Mara-Meru Cheetah Project

PROGRESS REPORT

2019

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INTRODUCTION

Since the beginning of 20th century cheetah population in the world reduced dramatically from over 100,000 to about 7,100 individuals (*Durant et al. 2017. The global decline of cheetah and what it means for conservation. Proc. Natl. Acad. Sci. USA 114, 528–533*) and the major cause is a human activity at a global scale. Therefore understanding human-cheetah interface is essential in promoting the survival of this species on a long term. The Mara-Meru Cheetah Project (MMCP) was founded to work in the human dominated areas of Kenya – Mara Ecosystem and Meru Conservation Area. The general goal of the current research is identification of behavioral adaptations and assessment of impact of social structure on reproductive success and survival of the cheetah in the protected areas under anthropogenic influence. Mission of the Mara-Meru Cheetah Project is to promote the conservation of cheetahs through scientific research, community involvement and education.

PROJECT TEAM

Project Founder and Principal Investigator –
Dr. Elena Chelysheva is a biologist with over 35 years of experience of working with cheetahs and studying them in captivity and in the wild. In 2001-2002, Elena was working as an Assistant Researcher at the first governmental Cheetah Conservation Project in Kenya, initiated by the Kenya Wildlife Service (KWS) in the Maasai-Mara region. At that time, Elena developed original method of cheetah identification (published in 2004), which is widely used now by different researchers. In 2008, Elena defended her PhD in cheetah ecology and behavior. Dr. Elena Chelysheva is a member of the IUCN Conservation Planning Specialist Group. Since 2011, Dr. Elena is leading the Mara-Meru Cheetah Project (MMCP).

Senior Project Advisor – Salim Mandela Mandere graduated from the University of Nairobi with a Bachelor's Degree in Wildlife Management and Conservation. Before joining the MMCP, Mandela completed several projects including assessment the contributions of private ranches in wildlife management and conservation; camera trapping and data analysis; game counts; community conservation education and conflict management. He joined the MMCP as a **Senior Research Assistant** in 2012 and took wide range of responsibilities including field data collection and analysis, community education programs development and implementation, conducting motivation talks to Kenyan students in different Universities and schools. Working in the Project, Mandela gained vast experience and skills, which allowed him to be chosen by the local community for the position of the Manager of the newly formed Olerai Conservancy in the Mara. At the moment, Mandela is completing his Master's thesis (based on the data collected while working at the MMCP) at the University of Nairobi and assists our team as the Senior Project Advisor and mentor of our new assistants.

Senior Research Assistant – Jackson Morara Otuke holds a bachelor's degree in Environmental Planning and Management from Kenyatta University. His professional interests are GIS and Remote Sensing (competent in using different programs- Arcgis, Q-GIS, Snap, Open foris Collect Earth tool, Google Earth, Global mapper), spatial planning and environmental management for sustainable urban, rural and regional development while conducting research, designing and preparing development plans with environmental related programs/projects. In the MMCP, Jackson's responsibilities include field data collection (wildlife behavior monitoring and recording), spatial analysis using GIS, developing and implementation of conservation outreach programs for the local community, rangers and local tour guides.

Research Assistant – Branson Togom Nalala graduated from the University of Nairobi in 2019 with a bachelor's degree in the Wildlife Management and Conservation. Coming from a pastoral community, Branson chose to take a course in the University that will give him knowledge to help his community in solving daily conflicts that arise from the close interaction of people and the wildlife.

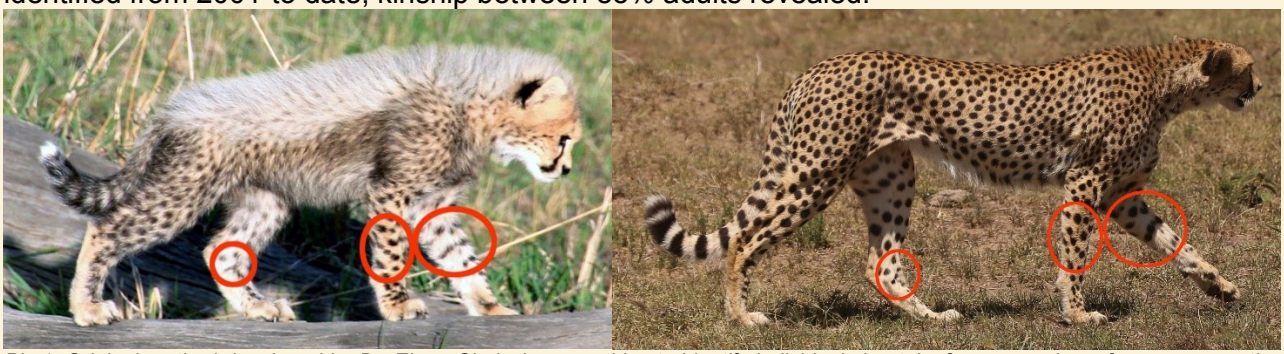
Research Assistant – Brian Mlamba Solomon, graduated from the University of Nairobi with Bsc. in Biomedical Sciences and Technology. Branson was responsible for processing bio samples collected by our research team in the field, at the Kenya Wildlife Service Forensic and Genetic laboratory in Nairobi. Brian's study was a part of his Master's project at the Department of Biochemistry and Biotechnology of the University.

Community Liaison Officer – John Ole Masek. John has over 13-year experience in assisting wildlife projects and tour guiding. His excellent knowledge of the Mara together with his strong communication and interpersonal skills made a significant contribution to our team. He became a team member in 2014 and assisting with all community activities, including interviewing of local pastoralists, conservation lessons at local schools and arrangement of meetings with local community representatives.

CHEETAH STUDY

I. CHEETAH POPULATION

1.1. Database. The database has been built on the basis of individual identification by the original method of cheetah identification, developed by Dr. Elena Chelysheva in 2001 (*Chelysheva, 2004, New Approach to Cheetah Identification.// CAT NEWS, 2004. № 41. P.27-29*). The method is based on the visual analysis of the unique spot patterns on front limbs (from toes to shoulder) and hind limbs (from toes to the hip), and spots and rings on the tail. It helps to identify individuals from the age of one month. In the example below, spot patterns (circled in red) of 1 month old cheetah cub match with those of an adult cheetah, revealing their phenotypical identity. Correct idenitification of cheetahs from collected photos enables building the Mara cheetah Pedigree, where the year a birth and kinship among cheetahs (parents/grandparents/littermates) has been revealed. Out of 204 adult individuals identified from 2001-to date, kinship between 85% adults revealed.



Pic.1. Original method developed by Dr. Elena Chelysheva enables to identify individual cheetahs from as early as from one month of age. Female Karembo at the age of 1,5 months (left) and two years (right)

1.2. Mara cheetah population trends. Determining the exact density of cheetahs is a difficult task for an area the size of the Mara Ecosystem where 1,510 km^2 is Maasai Mara National Reserve and 1,500 km^2 is surrounding conservancies' territories. Our initial SCR modeling efforts suggested a >50% decline in cheetah density between 2005 and 2013 (Green et al. 2014). More protected areas formed around the MMNR since 2005, offer secure habitats for predators, and therefore cheetah density in the Reserve alone becomes lower than the density in the entire Ecosystem.

