

PROGRESS REPORT 2020

Attn: TAWIRI, NCAA, COSTECH & other relevant stakeholders

Research project: *Balancing Pastoralist Livelihoods and Wildlife Management in Ngorongoro*

Progress report period: April 2019 to April 2020

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Abbreviations:

- » CIP – Conservation Incentive Payment
- » GPS – Global Positioning System
- » HWC – Human Wildlife Conflict
- » NCA – Ngorongoro Conservation Area
- » NCAA – Ngorongoro Conservation Area Authority
- » NPC – Ngorongoro Pastoralist Council

Introduction

This Progress report summarizes the progress from the on-going research project entitled, “**Balancing Pastoralist Livelihoods and Wildlife Management in Ngorongoro**”, headed by Associate Prof. Goran Spong of the Swedish University of Agricultural Sciences. This project conducts the research that complements the conservation activities by KopeLion Inc. (abbreviation for Korongoro People’s Lion Initiative). KopeLion Inc. got registered in Tanzania in July 2019 as an I-NGO with a mission to link lion research with community participatory lion conservation and monitoring. It is a largely locally run organization, that evolved as part of a strategy to promote long-term and sustainable human-lion coexistence in this multiuse landscape – being the main objective with of our research project.

The report is divided into two sections. Section one summarizes our progress on implementation and explorations of strategies for sustainable coexistence, activities done in participation with key stakeholders. This include introduction and operation of the Lion Guardians model, community outreach to strengthen conservation awareness, and exploration of a Conservation Incentive Payment (CIP) model as an alternative incentive driven HWC mitigation approach. We observe a general increase in conservation engagement by the communities through acts of increased tolerance for lions, as well as increasing lion presence across NCA’s multiuse area. Section two summarizes our ongoing long-term ecological study on lions including an update on lion demography of the Ngorongoro Crater and the Ndutu region lion sub-populations; estimated lion numbers and presence across the wider NCA; update on GPS collared lions; and progress on our lion genetic study.

1 Exploring opportunities for coexistence

A main goal with our project in NCA, being a multiuse area, is to explore and in participation with key stakeholders develop and implement a model for long-term coexistence. Our participatory approach for lion research and conservation builds on the Lion Guardians model (see www.lionguardians.org), which we have adapted to the NCA conditions and included our long-term and detailed understanding of the local lion population. We currently employ twenty pastoralists,

residents of NCA, from the warrior age-set as Ilchokuti (meaning Guardian in *Maa*), whose duties make up our main HWC mitigation tool. Each of them is responsible for covering a zone, on average 70 km² large, that includes his home community. These zones cover approximately 1,500 km² and extends from Ndutu/Masek region by the border of Serengeti N.P., across the multiuse NCA to Eyasi escarpment and to the Crater Highlands, encompassing the southern and western slopes of the Ngorongoro Crater. We also have a large and disconnected zone in Northwest NCA; an effort in community outreach and as information network in an area with only the occasional lion visits, but where lions are still vulnerable to ritual lion killings (see map, Figure 1). After a slow start and being met with much suspicion by the communities, KopeLion is now viewed favorably. Our expansion into new areas is now driven by communities' unprompted requests and invitations, as well as the presence and conflicts with lions.

The duties of the Ilchokuti include direct human-wildlife conflict mitigation (reinforcing bomas, treating wounds on livestock injured by predators, finding and retrieving lost livestock, warning herders of lion presence), monitoring lions, preventing and stopping lion hunts, and recording lion-livestock depredation events. Measurable achievements in conflict mitigation and monitoring of lions and lion conflicts by our local staff during the period April 2019 – March 2020, include:

- ✓ helped reinforced 141 bomas
- ✓ treated wounds on 1,043 livestock injured by predators on 726 occasions
- ✓ searched for and found 87% of 3,513 lost livestock on 206 events
- ✓ recorded lions or signs of lions on 1,171 occasions, including 176 visual observations
- ✓ Recorded 69 events of lion – livestock attacks.

