008	Ragnhild Lyngved	PhD Biology	Somatic embryogenesis in *Cyclamen persicum.* Biological investigations and educational aspects of cloning
2008	Line Elisabeth Sundt-Hansen	PhD Biology	Cost of rapid growth in salmonid fishes

2008	Line Johansen	PhD Biology	Exploring factors underlying fluctuations in white clover populations – clonal growth, population structure and spatial distribution
2009	Astrid Jullumstrø Feuerherm	PhD Biology	Elucidation of molecular mechanisms for pro-inflammatory phospholipase A2 in chronic disease
2009	Pål Kvello	PhD Biology	Neurons forming the network involved in gustatory coding and learning in the moth *Heliothis virescens:* Physiological and morphological characterisation, and integration into a standard brain atlas
2009	Trygve Devold Kjellsen	PhD Biology	Extreme Frost Tolerance in Boreal Conifers
2009	Johan Reinert Vikan	PhD Biology	Coevolutionary interactions between common cuckoos *Cuculus canorus* and *Fringilla* finches
2009	Zsolt Volent	PhD Biology	Remote sensing of marine environment: Applied surveillance with focus on optical properties of phytoplankton, coloured organic matter and suspended matter
2009	Lester Rocha	PhD Biology	Functional responses of perennial grasses to simulated grazing and resource availability
2009	Dennis Ikanda	PhD Biology	Dimensions of a Human-lion conflict: Ecology of human predation and persecution of African lions (*Panthera leo*) in Tanzania
2010	Huy Quang Nguyen	PhD Biology	Egg characteristics and development of larval digestive function of cobia (*Rachycentron canadum*) in response to dietary treatments - Focus on formulated diets
2010	Eli Kvingedal	PhD Biology	Intraspecific competition in stream salmonids: the impact of environment and phenotype
2010	Sverre Lundemo	PhD Biology	Molecular studies of genetic structuring and demography in *Arabidopsis* from Northern Europe
2010	Iddi Mihijai Mfunda	PhD Biology	Wildlife Conservation and People's livelihoods: Lessons Learnt and Considerations for Improvements. Tha Case of Serengeti Ecosystem, Tanzania
2010	Anton Tinchov Antonov	PhD Biology	Why do cuckoos lay strong-shelled eggs? Tests of the puncture resistance hypothesis
2010	Anders Lyngstad	PhD Biology	Population Ecology of *Eriophorum latifolium*, a Clonal Species in Rich Fen Vegetation
2010	Hilde Færevik	PhD Biology	Impact of protective clothing on thermal and cognitive responses
2010	Ingerid Brænne Arbo	PhD Medical technology	Nutritional lifestyle changes – effects of dietary carbohydrate restriction in healthy obese and overweight humans
2010	Yngvild Vindenes	PhD Biology	Stochastic modeling of finite populations with individual heterogeneity in vital parameters
2010	Hans-Richard Brattbakk	PhD Medical technology	The effect of macronutrient composition, insulin stimulation, and genetic variation on leukocyte gene expression and possible health benefits
2011	Geir Hysing Bolstad	PhD Biology	Evolution of Signals: Genetic Architecture, Natural Selection and Adaptive Accuracy
2011	Karen de Jong	PhD Biology	Operational sex ratio and reproductive behaviour in the two-spotted goby (*Gobiusculus flavescens*)