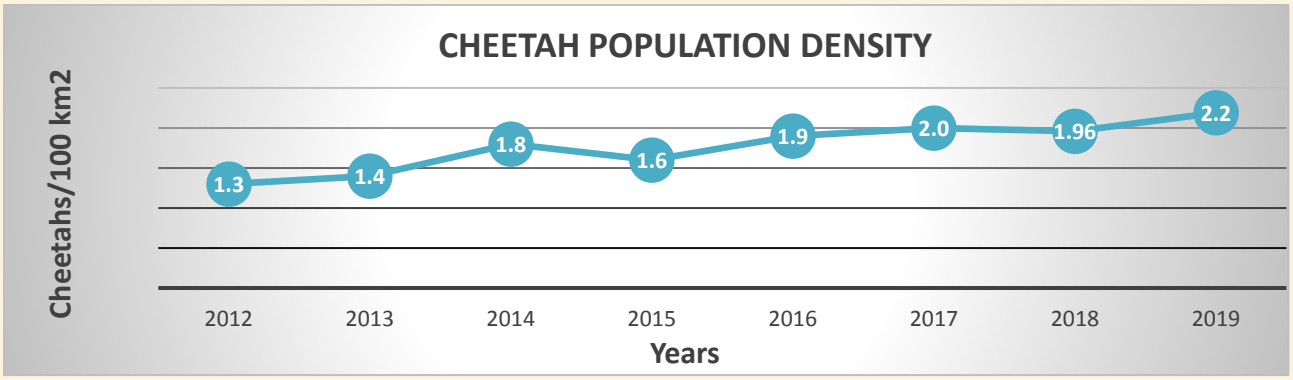
The magnitude of individual movements in cheetahs can make annual density an erratic statistic, especially in the presence of nonresident, "floater" males. Some cheetahs "disappear" for 1.5 to 2 years in the neighboring Serengeti National Park or outside protected areas of the Mara, until the next sighting in the Reserve or in the conservancy. For the years such individuals have not been spotted, they are excluded from the calculation. In general, the species density in the Mara Ecosystem is fluctuating with a tendency of slow growing in 2016 and 2017, decreasing in 2018 and increasing in 2019.

In 2018, in total 64 adult cheetahs (32 males and 32 females) have been observed in the Mara (3010 km^2), which gives the density of 2.12 cheetahs/100 km^2. However, by 31.12.2018, 5(2.3) adult individuals have been recorded lost, out of which 2(1.1) confirmed dead. That gives 59 (30.29) adult individuals recorded by the end of 2018, with the density of 1.96 cheetahs/100 km^2. (Pic.2). Several factors contributed to decreasing of cheetah density in 2018, included the following:

* Death of adult individuals of reproductive age. Two cheetahs (1 male and 1 female) died (cases documented), and two adult females disappeared.
* Relatively low recruitment rate: in 2018, 4 females raised 7 cubs to independence comparably to 2017, when 10 females raised 23 cubs to independence. By 31.12.2018, 9 females had cubs aged from 1 to 20 months.

In 2019, in total 71 (42.29) adult cheetahs have been observed in the Mara (2.35 cheetahs/100 km^2), but by the end of 2019, 5 (4.1) adult cheetahs have died, which gives 66 (38.28) adults or 2.2 cheetahs/100 km^2. Compared to the previous years, cheetah density increased due to the following reasons: 1) Recruitment rate exceeded the death rate of adults; 2) New adult cheetahs (9 males including 2 floaters and 3 coalitions of 2 and 3 individuals) from outside of protected areas or from the Serengeti NP) established their home ranges within the Mara Ecosystem or at the areas bordering Serengeti.

Carnivore populations in the MMNR have historically been high compared to other areas in sub-Saharan Africa (Craft et al. 2015), and the Mara–Serengeti ecosystem is considered a stronghold for large carnivores in East Africa (Ogutu and Dublin 2002; Riggio et al. 2013). Our density estimate indicates that MMNR provides important cheetah habitat in Africa.



Pic.2 Cheetah population dynamics

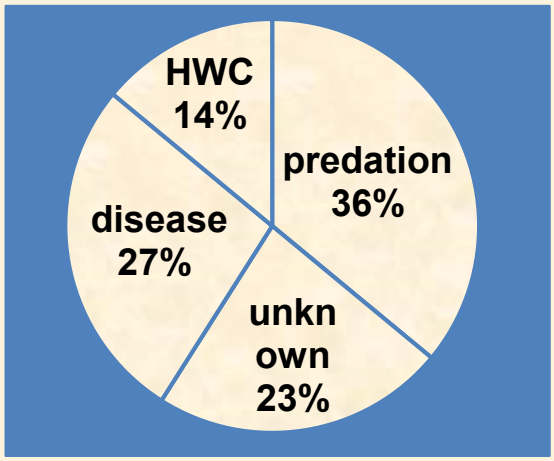
1.3. Lifespan of cheetah females in the Mara Ecosystem is longer than of males. Maximum documented age for males is 11 years and for females is 13 years.

1.4. Causes of death. Since 2012 to date, 22 (11.11) adult cheetahs died of different causes (*See Table 1 for details*). In 2014, the death of a male was indirectly caused by another predator - M34 died of a heart failure after he had been chased by a lion. Two adult females F57 (in 2017 in the Reserve) and F64 (in 2018 in the Mara Triangle) died of unknown disease with similar symthoms. In 2018, one female possibly drowned in the river while crossing it and one disappeared having 2 months old cubs. They can be considered dead, since both had cubs of different ages (including lactating).

Pic.3 M47 killed by a lion in 2018

Cubs in both cases have been left and both females have not been spotted again. An adult male M47 died of a lion attack on 13 August 2018, when he was possibly following the female F69 in oestrus. The cause of death was a puncture of the skull - a distinctive way of a lethal attack on a cheetah by a lion (Pic.3)

In 2019, in two cases, the cause of the death of cheetahs was the human-wildlife conflict, including retaliatory killing of two cheetah littermates in response to their preying on a goat in Tanzanian village, and road accident, when one young cheetah had been severely injured by a vehicle and was euthanized by the KWS Veterinary team. All cases except for 3 (1.2) in 2018, confirmed by sightings.



Pic.4 Causes of death of cheetahs in the Mara

In 2019, 11-years old male died of predation (lion attack). He was the oldest male recorded in the Mara.

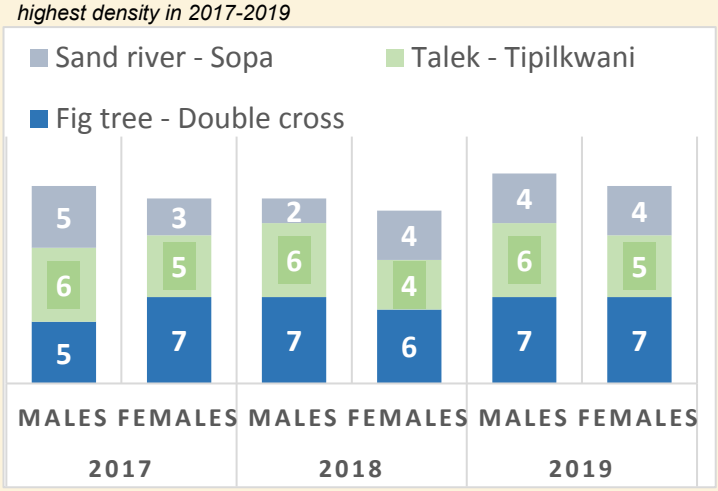
Table 1. *Death cases documented from 2012 to date*