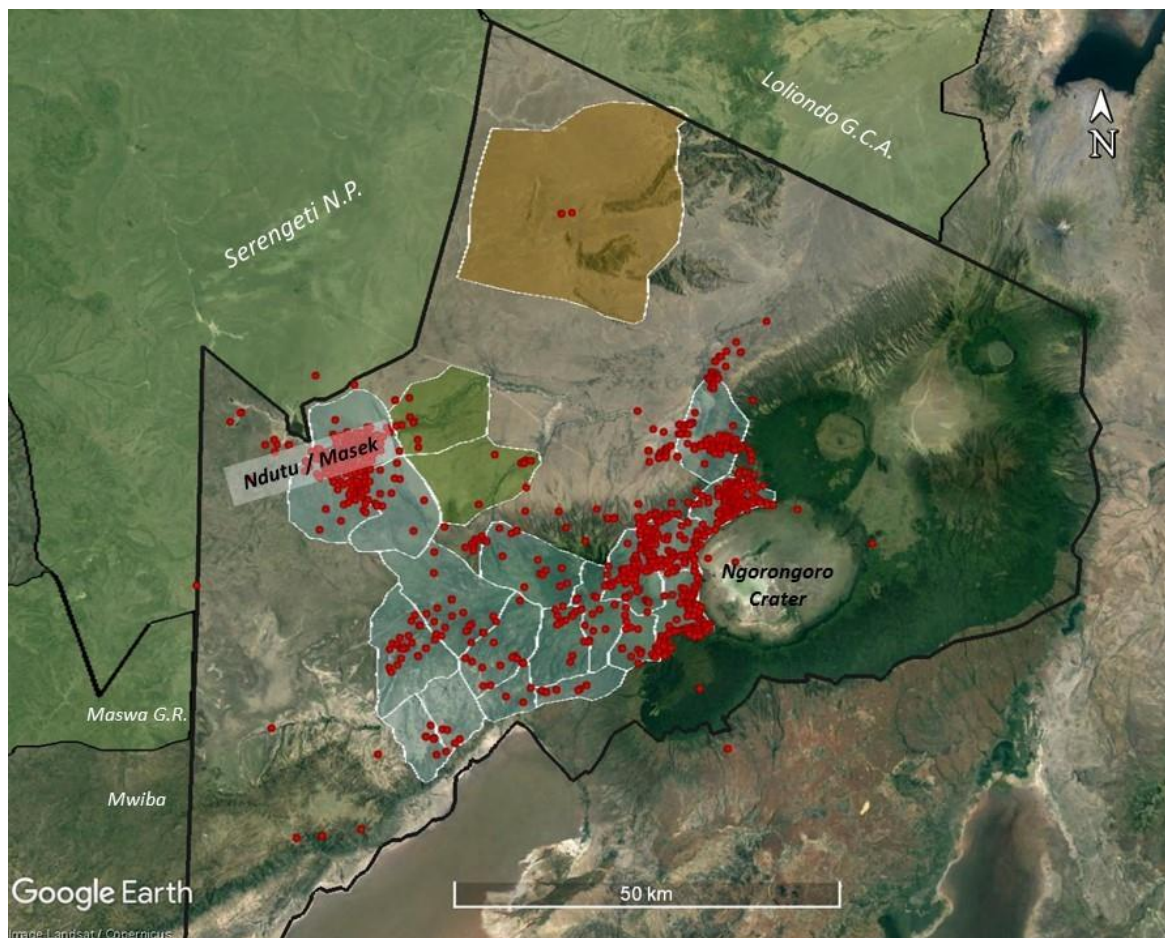


Fig. 1. Ngorongoro Conservation Area, boundaries outlined in black; pale colored blocks are the zones of the “Ilchokuti”, KopeLion’s field staff; pale green blocks are wet season zones when pastoralist move away from the Ndutu region; pale orange section in north-western NCA is a zone with limited operations; red dots are locations of lion observations recorded by our field staff between Apr. 2019 to March 2020.

Boma reinforcements

Our team reinforced 141 bomas (livestock enclosures), see Figure 2A. This assistance is provided to community members following attacks by predators on the boma, or in cases when the boma is weak and prone to predator attacks.

Wound treatment

Our team provided wound treatment to livestock attacked and injured by predators in a total of 726 events, including 1,043 livestock, see Figure 2B. This included treatments of 387 cattle, 130 goats, 212 sheep, and 13 donkeys. These attack-injuries were claimed to be caused by spotted hyena (404 events, 612 livestock); leopard (73 events, 99 livestock); lion (28 events, 28 livestock); striped hyena (37 events, 51 livestock); jackal (9 events, 10 livestock); buffalo (4 events, 4 livestock); baboon (2 events, 2 livestock); cheetah (2 events, 3 livestock); and another 10 events with 16 livestock by caracal, honey badger and cases where predator was either not know, or not recorded.

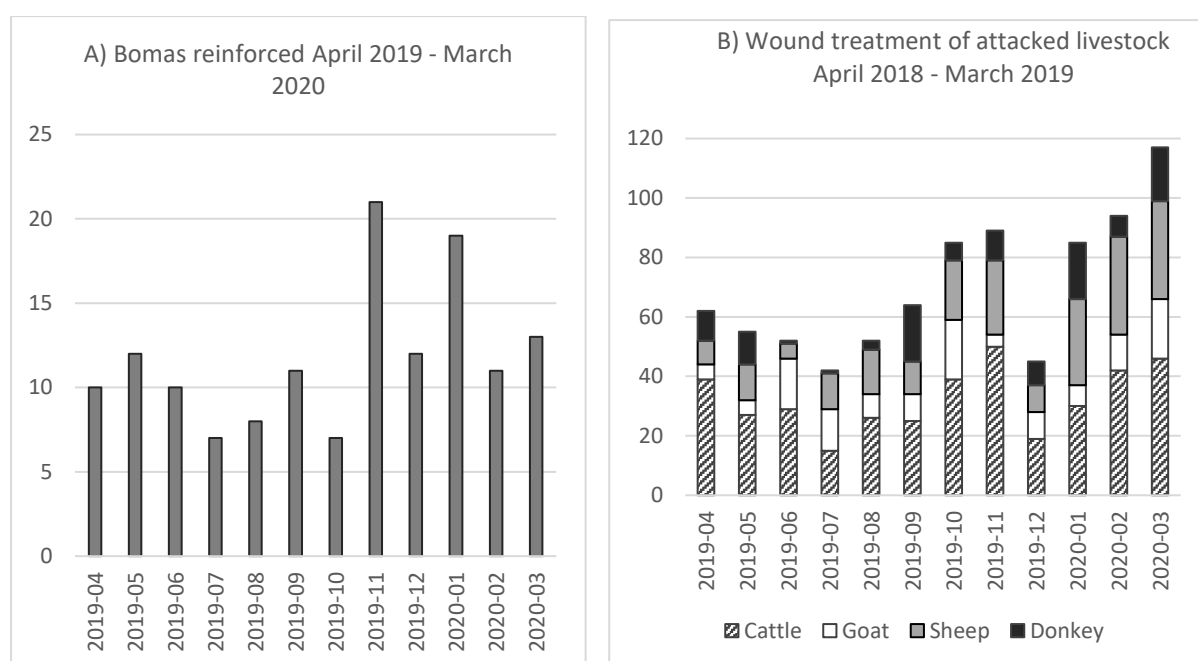


Figure 2. The number of boma reinforcements (A) and wound treatments of predator attacked livestock (B) provided by our team each month between April 2019 and March 2020.

Lost livestock recovery

Our team searched for lost livestock (N 2,761) on 206 events, and successfully recovered 84% (N 2,317), see Figure 3A. Another 206 livestock were found dead. Lost livestock left out are highly vulnerable to attacks from predators. The approximate monetary value for these recovered livestock amounts to USD 214,000 (688 cattle at value of USD 200; 2,512 small stock at value of USD 30; and 17 donkeys at value of USD 60).

Lion observations

Our team recorded signs of lions on 1,171 occasions, from a total of 2,658 individuals. See map in Figure 1 and monthly lion observations in Figure 3B. Of these, they recorded 177 visual observations of 575 lions; 699 tracks observations of 1,711 lions, and 56 scat or hair observations from 81 lions. NOTE that many of these observations are re-sightings of the same individuals as lions are frequently monitored by our field staff on site to provide early warning to herders.