2011	Ann-Iren Kittang	PhD Biology	*Arabidopsis thaliana* L. adaptation mechanisms to microgravity through the EMCS MULTIGEN-2 experiment on the ISS:– The science of space experiment integration and adaptation to simulated microgravity

2011	Aline Magdalena Lee	PhD Biology	Stochastic modeling of mating systems and their effect on population dynamics and genetics
2011	Christopher Gravningen Sørmo	PhD Biology	Rho GTPases in Plants: Structural analysis of ROP GTPases; genetic and functional studies of MIRO GTPases in Arabidopsis thaliana
2011	Grethe Robertsen	PhD Biology	Relative performance of salmonid phenotypes across environments and competitive intensities
2011	Line-Kristin Larsen	PhD Biology	Life-history trait dynamics in experimental populations of guppy (*Poecilia reticulata*): the role of breeding regime and captive environment
2011	Maxim A. K. Teichert	PhD Biology	Regulation in Atlantic salmon (*Salmo salar*): The interaction between habitat and density
2011	Torunn Beate Hancke	PhD Biology	Use of Pulse Amplitude Modulated (PAM) Fluorescence and Bio-optics for Assessing Microalgal Photosynthesis and Physiology
2011	Sajeda Begum	PhD Biology	Brood Parasitism in Asian Cuckoos: Different Aspects of Interactions between Cuckoos and their Hosts in Bangladesh
2011	Kari J. K. Attramadal	PhD Biology	Water treatment as an approach to increase microbial control in the culture of cold water marine larvae
2011	Camilla Kalvatn Egset	PhD Biology	The Evolvability of Static Allometry: A Case Study
2011	AHM Raihan Sarker	PhD Biology	Conflict over the conservation of the Asian elephant (*Elephas maximus*) in Bangladesh
2011	Gro Dehli Villanger	PhD Biology	Effects of complex organohalogen contaminant mixtures on thyroid hormone homeostasis in selected arctic marine mammals
2011	Kari Bjørneraas	PhD Biology	Spatiotemporal variation in resource utilisation by a large herbivore, the moose
2011	John Odden	PhD Biology	The ecology of a conflict: Eurasian lynx depredation on domestic sheep
2011	Simen Pedersen	PhD Biology	Effects of native and introduced cervids on small mammals and birds
2011	Mohsen Falahati-Anbaran	PhD Biology	Evolutionary consequences of seed banks and seed dispersal in *Arabidopsis*
2012	Jakob Hønborg Hansen	PhD Biology	Shift work in the offshore vessel fleet: circadian rhythms and cognitive performance
2012	Elin Noreen	PhD Biology	Consequences of diet quality and age on life-history traits in a small passerine bird
2012	Irja Ida Ratikainen	PhD Biology	Foraging in a variable world:adaptions to stochasticity
2012	Aleksander Handå	PhD Biology	Cultivation of mussels (*Mytilus edulis):*Feed requirements, storage and integration with salmon (*Salmo salar*) farming
2012	Morten Kraabøl	PhD Biology	Reproductive and migratory challenges inflicted on migrant brown trour (*Salmo trutta* L) in a heavily modified river
2012	Jisca Huisman	PhD Biology	Gene flow and natural selection in Atlantic salmon
	Maria Bergvik	PhD Biology	Lipid and astaxanthin contents and biochemical post-harvest stability in *Calanus finmarchicus*
2012	Bjarte Bye Løfaldli	PhD Biology	Functional and morphological characterization of central olfactory neurons in the model insect *Heliothis virescens*.