Year	Total number	ID	Details	Age (years)	Cause of death
2012	1 (0.1)	F9 Resy	Single female	13	Unknown
2013	2 (1.1)	M1 Honey Boy	One male from a coalition of 2	7	Predation (lion)
		F2 Hanna	Female with cubs	5	Predation (lion)
2014	6 (4.2)	M26, M27 Kisiri's Sons	Two males in a coalition of 2	3	Infectious disease
		M4 Oloololo Brother	One male from a coalition of 2	5	Infectious disease
		M34	One male from a coalition of 2	3	Heart failure
		F4 Sidai	Single female	10	Predation (leopard)
		F5 Saba	Single female	10	Unknown
2015	1 (0.1)	F16 Narasha	Single female	12	Predation (lion)
2016	1 (0.1)	F39 Nabiki	Single female	6	Unknown
2017	2 (1.1)	M38 Chiko	Single male	4	Predation (lion)
		F57 Malkia	Last trimester of pregnancy	3	Disease
2018	5 (2.3)	M5 Martin (Oloololo Brother)	Single male (previously a member of a coaliton of 2)	10	Predation
		M47	Single male	unk	Predation (lion)
		F64 Naretoi	Single female	4	Disease
		F13 Malaika	Single female	10,3	Possibly drowned
		F40 Kisiri	Single female	Appr.9	Unknown
2019	4 (3.1)	M16 Siriwua	Single male	11	Predation (lion)
		M68, F79	Littermates	2	HWC in Tanzania
		Cub of F85	Sub-adult cub male with the mother and littermates	1	HWC Road accident

1.5. Territory utilization. From 2012 to date, out of total 176 (109.67) identified adult individuals observed in the Mara Ecosystem, majority of cheetahs – 73% utilized the territory of the Reserve and Triangle (1,510 km^2), surrounding Conservancies (1,500 km^2), and areas at the Tanzanian border, while 27% (n=48, out of which 20 males and 28 females) have not been spotted in the Reserve.

1.6. Cheetah distribution in the MMNR. Population monitoring is key to wildlife conservation and management. Our long-term observations (*Linden DW, Green DS, Chelysheva EV, Mandere SM, Dloniak SM. Challenges and opportunities in population monitoring of cheetahs. Population. 2020*) revealed a trend in the spatial distribution of cheetahs in the MMNR – in different years, the highest density have been recorded in the following areas: Fig Tree-Double Cross (#1), Talek-Tipilikwani (#2) and Sand River-Sopa (#3) areas (*See Pic.6-8*).Total number of different individuals who have been using three areas in 2017-2019 was 32 (15.17), out of which 20 (8.12) were observed in Area 1; 15 (7.8) in Area 2, and 14 (7.7) in Area 3.

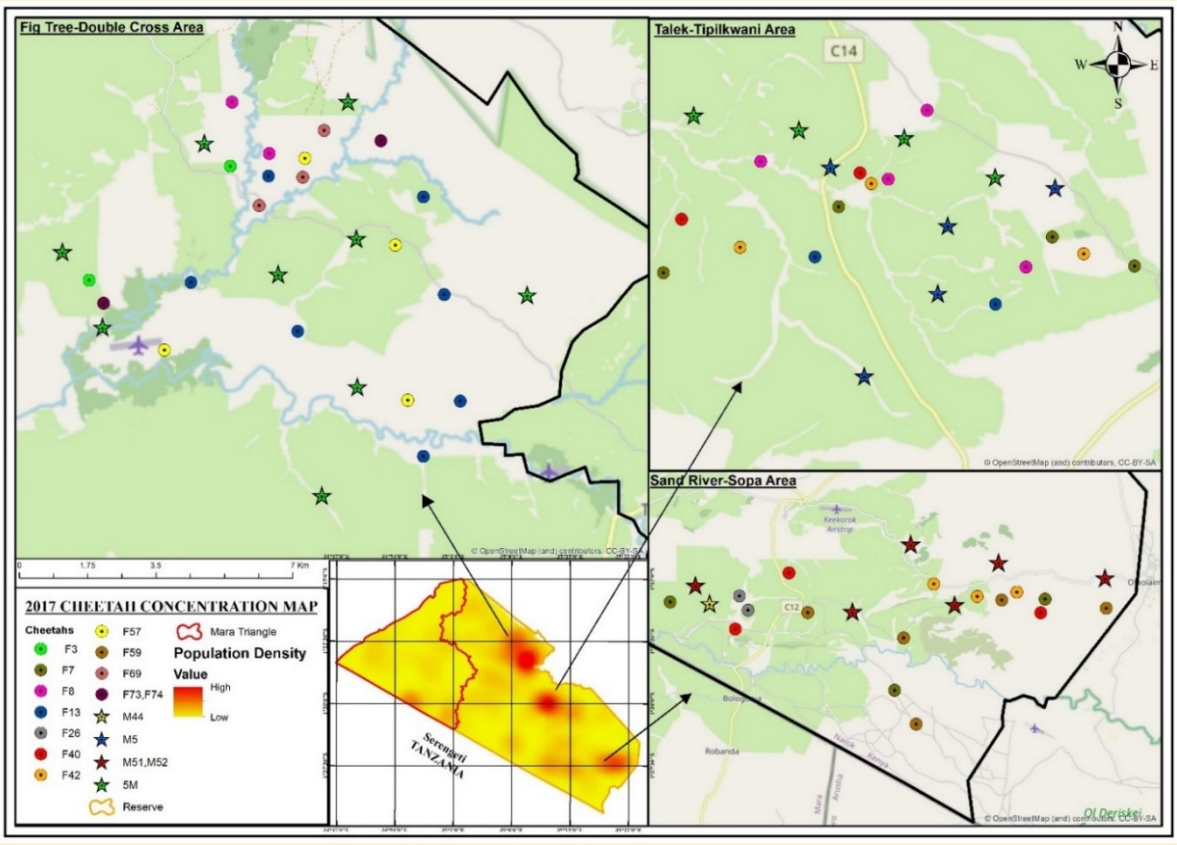
Pic.5 Number of cheetahs in three areas of the MMNR with the highest density in 2017-2019



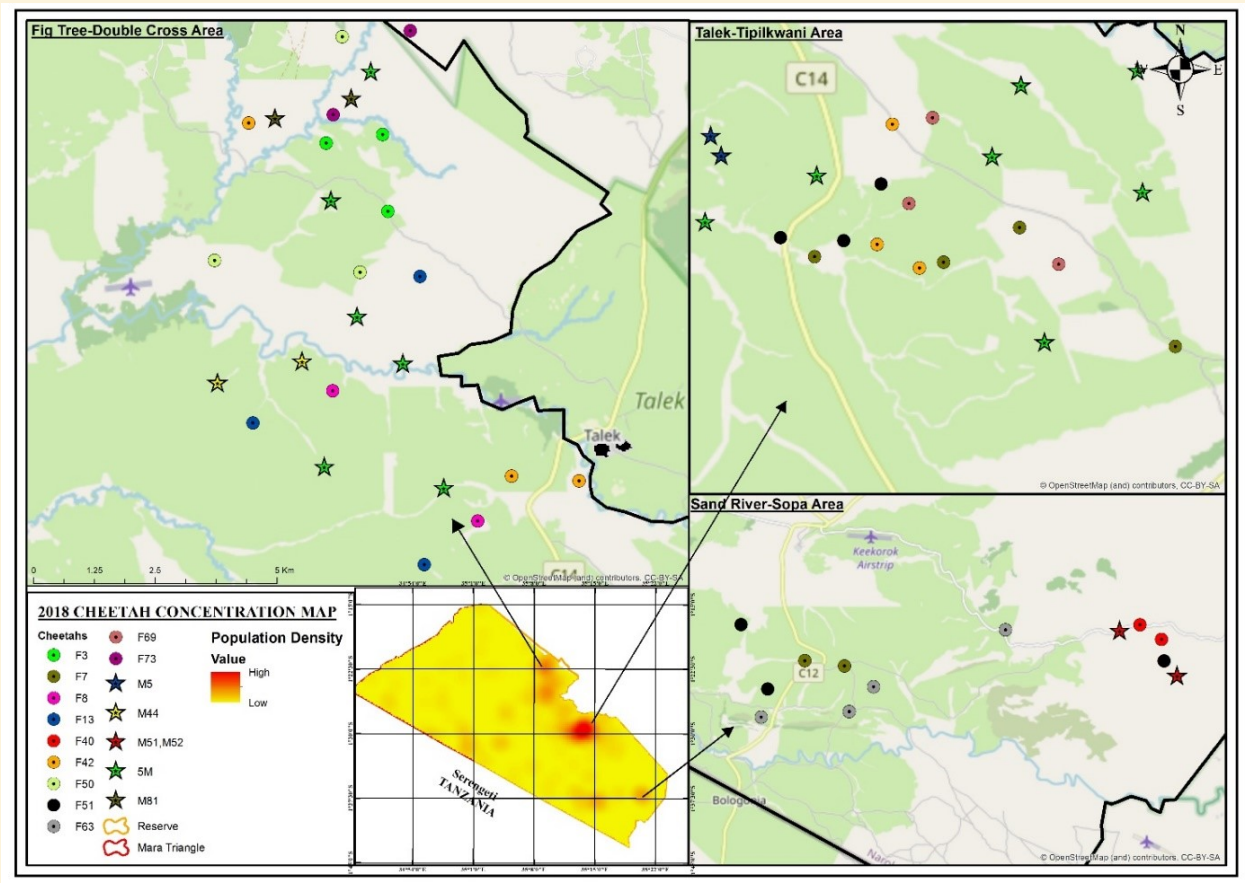
Area 1 (Fig Tree-Double Cross) is the most used area among three, although it is divided by the Talek River. Rivers do not limit movements of cheetahs, and some individuals cross even raging streams.