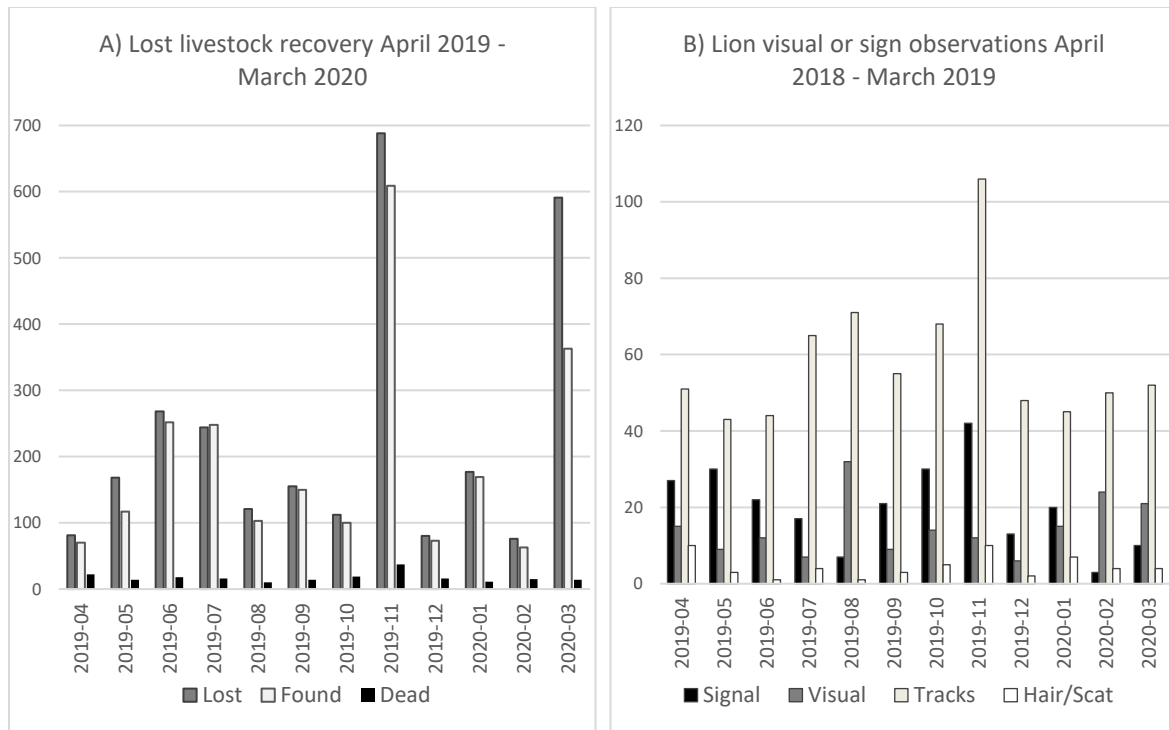


Figure 3. The number of livestock searched for (lost), numbers found, or was found dead (A) and records of lion observations broken up into telemetry signal, visuals, or finding signs like tracks, scat or hair (B) provided by our team each month between April 2019 and March 2020.

Lion – livestock attacks

During this period, we recorded 69 events of lion – livestock attacks, which is an increase from last year's 42 attacks. See Figure 4. This increase in attacks reflects the increased lion presence in NCA's multiuse region, widely used for livestock grazing. Through our teams daily and on-the-ground presence, providing early warning to the livestock herders, uncounted number of attacks have been prevented. Yet, attacks happen, incurring at times very large costs to affected families. In total, the losses from livestock attacked by lions for this period is estimated to USD 13,450 (Table 1). In many events the carcass of the killed livestock is retrieved partly or fully, and the meat can still be consumed.

The dataset for this attacks is not complete; while our team went to verify each reported attack shortly after incident, we are still working on compiling the full context of attack – such as attack on boma or at pasture, lost or herded, time of day, season, response by people.

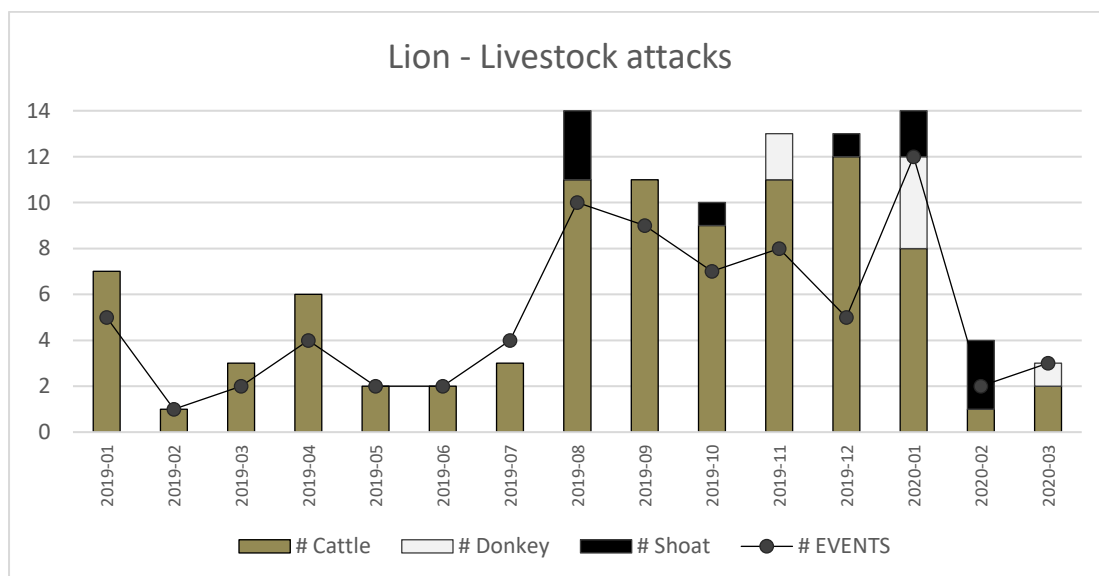


Figure 4. Number of livestock attacked, cattle, donkey and "shoat" (= sheep and goat), and the number of attack events recorded per month between January 2019 and March 2020 in KopeLion's area of operations.

Table 1: Number of livestock attacked by lions, and of those the number and percentage killed between April 2019 and March 2020, at a loss of an approximate value using \$200 per cattle, \$60 per donkey, and \$30 per sheep or goat.