2012	Karen Marie Hammer	PhD Biology	Acid-base regulation and metabolite responses in shallow- and deep-living marine invertebrates during environmental hypercapnia
2012	Øystein Nordrum Wiggen	PhD Biology	Optimal performance in the cold
2012	Robert Dominikus Fyumagwa	Dr. Philos Biology	Anthropogenic and natural influence on disease prevalence at the human –livestock-wildlife interface in the Serengeti ecosystem, Tanzania
2012	Jenny Bytingsvik	PhD Biology	Organohalogenated contaminants (OHCs) in polar bear mother-cub pairs from Svalbard, Norway. Maternal transfer, exposure assessment and thyroid hormone disruptive effects in polar bear cubs
2012	Christer Moe Rolandsen	PhD Biology	The ecological significance of space use and movement patterns of moose in a variable environment
2012	Erlend Kjeldsberg Hovland	PhD Biology	Bio-optics and Ecology in *Emiliania huxleyi* Blooms: Field and Remote Sensing Studies in Norwegian Waters
2012	Lise Cats Myhre	PhD Biology	Effects of the social and physical environment on mating behaviour in a marine fish
2012	Tonje Aronsen	PhD Biology	Demographic, environmental and evolutionary aspects of sexual selection
	Bin Liu	PhD Biology	Molecular genetic investigation of cell separation and cell death regulation in *Arabidopsis thaliana*
2013	Jørgen Rosvold	PhD Biology	Ungulates in a dynamic and increasingly human dominated landscape – A millennia-scale perspective
2013	Pankaj Barah	PhD Biology	Integrated Systems Approaches to Study Plant Stress Responses
2013	Marit Linnerud	PhD Biology	Patterns in spatial and temporal variation in population abundances of vertebrates
2013	Xinxin Wang	PhD Biology	Integrated multi-trophic aquaculture driven by nutrient wastes released from Atlantic salmon (*Salmo salar*) farming
2013	Ingrid Ertshus Mathisen	PhD Biology	Structure, dynamics, and regeneration capacity at the sub-arctic forest-tundra ecotone of northern Norway and Kola Peninsula, NW Russia
2013	Anders Foldvik	PhD Biology	Spatial distributions and productivity in salmonid populations
2013	Anna Marie Holand	PhD Biology	Statistical methods for estimating intra- and inter-population variation in genetic diversity
2013	Anna Solvang Båtnes	PhD Biology	Light in the dark – the role of irradiance in the high Arctic marine ecosystem during polar night
2013	Sebastian Wacker	PhD Biology	The dynamics of sexual selection: effects of OSR, density and resource competition in a fish
2013	Cecilie Miljeteig	PhD Biology	Phototaxis in *Calanus finmarchicus* – light sensitivity and the influence of energy reserves and oil exposure
2013	Ane Kjersti Vie	PhD Biology	Molecular and functional characterisation of the IDA family of signalling peptides in *Arabidopsis thaliana*
2013	Marianne Nymark	PhD Biology	Light responses in the marine diatom *Phaeodactylum tricornutum*
2014	Jannik Schultner	PhD Biology	Resource Allocation under Stress - Mechanisms and Strategies in a Long-Lived Bird
2014	Craig Ryan Jackson	PhD Biology	Factors influencing African wild dog *(Lycaon pictus*) habitat selection and ranging behaviour: conservation and management implications

2014	Aravind Venkatesan	PhD Biology	Application of Semantic Web Technology to establish knowledge management and discovery in the Life Sciences
2014	Kristin Collier Valle	PhD Biology	Photoacclimation mechanisms and light responses in marine micro- and macroalgae
2014	Michael Puffer	PhD Biology	Effects of rapidly fluctuating water levels on juvenile Atlantic salmon (*Salmo salar* L.)
2014	Gundula S. Bartzke	PhD Biology	Effects of power lines on moose *(Alces alces)* habitat selection, movements and feeding activity
2014	Eirin Marie Bjørkvoll	PhD Biology	Life-history variation and stochastic population dynamics in vertebrates
2014	Håkon Holand	PhD Biology	The parasite *Syngamus trachea* in a metapopulation of house sparrows
2014	Randi Magnus Sommerfelt	PhD Biology	Molecular mechanisms of inflammation – a central role for cytosolic phospholiphase A2
2014	Espen Lie Dahl	PhD Biology	Population demographics in white-tailed eagle at an on-shore wind farm area in coastal Norway
2014	Anders Øverby	PhD Biology	Functional analysis of the action of plant isothiocyanates: cellular mechanisms and in vivo role in plants, and anticancer activity
2014	Kamal Prasad Acharya	PhD Biology	Invasive species: Genetics, characteristics and trait variation along a latitudinal gradient.