Area 2 (Talek-Tipilikwani) covers the territory close to the Talek gate of the Reserve with the net of main roads with intensive traffic of vehicles. It has been utilized by majority of cheetahs, who became tolerant to tour cars. Interestingly, in 2017, during the first year after formation, a group of 5 shy males (Tano Bora) was avoiding the part of this area close to the Park gate, but from 2018, started intensively using that part.

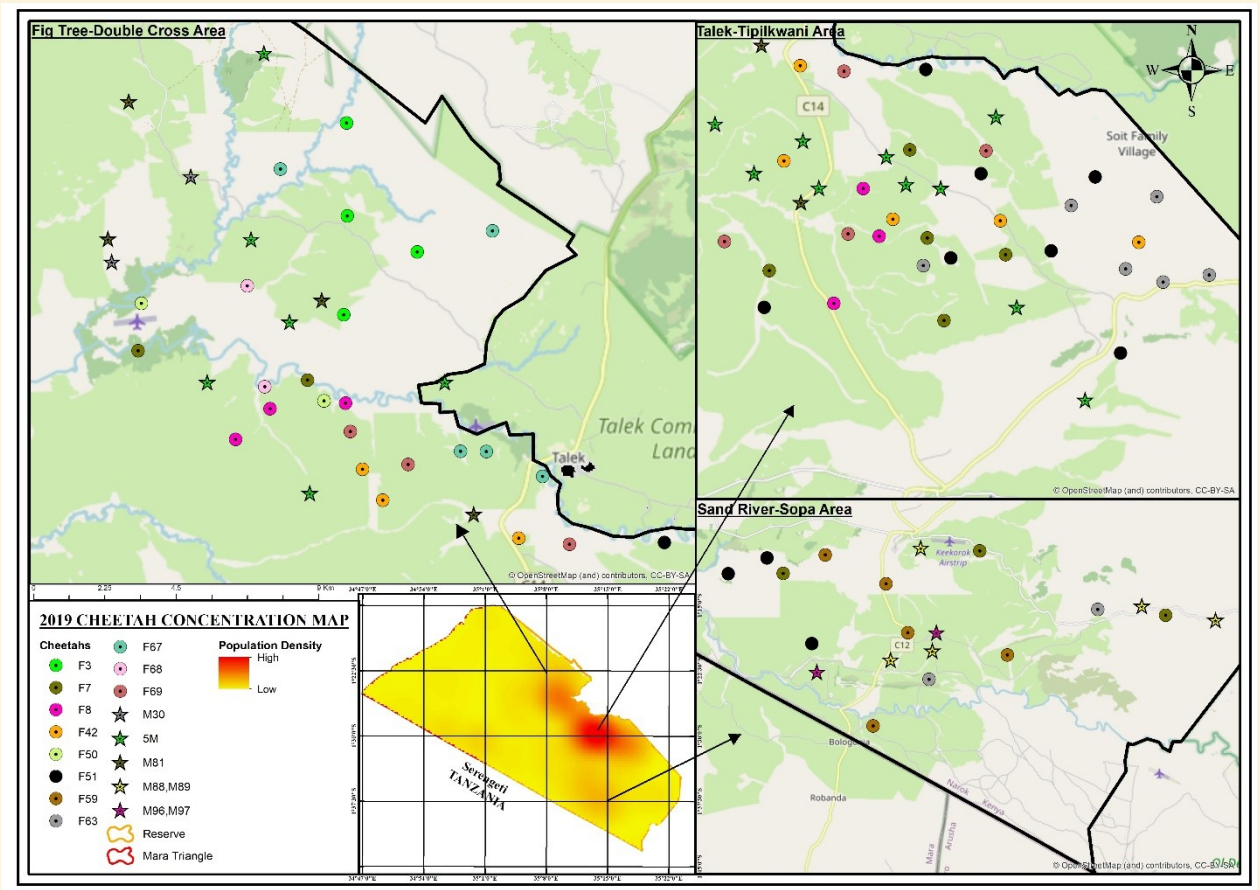
Area 3 (Sand River-Sopa) characterized by hills and valleys, which create suitable environment for cheetahs and is intensively used by different individuals and groups as a part of their territories/home ranges.



Pic.6. Adult cheetahs spotted in the areas of the highest density of the species in the MMNR in 2017



Pic.7-8. Adult cheetahs spotted in the areas of the highest density of the species in the MMNR in 2018 and 2019



1.7. Areas of the highest cheetah density in the Reserve. Some cheetahs use the same core areas for several years, some change their core areas through years. For example, male, **Olchorre** (M81) lost his coalition-mate in the beginning of 2018 in Fig Tree area and moved to the Double Cross area. In 2019, he was using both Double Cross and Talek areas (Pic.6). Female **Kisiri** (F40) was using both Talek and Sopa areas in 2017, but from September 2017, was seen only in Sopa area, where she was raising cubs and where disappeared in the end of February 2018. Female **Nora** (F42) in 2017 was also using Talek and Sopa area, but in 2018 and 2019 was using Talek and Double Cross areas (Pic.6). Female **Miale** (F7) in 2017 and 2018 was using Talek and Sand River areas, and in 2019 was using all the areas. Female **Nashipai** (F69) in 2017 was using Double Cross area, then moved to Talek area in 2018, which she was using also in 2019.

Although, some cheetahs have been continually observed in the same areas of the Mara, some of them change their territory/home range by moving to other areas permanently or for significant time period. In 2017, after losing his coalition-mate **Mugi** (M44) has been roaming in the same area (Sand river), but in 2018 moved to the Double cross area (Pic.6-8). It is more difficult for single cheetah males to establish and defend their territories if there are male coalitions in the area, and it is more difficult for smaller coalitions in presence of a large coalition. However, to maintain the genetic diversity of the population, participation in the reproduction of as many unrelated males as possible is necessary. Therefore, single males, like members of small coalitions, use every opportunity to explore the territory of competitors in their absence because encounters of coalitions may be fatal. For example, when the coalition of 5 males (**Tano Bora**) temporary left the Reserve for Olare-Motorogi Conservancy, a coalition of two males (M88 and M89) came from Sopa area to a part of their territory near Kikorok. They headed back towards Sopa the same day when the Tano Bora has returned from the Conservancy to the Reserve.