	Cattle	Donkey	Sheep/Goat	Total
Number Attacked	78	7	10	95
Number killed	65	3	9	77
Percentage killed	82%	43%	90%	80%
Approx. value (USD) of the killed livestock	\$ 13,000	\$ 180	\$ 270	\$ 13,450

Wildlife observations

Our team recorded tracks and/or visual observations from selected wildlife species: Elephant 6,420; Cheetah 215; Leopard 667; Spotted Hyena (visual only) 1,161; Striped Hyena 303; Wild dog 12, see Figure 5. We have collected, but not yet processed GPS location data for these observations. The spotted hyena is common throughout, and we limited the recording to visual sightings only. The cheetah, spotted hyena, wild dog, and elephant are monitored by other research projects in NCA, however their study areas rarely include NCA’s multiuse zones. Other species like the leopard and striped hyena are currently not being monitored. This wildlife observation data reveals additional insight in range and trends of the NCA’s wildlife populations.

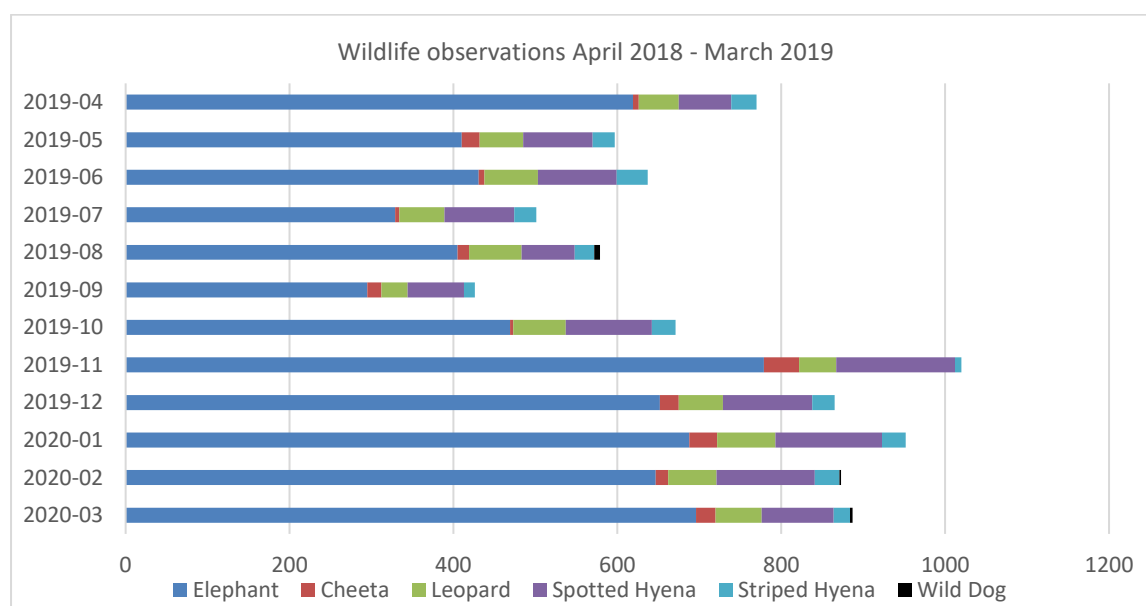


Figure 5. Records of observation of signs or visuals of selected wildlife species by our field staff, as they monitor their zones between April 2019 and March 2020.

1.1 Feasibility of a CIP model for conflict mitigation

We have progressed with our feasibility survey of a Conservation Incentive Payment (CIP) model as an alternative HWC mitigation strategy in NCA. Progress made so far:

- » 2017; initial feasibility survey resulting in a report (Pekor, A. et al, 2018. *Assessing the feasibility of establishing a Conservation Incentive Payment program to mitigate human-lion conflict in the Ngorongoro conservation area - Findings and Recommendations*). The report was submitted to NCA Authority, NCA communities and other stakeholders. Main finding was an enthusiastic interest from stakeholders to pursue this idea further.
- » 2018, March; joint stakeholder workshop, resulting in agreement to propose a plan for a 3-year CUP trial in 3 of NCA’s 11 wards. Report: *Pekor, A. et al. July 2018 Conservation Incentive Payment Program; Joint Stakeholder Workshop - Results and next steps*
- » 2018, August; KopeLion secured 50% of the funding for the CIP pilot for international conservation organization.

- » 2018; the CIP as an approach to mitigate human-wildlife conflict got recommended in the jointly developed 2018 NCAA Carnivore Action Plan.
- » 2019, April; Initial meeting a CIP Design steering committee, set up for the purpose of designing the CIP framework and operating conditions. CIP framework agreed on, and a draft for a CIP plan prepared.
- » 2020, February; CIP pilot proposal approved by NCAA Board of directors.

With the key stakeholders we have jointly agreed that the planned CIP pilot will run for 2-3 years in three wards; Endulen, Misigiyo, and Ngorongoro. Payments will be based on verified minimal count of lions on ward-land each month, estimated on our ongoing lion monitoring activities. There will be penalties in case of any lion killings, unless proven to be in self-defence. The amounts that communities shall earn is based on a lion's estimated cost to a community in terms of number of livestock attacked; TZS 450,000/= per month per lion (juveniles and adults)

Given this progress, and with the uncertainty of the Corona-pandemic, we anticipate to implement this CIP pilot later in 2020. *Documents on the plan, meeting minutes and reports are available upon request.*

2 Lion Monitoring

We have maintained the regular and long-term demography monitoring of NCA's lion strongholds, the sub-populations of Ngorongoro Crater and Ndutu/Masek region. Here each lion is individually recognized and monitored throughout their lifespan. There are a few elusive lions that inhabit or traverse the multi-use central section of NCA, linking the two strong-holds. We have managed to identify most of those lions, which were of known origin from either Ngorongoro Crater or Ndutu. Map in Fig.1 gives an indication of areas where lions are found.

To study lions' behavior through fine scale movement patterns we deploy GPS collars on a few individuals in the multi-use parts of NCA. We record lion presence in the same area by GPS-logging any signs of lions we encounter in area.