2014	Ida Beathe Øverjordet	PhD Biology	Element accumulation and oxidative stress variables in Arctic pelagic food chains: Calanus, little auks (alle alle) and black-legged kittiwakes (Rissa tridactyla)
2014	Kristin Møller Gabrielsen	PhD Biology	Target tissue toxicity of the thyroid hormone system in two species of arctic mammals carrying high loads of organohalogen contaminants
2015	Gine Roll Skjervø	Dr. philos Biology	Testing behavioral ecology models with historical individual-based human demographic data from Norway
2015	Nils Erik Gustaf Forsberg	PhD Biology	Spatial and Temporal Genetic Structure in Landrace Cereals
2015	Leila Alipanah	PhD Biology	Integrated analyses of nitrogen and phosphorus deprivation in the diatoms *Phaeodactylum tricornutum* and *Seminavis robusta*
2015	Javad Najafi	PhD Biology	Molecular investigation of signaling components in sugar sensing and defense in *Arabidopsis thaliana*
2015	Bjørnar Sporsheim	PhD Biology	Quantitative confocal laser scanning microscopy: optimization of in vivo and in vitro analysis of intracellular transport
2015	Magni Olsen Kyrkjeeide	PhD Biology	Genetic variation and structure in peatmosses (*Sphagnum*)
2015	Keshuai Li	PhD Biology	Phospholipids in Atlantic cod (*Gadus morhua* L.) larvae rearing: Incorporation of DHA in live feed and larval phospholipids and the metabolic capabilities of larvae for the de novo synthesis
2015	Ingvild Fladvad Størdal	PhD Biology	The role of the copepod *Calanus finmarchicus* in affecting the fate of marine oil spills
2016	Thomas Kvalnes	PhD Biology	Evolution by natural selection in age-structured populations in fluctuating environments
2016	Øystein Leiknes	PhD Biology	The effect of nutrition on important life-history traits in the marine copepod *Calanus finmarchicus*

2016	Johan Henrik Hårdensson Berntsen	PhD Biology	Individual variation in survival: The effect of incubation temperature on the rate of physiological ageing in a small passerine bird
2016	Marianne Opsahl Olufsen	PhD Biology	Multiple environmental stressors: Biological interactions between parameters of climate change and perfluorinated alkyl substances in fish
2016	Rebekka Varne	PhD Biology	Tracing the fate of escaped cod (*Gadus morhua* L.) in a Norwegian fjord system
2016	Anette Antonsen Fenstad	PhD Biology	Pollutant Levels, Antioxidants and Potential Genotoxic Effects in Incubating Female Common Eiders (*Somateria mollissima*)
2016	Wilfred Njama Marealle	PhD Biology	Ecology, Behaviour and Conservation Status of Masai Giraffe (***Giraffa camelopardalis tippelskirchi***) in Tanzania
2016	Ingunn Nilssen	PhD Biology	Integrated Enviromental Mapping and Monitoring: A Methodological approach for endusers.
2017	Konika Chawla	PhD Biology	Discovering, analysing and taking care of knowledge.
2017	Øystein Hjorthol Opedal	PhD Biology	The Evolution of Herkogamy: Pollinator Reliability, Natural Selection, and Trait Evolvability.
2017	Ane Marlene Myhre	PhD Biology	Effective size of density dependent populations in fluctuating environments
2017	Emmanuel Hosiana Masenga	PhD Biology	Behavioural Ecology of Free-ranging and Reintroduced African Wild Dog (Lycaon pictus) Packs in the Serengeti Ecosystem,Tanzania
2017	Xiaolong Lin	PhD Biology	Systematics and evolutionary history of Tanytarsus van der Wulp, 1874 (Diptera: Chironomidae)
2017	Emmanuel Clamsen Mmassy	PhD Biology	Ecology and Conservation Challenges of the Kori bustard in the Serengeti National Park
2017	Richard Daniel Lyamuya	PhD Biology	Depredation of Livestock by Wild Carnivores in the Eastern Serengeti Ecosystem, Tanzania