1.8. Cheetahs' territories and home ranges. Cheetahs may hold territories or have home ranges. Territory is the sociographical area that traversed by an individual or a group of cheetahs, (e.g. male coalition, female with cubs, group of siblings) in its normal activities of hunting, mating, and caring for offspring. Home range is the area, which is not exclusively held not defended by cheetahs and significantly exceeds the size of the territory. Each home range has a core area, defined as an area of intensive use or most concentrated ranging. Location of the core area within the home range may change with time. Territorial male cheetahs consistently defend their territory from potentially intruding conspecifics and occasionally animals of other species. Other males adopt a "floater" tactic characterized by large home ranges and lack of territorial defense. Overlapping ranges facilitate social interactions, gene flow, and reproduction. Female home ranges encompass several male territories and overlap with the home ranges of floaters, therefore allowing them access to several males. The following factors and their combinations contribut to cheetah movements and affect the size of their territories/home ranges:

* Availability of suitable habitat (landscape; vegetation; rivers; roads)
* Environmental conditions (weather; burning of the area etc.)
* Availability of appropriate prey
* Cheetah population density
* Presence and activity of other predators and conspecifics
* Social, health and reproductive status (single or in a group; lone after losing coalition-mate, mothers with cubs, couples/groups in courtship)
* Age
* Personal experience and success
* Human activity in the area, the level of disturbance (tourists following animals during hunting or raising cubs etc.) and tolerance towards humans (tourists, and herders with livestock, locals on foot and on transport)
* Conservation status of the area (protected/not protected)

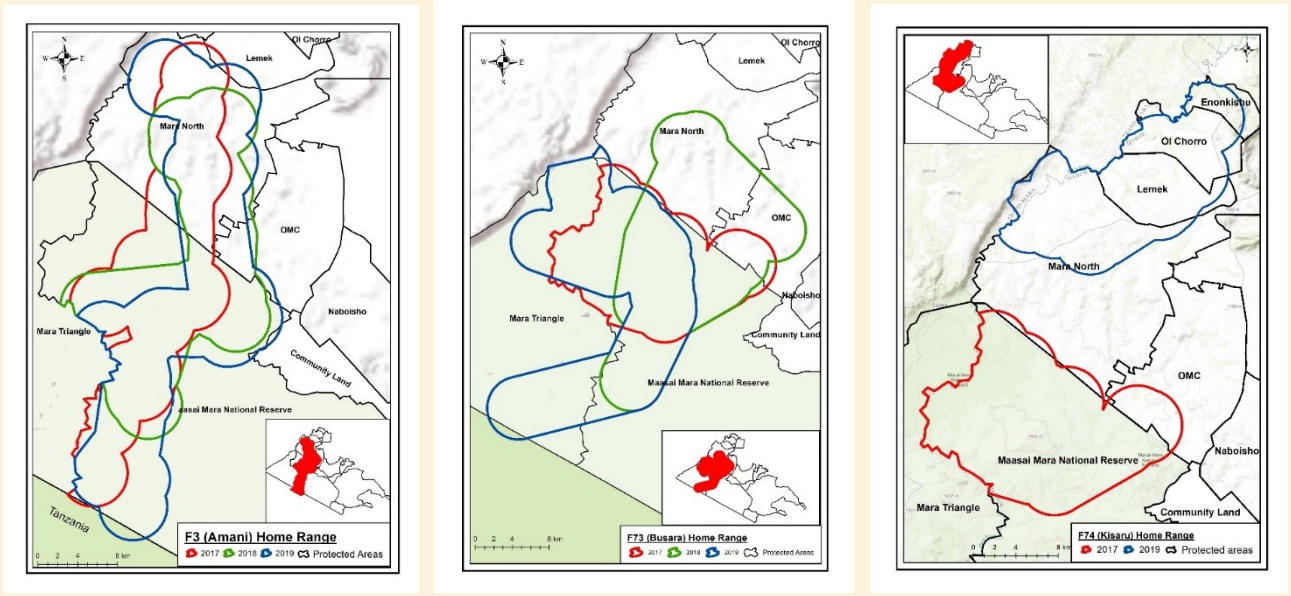
Unlike males, female cheetahs do not defend their territories and avoid interactions with conspecifics, especially when raise cubs and when not in estrus. Therefore, their areas where females roam, can be defined as home ranges. It is important to note, that in presence of large

coalitions, members of smaller coalitions also do not defend their territories and do not mark objects (as indicator of their presence) in the areas where their home ranges overlap.

Size of annual home range in the Mara Ecosystem in different individuals ranges from 215 km² to 889 km², wherein overall home range determined for three years (2017, 2018 and 2019) in different individuals ranges from 485 km² to 933 km², with similar mean for males and females - 688 km² (n=4) and 644 km² (n=5) respectively. Annual home ranges of different cheetahs differ in size from one year to the next on average by 30%.

Dispersing adolescents, females with cubs, males who lost their coalition-mate, or "floaters" engage in wide-ranging behaviour, which may temporarily expand the boundaries of their ranges. For example, when young males formed a coalition (Tano Bora) after they had dispersed from their mothers and started exploring areas, their home range in the first year was larger than in next year - 749 km² in 2017 and 432 km² in 2018. Numerous studies have shown that cheetah home ranges can be similar in size for males and females and overlap in areas where prey are non-migratory (*Broomhall et al. 2003*). In contrast, where ungulate prey are migratory, home ranges are comparatively larger with males forming small territories and females exhibiting roving behaviors (*Caro 1994*). Although there is a seasonal influx of migrant herbivores into the MMNR each year (*Bell 1971; Sinclair and Norton-Griffiths 1995; Stelfox et al. 1986*), resident herbivores are also present year-round in relatively high numbers. In addition, cheetah space use has been shown to be highly concentrated within a small portion of the home range (~14% of the total area), even for individuals that otherwise occupy large areas (Marker et al. 2008).

In the Mara, home ranges for males and females have similar sizes, icreasing and decreasing in differet years. For example, home range of the male **Martin** (M5) in 2018 was 372 km² and female **Amani** (F3) – 350 km²; home range of the male **Olchorre** (M81) in 2018 was 646 km², and home range of female **Imani** (F50) in 2019 was 766 km². Large home ranges might be a result of low carrying capacity of the area, e.g. high density of other predators (lions and hyenas – major cheetah competitors); increased density of cheetahs; low prey availability; human-wildlife conflict and habitat perturbation, such as bush encroachment etc.). Often, cheetahs will temporarily venture outside their normal home range due to natural or anthropogenic disturbances or for exploratory purposes (Laver, 2005; Marker, 2002), which also contributes to extension of the home range.