2.1 Lion demographics: Ngorongoro Crater and immediate surrounding

The demographic trends and pride compositions of the Crater lion sub-population are described in Figure 6 and Table 2, and with following notes:

- » By March 2020 the total number of lions¹ on the Crater floor is 66 (possibly 73²). This is a decrease, following the last six years upward trend.
- » The proportion of adults, i.e. 4 years and older, is 47%. This is higher compared to 41% in 2019, and 32% in 2018.
- » There are the eight prides, of which five consisting of only 2-3 adult females.
- » There are two groups of nomadic males – and we anticipate that one group of nomads is beginning to compete for pride take-overs.
- » There has been low cub recruitment in the Crater this last year with only 4 successful litters with a total of 8 cubs. The largest prides, Munge Mabinti and Lakes, were busy raising offspring, hence not ready for new cubs.
- » The former dominant pride in the Crater, Munge pride, has lost strength, and shifted their range

¹ Definition for our total count is based on a minimal count estimation of lions seen in the last six months.

² This higher estimate includes lions that we have reason to assume (based on lion reports, range) are still alive, but staying outside the Crater.

from the rich Munge River area to the Crater's north-west plains.

- » The 5-male coalition, the Crater-born Lake Quintet, spend most time in the Crater's south section and they are the resident males for 3 of the Crater prides.
- » The 3-male coalition, Lake Trio, are the younger half-brothers to Lake Quintet. They are resident males in 2 of the Crater prides.
- » The Lake pride scattered as the Lake Quintet males shifted south. Since April 2019 we have occasionally found and identified Lake-members in the highly populated slope and plains north-west of the Crater.
- » The Lagunita-pride scattered following arrival of Lake Quintet, and since late 2018 we have not seen one adult female and 6 juveniles. We had a few reports of lions on the rim, that may have been this group, but for this count we regard them as lost.
- » A 5-year old male from Ndotu's Twin Hill pride, TWH-2 *a.k.a. Laipangwa*, started to join the roaming Lake-pride females. He is now regarded as their resident male.
- » The 5-year old male from Ndotu's Masek pride, MAS-13 *a.k.a. NguvuKazi*, have continued in company with females of the Lake pride, and likely siring the offspring of LK107 *a.k.a. Noongoile*. After spending much time in the Crater, *NguvuKazi* joined juvenile males of the Lake pride, and as nomadic coalition they left the Crater floor – likely pushed away by the Crater's dominant male groups.

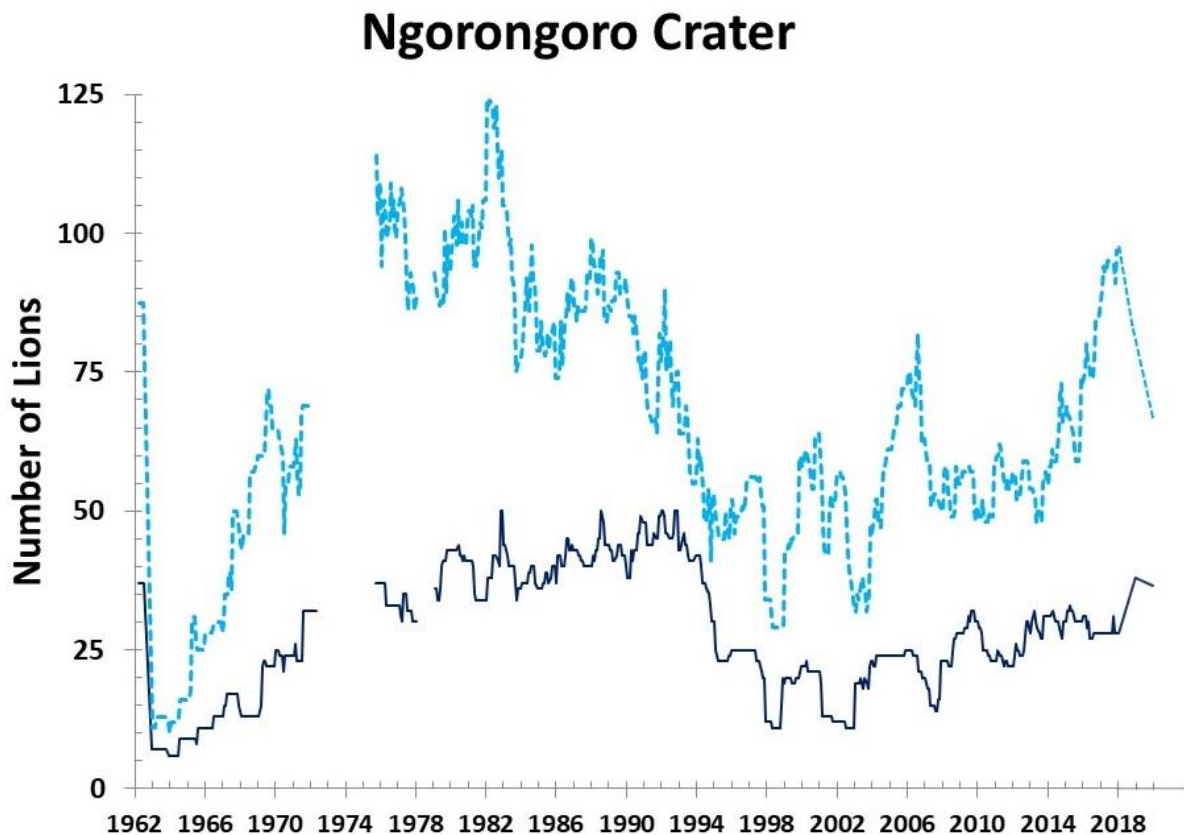


Figure 6. Yearly population totals for lions living on the Crater floor, from 1962 until March 2020. Dotted blue line includes all individuals; dark blue only includes adults that are at least four years of age.

Table 2: The current composition of the Ngorongoro Crater lion population, divided into pride membership and age cohort (adult = at least 4 years old; juveniles = 1 - <4 years; cub = 0 - <1 year). Lost litters are the number of litters born, indicated by lactation stains on a lioness, but that were lost before we saw any cubs.

Pride	Total	Adult females	Juveniles	Cubs (litters)	Lost Litters	Resident males
Munge (MG)	4-5	2-3	2	0	1	Lake Trio (3 males)
Munge Mabinti (MGB)	17	6	8	3 (1)	1	Lake Quintet (5 males)
MungeTati (MT)	5	2	0	2 (1)	-	Uncertain, none stable
Mungedge (MGE)	2	2	0	0	2	Lake Trio (3 males)
Lakes (LK)	9-15	2-7	4-5	3 (2)	-	Single male: TWH-2
Lagunita (LAG)	4	4	0	0	3	Lake Quintet (5 males)
Lakette (LA)	3	3	0	0	3	Lake Quintet (5 males)
Lucia (LUC)	2	2	0	0	-	Uncertain, none stable
Resident males	8	Coalitions: Lake Quintet (LK115, 116, 117, 120 & 123, Crater-origin); Lake Trio (LK125, LK130, LK131, Crater-origin); solitary TWH-2, Ntutu/Masek-origin.				
Nomadic males	12	3 groups: I) 5 juveniles from Munge; II) 3 juveniles from Lakes + MAS-13, Ntutu/Masek-origin; III) 3 juveniles from MGB.				

2.2 Lion demographics: Ndotu region

The status and pride composition of the Ndotu/Masek lion sub-population is described Table 3, and with following notes:

- » By March 2020 the total number of lions³ in the Ndotu/Masek region is 30 (possibly 44⁴).
- » The proportion of adults, i.e. 4 years and older, is 93% (or possibly 63% if Big Marsh's 12 cubs are still alive).
- » There are the four prides, consisting of 2-6 adult females.
- » Many litters and cubs have been born to the Ndotu/Masek prides this last year. Big Marsh had success with 5 litters with 17 cubs born, and 12 of those still surviving by December 2019. The other prides experienced very low cub survival rates. Of 14 litters born in 3 prides, all the >31 cubs got lost. We assume that the losses were due to starvation and infanticide. The harsh dry season with limited prey caused cub losses for the Thin and Big Marsh prides. Arrival of new males and pride take-overs coincided with Twin Hill and Masek prides' cub losses.
- » We documented the arrival of two different male coalitions originating from the Ngorongoro Crater; a 4-male coalition born 2014 in the Munge pride, and a 3-male coalition born 2016 in the Lagunita pride. The Munge coalition arrived in May 2019, and soon took over 3 of the 4 Ndotu/Masek prides. The Lagunita-males arrived in January and made moves to take over the Masek pride.

Table 3: The current composition of the Ndotu/Masek lion population, divided into pride membership and age cohort (adult = at least 4 years old; juveniles = 1 - <4 years; cub = 0 - <1 year). Lost litters are the number of litters born, in which all cubs were lost.

Pride	Total	Adult females	Juveniles	Cubs (litters)	Lost Litters	Resident males
Big Marsh	6-18	6	0	12? (5)	-	Lol-gang (1 male remain)
Thin Pride	2	2	0	0	2 (8+ cubs)	Lol-gang (1 male remain)
Masek	4	4	0	0	5 (10+ cubs)	Uncertain; MG-males or LAG-males
Twin Hill	5	3	2	0	7 (13+ cubs)	MG-males (3 males)
Big Marsh Cousins	4	4	0	0	2	Uncertain
Resident males	4	Coalitions: Lol-gang (1 male: Loji – the only one remaining of a 4-male coalition), unknown origin; MG-males (3 males: MG120, MG127, MG130), born in Crater.				
Nomadic males	5+	Uncertain. 3 groups: I) Nemeju & Liangata (unknown origin); LAG-males (LAG-P, LAG-Q, LAG-R, born in Crater). Other males have been seen, incl. MG106 (born in Crater)				

³ Definition for our total count is based on a minimal count estimation of lions seen in the last six months.

⁴ This higher estimate includes lions that we have reason to assume (based on lion reports, range) are still alive.

2.3 *Lion demographics: Ngorongoro Conservation Area*

While we have a close to accurate total estimation of lions for the easy-to-monitor lion populations in the Ngorongoro Crater and the Ndotu region, we can only roughly estimate the number of lions in the entire NCA. Based on our opportunistic and community participatory monitoring, we assume that lions in NCA's Multiuse area may not be more than 10 – giving an estimate of approximately 100-130 lions in the entire NCA. We are aware of a few distinct individuals/groups; a) the lone male Kalamas (GPS-collared by a neighboring project) that has spent most part of 2019 in the NCA Crater highlands, occasionally in company with females, b) one female with cubs in the escarpment between Misigiyo and Olpiro, c) at least one male not matching known lions on the Crater rim. In addition, rangers and tour-operators from the south-west of NCA (Kakessio) occasionally report lions - likely lions that range across neighboring protected areas Maswa GR, Mwiba, and Serengeti National Park.

2.4 *Lion demographics: Mortality*

We have recorded of five cases of lion deaths since April 2019 within NCA. Of these, one remains unconfirmed and were reportedly killed in a hunt. Details of the documented cases:

- Remains of adult male lion found in Ngidokun, Esere on 01/04/2019, likely the missing 5th male of the MG-male coalition (MG131). Reason for death unknown, but no sign of conflict found.
- Remains of adult male lion found in Ndotu on 11/07/2019 – this was likely the remains of Lope – a male of the Lol-gang coalition (see table 3). The carcass was found near the location where the GPS collared Lemunge and his MG-males had interacted with the Lol-gang.
- On 13/08/2019 a cub was found killed and partly eaten by lions. The cub was likely from Big Marsh or Thin Pride. The males seen killing the male took off into Serengeti NP and could not be identified.
- On 21/02/2020 an unknown old and emaciated male lion was killed by spearing in self-defence as he attacked a boma at night in the densely populated Kiloki Valley area.
- On 24/02/2020 a carcass of an adult male lion was found in the Ndotu area. This is likely to have been Loji, the last male of the Lol-gang, and death likely caused by fight with other lions.
- We have received unverified rumours of one case of lion killing on the Endulen – Ndotu plains

2.5 *GPS collars: Lion movements and conflict mitigation*

We have continued the fine-scale monitoring of lion movements by GPS collars. See Table 4 for the operation of collars since we received collaring permission in 2012, and Figure 7 for a map of the movement patterns in the lions in the Crater Highlands. Earlier conflict in these areas frequently led to retaliatory and pre-emptive hunts.