Pic 9-11. Home ranges of the mother and two independent cubs females

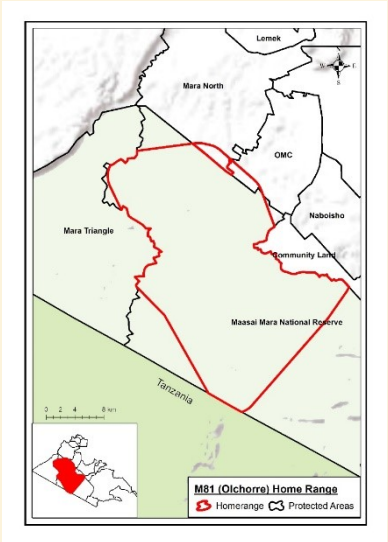
Females roam alone or with their dependent offspring in large overlapping home ranges (Serengeti NP: 833 km2; n = 19; east-central Namibia: 857 km2, n = 20, north-central Namibia: 1836 km2, n = 15; Marker et al., 2008), primarily overlapping with related individuals. Females without offspring have bigger home ranger than when they raise cubs. When dependent cubs become older, home ranges of females increase. For example, when in 2017 two sisters **Kisaru** (F74) and **Busara** (F73)

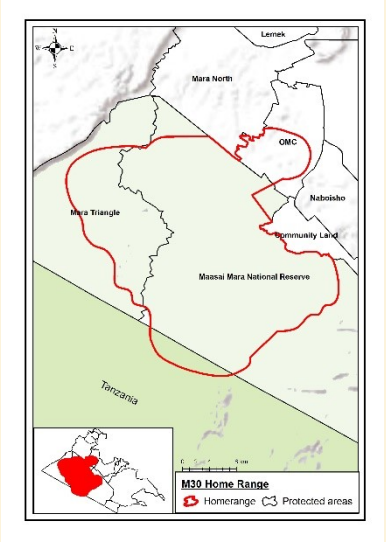
were roaming together after their mother **Amani** (F3) had left them, their home range was 265 km². In 2018-2019, when Kisaru was raising 6 cubs, her home range decreased to 215 km², while her sister have not raised any litter, and her home range became bigger and covered 379 km² in 2018 and 376 km² in 2019 (Pic.9-11).

All females, who have been visiting the Reserve as a part of their mothers' home range, also bring their own offspring to the Reserve at least once, and some – for several times. Thus, sizes of their home ranges do not vary much from year to year. For example, **Amani** (F3) home range in 2017, when she lost at least two litters in the reserve and in the Mara North Conservancy, was 419 km². In 2018 and in 2019, she was raising a litter of three cubs, and her home ranges were 350 km² and 461 km² respectively. In 2018 Amani with offspring spent most of the time in the remote conservancies, and in 2019, she brought her sub-adult cubs to the Reserve, which contributed to increasing her home range. Also, female can increase home range after losing cubs and start travelling. For example, home range of **Imani** (F50) in 2017 was 335.5 km², in 2018, after she lost cubs increased it to 548 km², and in 2019 – to 766 km².

Female cheetahs decrease their home ranges when get older and fail raising cubs for several years. For example, female **Nora** (F42) in 2017 and 2018 had 413 and 533 km² respectively and in 2019, when turned seven years, decreased her home range to 258 km².

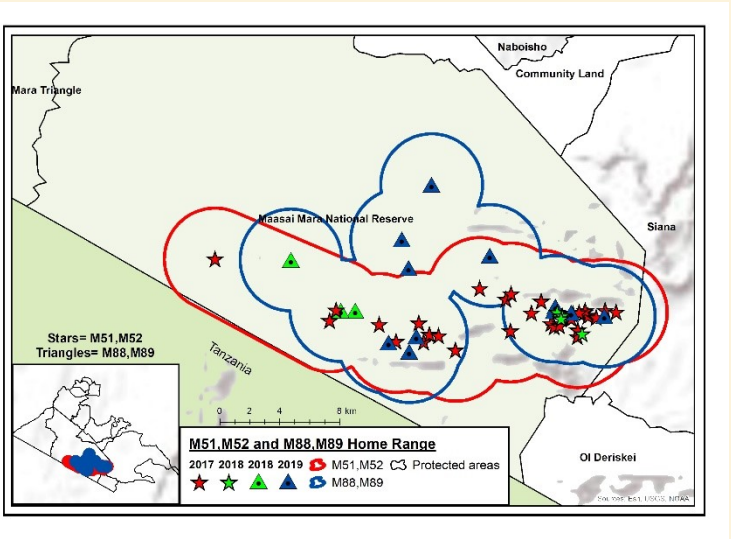
At independence, individuals seek to establish their own home ranges; young females remain in proximity to their maternal range, whereas young males have been known to disperse up to 200 km from their natal range (Marker et al., 2008a). In the Mara, home ranges of family members (mother and offspring after reaching independence) overlap. Thus, males have high chances to meet their littermates females and also elder sisters from the previous litters. If female in estrus, such encounter can lead to inbreeding. For example, in 2018, male **Hodari** M30 (born in 2012) mated with his younger sister **Kisaru** (F74, born in 2016). As a single male, Hodari's home range – in 2017-2019, was 933 km², similar in size to the home range of his sister-littermate **Imani** (F50), whose home range in 2017-2019 was 889 km². Home range of another single male **Olchorre** (M81) in 2017-2019 since he lost his coalition-mate was smaller– 646 km² (Pic. 12,13)





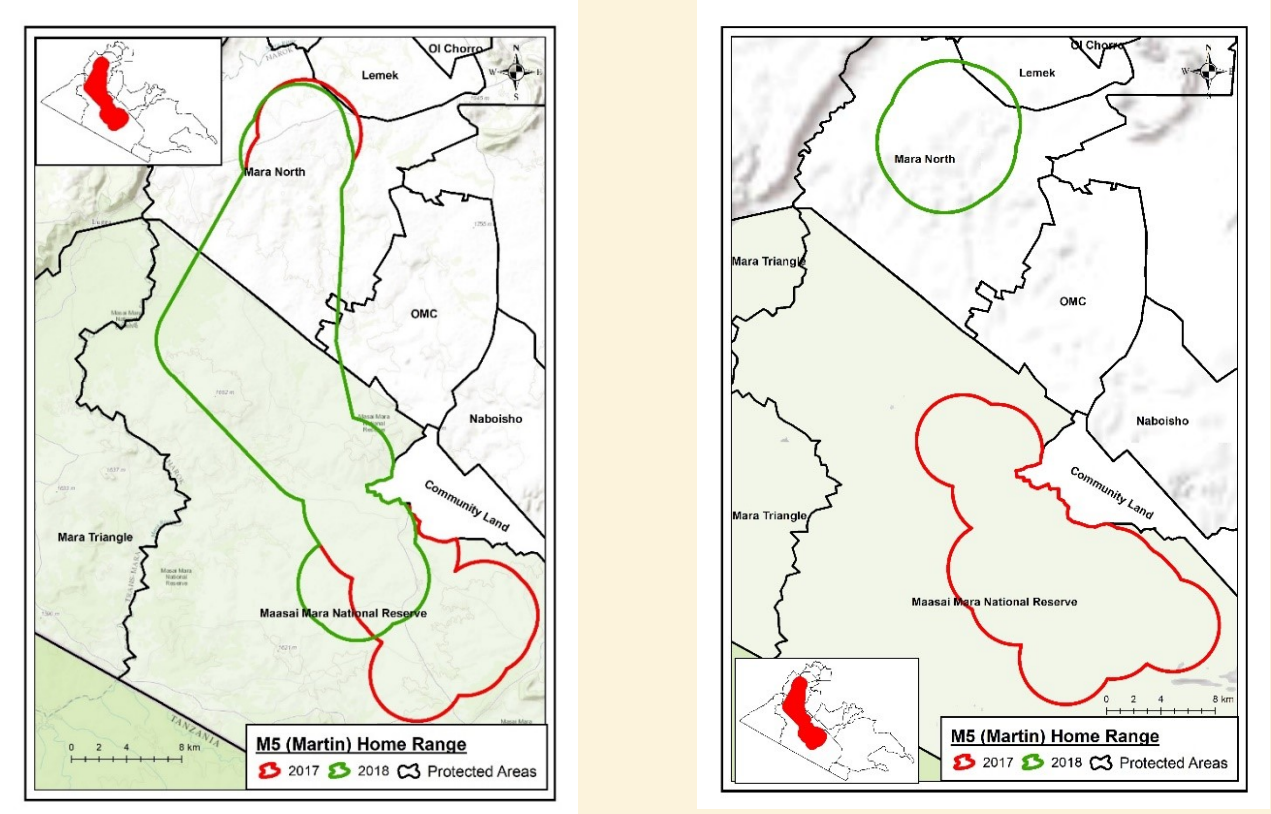
Pic 12,13 Home ranges of two single males

Since 2011, we have observed several singletons and male coalitions (including the largest cheetah coalitions of 5 males) in Area 3 (Pic.6-8). In 2011-2013, a male coalition of two males (M10 and M11) was dwelling in the area. When it disappeared in the middle of 2013, a single male **Bawa** (M15, Malaika's son) established his territory in that area. In 2016, another male coalition – **Mugi** and **Mukiri** (M44, M45) - Miale's sons took over, forcing **Bawa** moving deeper into the Serengeti. However, in the middle 2016, after losing his coalition-mate, **Mugi** ceded



Pic 14. Home ranges of two coalitions

his territory to another couple of young males – **Kisaru** (M51) and **Kingamu** (M52), also known as **Sopa Boys** (Pic.14). Unfortunately, **Kisaru** got an eye injury and since the middle 2018, has been roaming alone. From September 2018, a new coalition of two shy males **Olaretoni** and **Olanyuani** (M88, M89) appeared at the border of the Serengeti, and by April 2019 settled in Sopa, getting more tolerant to tour vehicles. Consequently, Kisaru had moved to Serengeti and have been visiting MMNR seldom. Home ranges of both coalitions (M51, M52 and M88, M89) at the Mara side are similar in size, and for a coalition of M51, M52 was 263 km² and for M88, M89 – 260 km². It is important to note that we determine only Kenyan part of the home range of both coalitions, which could cover large areas in Serengeti.

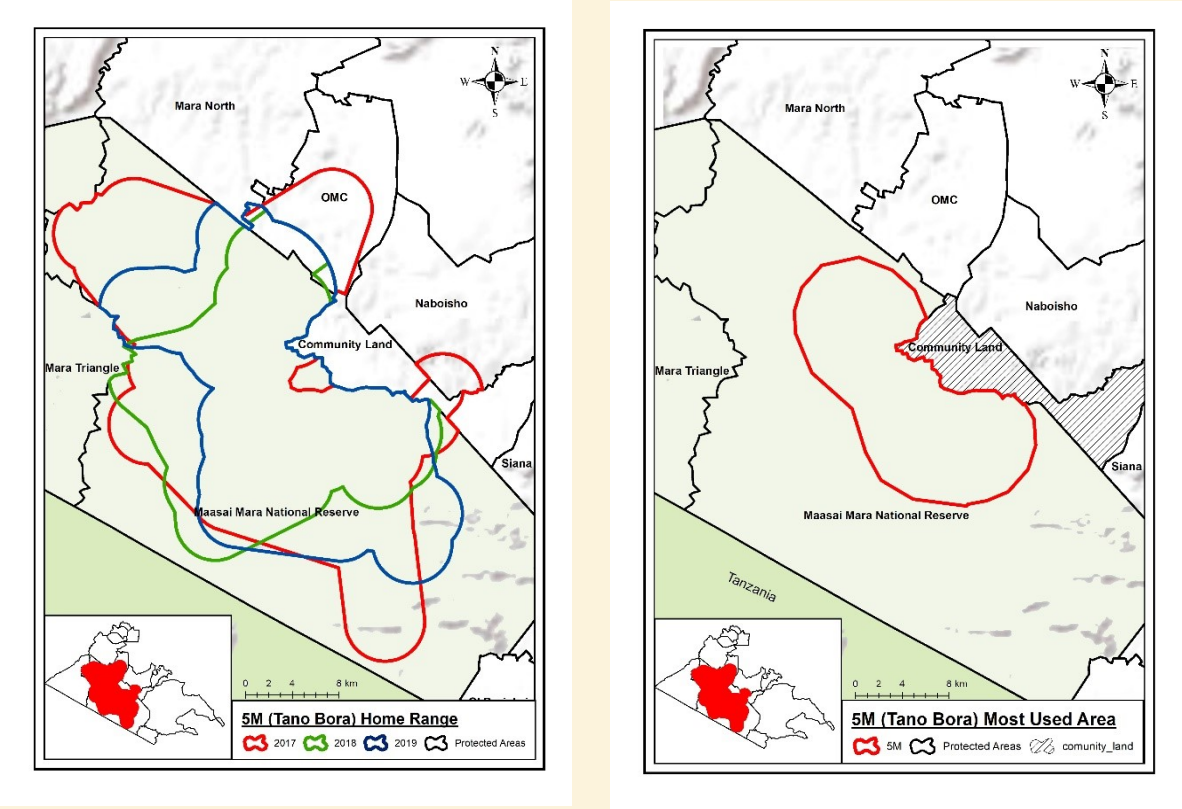


Pic 15,16 Home range of a single male Marin (M5) – calendar (left) and his territory within an actual year (right)

Some coalitions replace the others with time. **Martin** (M5) first was spotted in the Mara Triangle in early 2011 together with his brother, M4. They were named **Ooolollo Brothers**. By 2013, they have settled in the Reserve, replacing a coalition of three Honey Boys, two of which had been killed by lions. After Martin lost his brother in October 2015, he was dwelling in Area 2 of the MMNR until mid-October 2017, and then moved to the Mara North Conservancy. At that time, coalition of 5 males established their territory in that area. Moving to the North, where there were no any male coalition, was an adaptation strategy. In July 2018, Martin started moving towards the Reserve via Olare-Motorogi Conservancy. The reason for his movement could be establishing in his territory a new male coalition of two brothers – Kiraposhe's sons (Milele and Mbili). By the end July 2018, Martin arrived in Hammerkop area of the Reserve, from where he had left 10 months ago. At that time, there were 8 male cheetahs in the area, including a coalition of 5. Unfortunately, on 1st August we found Martin with injured haunch and 1/3 tail missing (see 4.2). He was treated by the Mara Mobile Vet Unit, but disappeared after several days. His home range in 2017 was 454,5 km² and in 2018 -372 km².

Tano Bora – a coalition of 5 males. The group of five young males came into the Reserve from the adjacent Naboisho Conservancy in the end of December 2016. In the beginning of 2016, we observed one of the males – **Olpadan** (M58) with his sister. Both siblings were very successful hunters, jointly bringing down adult Impala males. By November 2016, Olpadan had split with his

sister and started an independent life. By December 2016, he united with four males hence becoming a member of the largest cheetah male coalition ever observed in the Mara. Olpadan was a leader of a group for almost 3,5 years. In 2017, just after the coalition was formed, it's home range was the largers and covered 749 km². In 2018 it reduced to 433 km², and in 2019 was 506 km² (Pic.17). The overall size of their home range for three years covered 812 km² with the core zone in Area 2 of the Reserve, and the size of the territory, which males of this coalition have been patrolling, marking and defending regularly during the same period was 232 km² (Pic.18). Part of their territory was located in the closed areas (Pic.30), where males spend 30% of their time.