The collars have a timer and remote-controlled drop-off function. If collar stays on the lion, it will automatically release the drop-off after a pre-set of lions collared during this reporting period. The collars are scheduled to take 14-24 positions day and night. We receive position updates regularly through satellite transmissions, showing the lion's current whereabouts and enabling our team to warn nearby herders about the lions' presence. The later has proven an effective tool in keeping both livestock and lions safer – an important mitigation tool here in NCA where lions tend to attack livestock in the afternoon and early evenings while at pasture. This conflict mitigation tool has led to greater survival of the lions, initially observed in the Ndotu/Masek prides and now also number of days (typically 770) of collar deployment. The remote drop-off function enables us to remove collar before this, if needed. We have done so in 4 cases; removal of a failing collar (2), removal of a 2nd collar in a pride (1), and removal of a collar before it got too tight on a growing individual (1).

Table 3: GPS collars status in NCA, showing date of collaring and collar removal, and area used as home range or territory by that animal. Animals marked in bold are still collared by April 2019.

Lion ID	Born	Sex	Collar on	Collar off	Home-range	Comment
THI-A (Tom)	2010	M	22/10/2012	03/12/2014	Ndutu, Makao	Collar released automatically after pre-set number of days
Puyol	2008	M	14/02/2013	28/10/2014 (died)	Masek	Died. Possible cause: septic wound caused by lion fight, or perhaps slow-acting poisoning.
Orbili	2011	M	14/02/2013	02/09/2013	Orbili	Collar remotely removed after 6.5 months (to avoid getting too tight on this still-growing lion)
Bahati	2007	M	02/12/2014	22/09/2015. Killed, suspected poisoning. Collar destroyed	Orbili, Kakesio	Shortly after collaring this male went to Kakesio ward. Killed in retaliatory poisoning in Osinone.
MAS-9 (Laetolia)	2012	M	08/03/2015	20/6/2015. Killed by spearing	Endulen, Esirwa	Lion from Masek pride. Dispersed as a nomad to Crater highlands. Twin brother with MAS-11.
Nayomi	2008	F	17/03/2015	28/12/2017. Found dead, cause of death could not be determined	Naibardad, L.Masek	Twin Hill Pride. Continued collaring for conflict mitigation purposes.
Kijana	2006	M	11/07/2015	30/12/2015 Removed (collar failure)	Crater rim, Crater floor	Male of unknown origin. In 2015 became a resident Crater male. Failing collar removed remotely.
MAS-11 (Museum)	2012	M	26/02/2016	14/01/2017 Killed by spearing	Western Crater Highlands, incl. Misigiyo	Lion from Masek pride. Dispersed as a nomad to Crater highlands. Twin brother with MAS-9.
MAS-8 (Nosikitok)	2012	F	08/09/2016	Still on	South of L. Ndutu	Masek Pride. Collared for conflict mitigation purposes. Collar replaced in Sept. 2018
Kalamas	2010	M	16/12/2017	1/3/2018 Collar failure (since 14 th Jan)	Wide range; Maswa GR to NCA highlands	Currently a resident male of pride in Mwiba, west of Kakessio. Collar removed remotely after failure.
MG74 (Noltepesi)	2004	F	15/04/2018	18/10/2018. Only collar found, cause of death could not be determined.	Uncertain. Include the west rim and slopes outside N. Crater.	Munge Mbili. Originating from the Crater. Since 2017 we observed her on the NW Crater rim and outside slopes.
MG2-C (Nebalaa)	2004	F	08/05/2018	18/8/2018. Removed as 2 nd collar in group.	Uncertain. Include the west rim and slopes outside N. Crater.	Munge Mbili. Found blind near village. Was captured, recovered, and collared. Returned to join collared mum MG74
Nadine	2012	F	30/7/2018	Still on	Naibardad, L.Masek	Twin Hill Pride. Collared for conflict mitigation purposes.
TWH-2 (Laipangwa)	2015	M	20/8/2018	Still on	Nomad, range widely across central NCA	Currently a solitary nomad. Was born in the Twin Hill pride of Ndutu.
MAS-13 (NguvuKazi)	2015	M	01/09/2018	Still on, but malfunctioning since 14 th Feb. 2020.	Crater, Malanja Depression, NW Crater rim.	Was born Ndutu's Masek pride. Now considered resident male in the Crater's Lakes pride. Documenting a dispersal. Collar failed (damaged?), and we are on search to find and remove or replace collar. We get reports of lions in area, so it is likely he is still around.
MG130 (Lemunge)	2014	M	28/05/2019	Still on	Ndutu/Masek, Engarusi Vally and Nasiusiu plains	Part of a 3-male coalition (was 5) originating from the Crater. They left Crater as 3-year old nomads, and appeared in Ntutu in May 2019.
LK107 (Noongoile)	2010	F	28/01/2020	Still on	Ngorongoro Crater, NW Crater rim	This collar was deployed as we knew this pride and this female use the rim and outside Crater slope

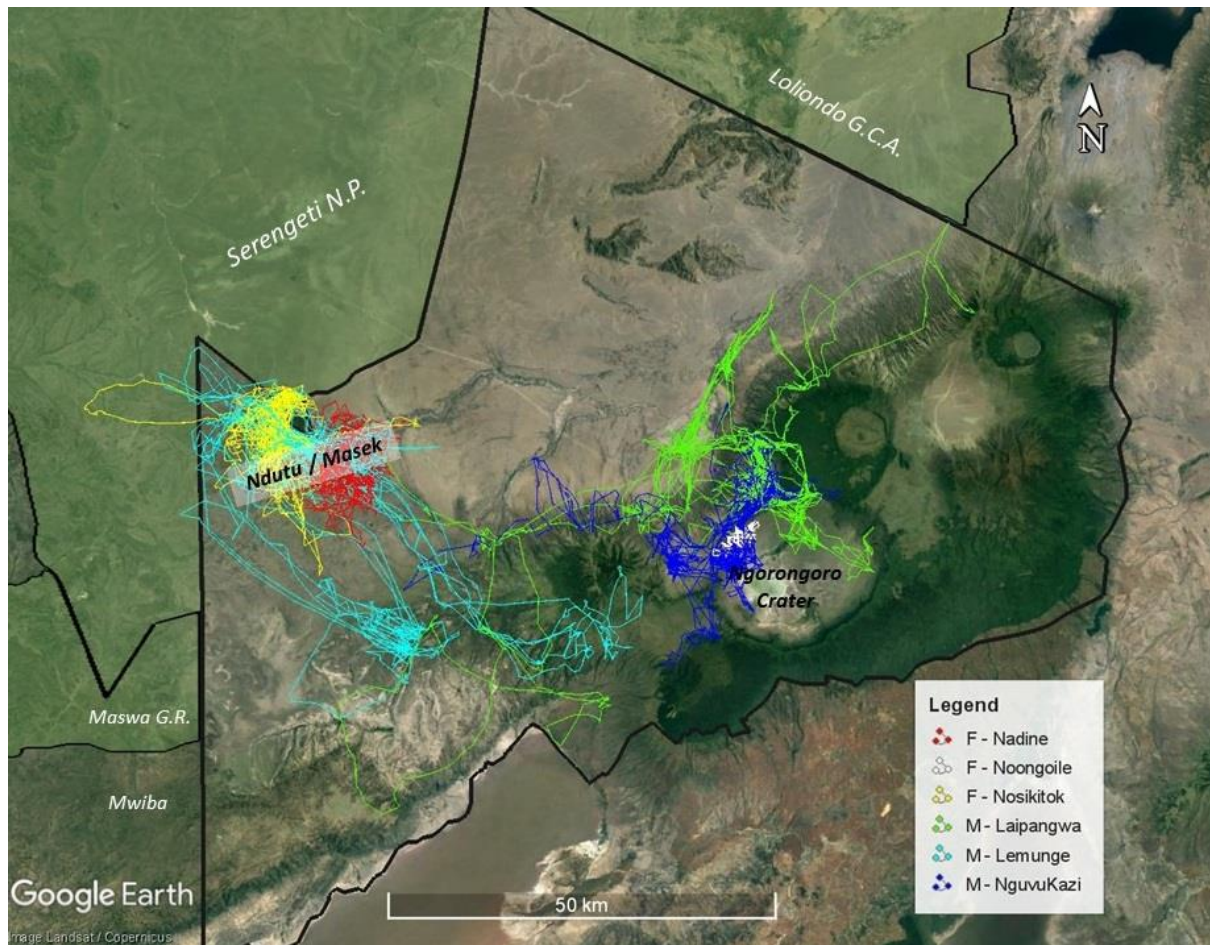


Figure 7: Map of the Ngorongoro Conservation Area, boundary outlined in black. The lines show movements from the 6 different lions GPS collared during the reporting period (April 2019 – March 2020). (map image: Google Earth).

2.6 Camera traps: Lion movements and lion presence verification

Due to challenges with theft and vandalism we suspended our camera trap survey in December 2017, after completing a 12-month coverage. A high focus on other parts of our program has not allowed us sufficient time to assess the results of this survey for lion occupancy, and effectiveness of study design for a CIP, hence it is work is still in process. In 2019 we had 2-4 cameras up in places of special interest, but we removed all after two got vandalized.

2.7 Lion genetics – progress with our analyses

An ultimate goal of this project will be to determine whether reduced human-lion conflict has an effect on lion population dynamics, including dispersal and genetic exchange between lions in the Crater and the rest of the Serengeti Ecosystem. To accomplish this, genetic assays will be essential. A challenge with genetic surveys is lack of species-specific markers or lack of resolution, particularly prominent for large and long-lived species as they often have relatively small population sizes. In theory, genotyping allows for the reconstruction of a population’s pedigree, a huge help in understanding past and current behavioural and demographic processes. Again, particularly for small populations, kinship patterns may often be conflated by consanguineous matings, making it hard to place individuals with incomplete kinship links to resolve the full pedigree. Using high throughput sequencing, we circumvent this problem by generating genotypes holding thousands of markers. This gives us great power to correctly assign kinship links and together with the observational data on pride membership, matings and births we now want to look in greater detail at the Crater lion

population's pedigree to understand more about how kinship patterns might affect survival, dispersal, mating behaviour, and reproductive success.

In 2015 we exported 264 samples containing lion DNA (faeces, hair and tissue) to our lab at SLU, where we proceeded with the genetic analyses. Our whole-genome assembly is continuing, and we have now procured short- and long-read sequence data, in addition to our HiC completed in 2019. We have also just finalized a SNP genotyping micro-array specifically designed to work well on non-invasive samples. We have tested this on faecal samples with good success (75% success rate). This resource will let us complement tissue sampling with faecal genetics, potentially detecting unknown individuals. While this resource does not provide the amount of information possible to get from tissue samples and whole-genome sequencing, it will allow us to build pedigrees and identify individuals with confidence. We are currently running tests to see if saliva, hair and ticks can also be used to generate reliable genotypes.

3 Recommendations

While we are seeing positive effects on human-lion coexistence through our participatory lion research and conservation activities, we recognize the limitations of peoples' tolerance to conflicts caused by lions. The NCA communities are increasingly eager for strategies that address the challenges and costs incurred from wildlife such as lions - from us as a lion research and conservation project, and from the NCA authorities. We have recently received approval from the NCAA Board of Directors for a 3-year CIP pilot, designed to be limited in time (2-3 years), area (3 wards), and scope (lion presence). If it is agreed to roll out the CIP scheme after the trial, it has the potential to expand over a larger scale, and to include other species and/or conservation services. The pilot CIP will be implemented in close collaboration with key stakeholders NCAA management, NCA communities, Ngorongoro Pastoralist Council, and tourism operators. The research input from our project would focus in particular on designing monitoring protocols for lion presence and lion number estimations in areas included in the CIP trial.

We recommend to use the household survey from 2019 (conducted by TAWIRI and NCAA, with assistance from Lincoln Parc Zoo), that included peoples' perceptions, attitudes and actions towards the coexistence with wildlife, as a baseline to monitor changes after the CIP trial. Finding a sustainable coexistence model – a main goal of our project – ultimately relies on the acceptance and participation by all relevant stakeholder groups and individuals, and the real impact it has on the overall socio-ecological landscape.

To measure the impact from our conservation strategies, we would use the long-term and continued lion monitoring. Our lion monitoring covering population, pride, and individual demography data, coupled with genetics gives a unique depth for an understanding of the effects our implemented strategies have on the NCA lions' long-term viability.

4 Acknowledgement

We thank the Tanzanian authorities TAWIRI, COSTECH and not the least NCAA, for permissions, support and positive collaboration in the past year. We are also grateful to the NCA communities for their committed engagement. We look forward to another year of good partnership.

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