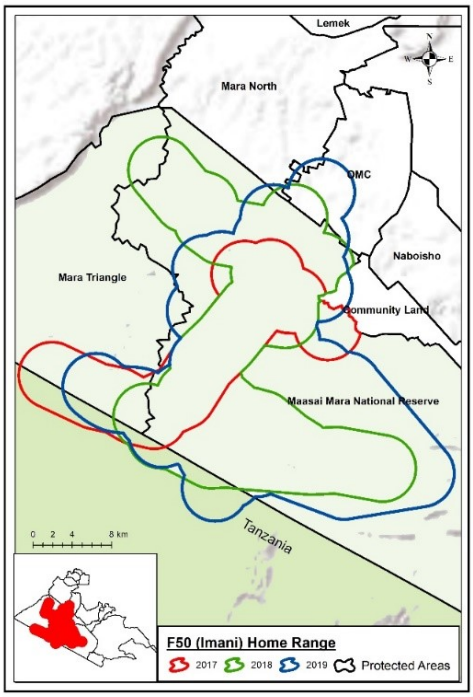


Pic 17-18 Home ranges and the territory of a coalition of five males Tano Bora

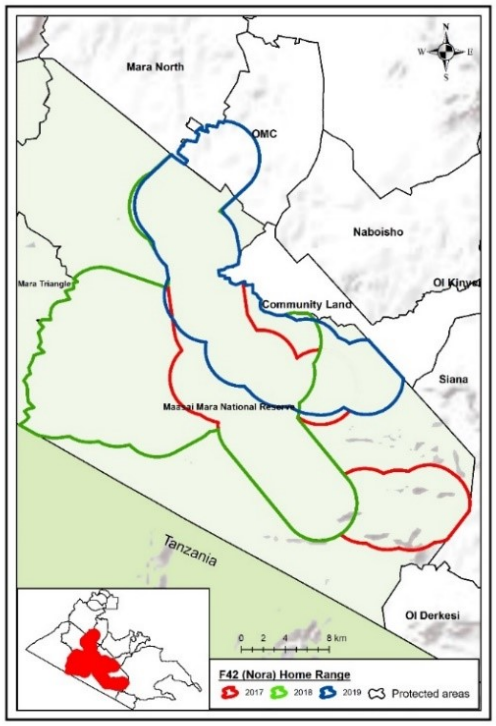
Our long-term data of distribution and movements of cheetahs in the Mara, collected for several years, reveals no significant trends in sizes of cheetah home ranges. In different cheetahs they change within a year and through years. When adolescents start independent life, their home ranges during the first several months larger than in the next year. However, with time the home range may change due to various factors and shrink or expand temporary. For example, home range of two sisters – Busara (F73) and Kisaru (F74) after separattion from the mother in July 2017 was 265 km², but after sisters split in January 2018, Kisaru settled in the remote conservancies, while Busara was roaming in the Reserve, adjacent conservancies and in the Mara Triangle. In 2018 and 2019, Kisaru was raising a litter of six cubs and her home range was much smaller (215 km²) than of Busara: 379 km² in 2018 and 376 km² in 2019. Their mother's (Amani) was raising a new litter since April 2017 and left her cubs in October 2019. Her home range in these years was 419 km² in 2017 and 350 km² in 2018, and increased in 2019 when she was taking cubs around, which possibly contributed to increasing the size of her home range.

It is important to indicate that sizes of home ranges are approximate because firstly, sizes calculated based on the GPS positions of cheetahs only when animals were available; secondly, cheetahs intensively move within Ecosystem throughout a year, and can temporary change area of habitat for remote area in the middle of the year. Thus, the territory that the cheetah used during the calendar year would exceed the size of the territory that the animal actually used. For example, when

coalition of 5 males (Tano Bora) started using the area in MMNR of a single male Martin (M5), the latter, moved to another area (Mara North Conservancy) and settled there for over 10 months. Martin moved to the remote conservancy in the middle of October 2017, and returned to his territory in the Reserve in the end of July 2018. Home range of Martin in 2017 was 455 km² and in 2018 – 373 km². However, tracking the male since he had left to the Mara North revealed that for 10 months his territory was 90,5 km², but once in 2018 another coalition settled in the Mara North, he started moving towards the Reserve, and his home range increased to 253 km². (Pic.16) Direct observations provide significant data on cheetah time budget, space use, activity and behavioral patterns, including territoriality. However, in unfenced biotopes, where animals move freely, finding them become challenging. Hence, determination of the home range become approximate.



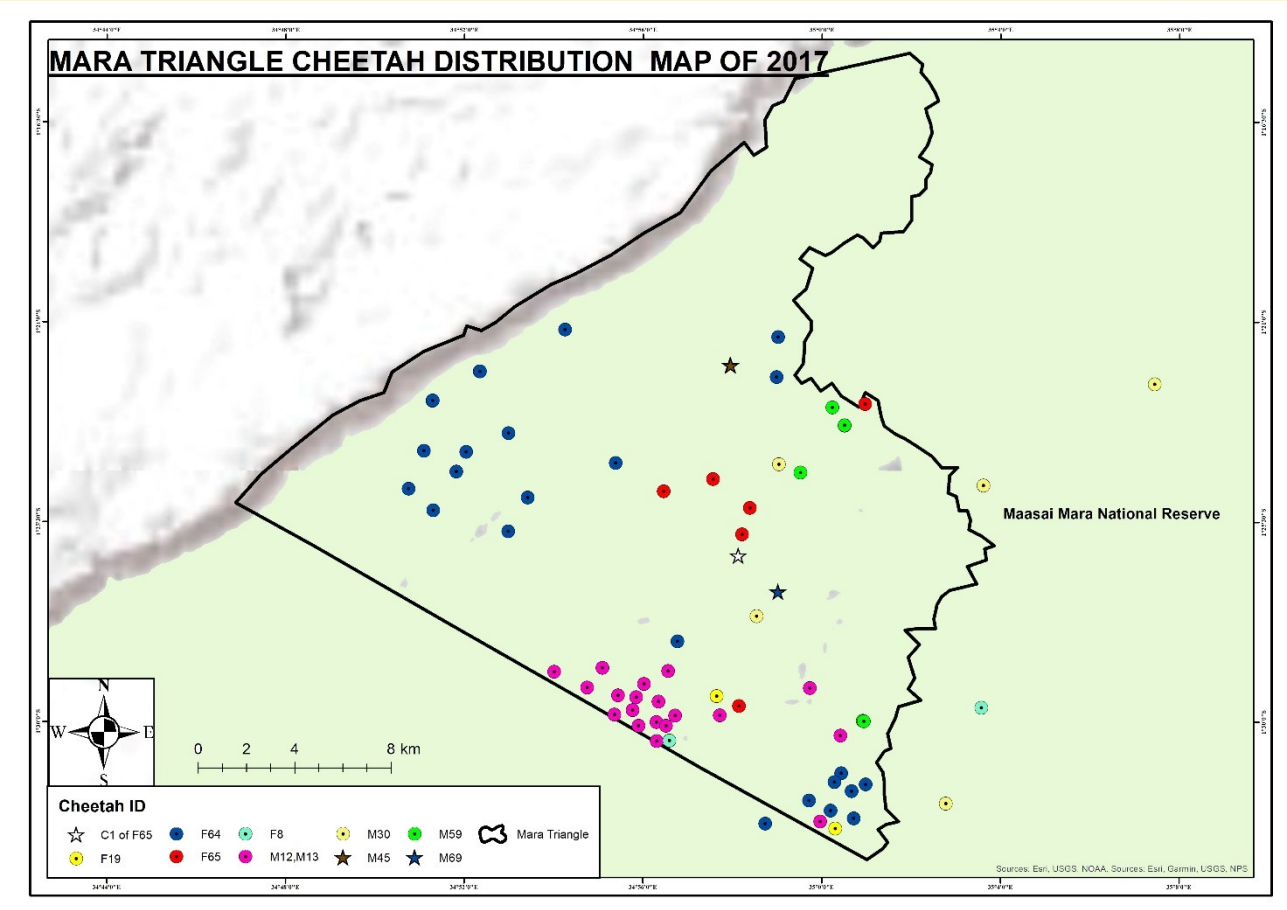
Pic.19 Home range of Imani (F50)



Pic.20 Home ranges of a single female

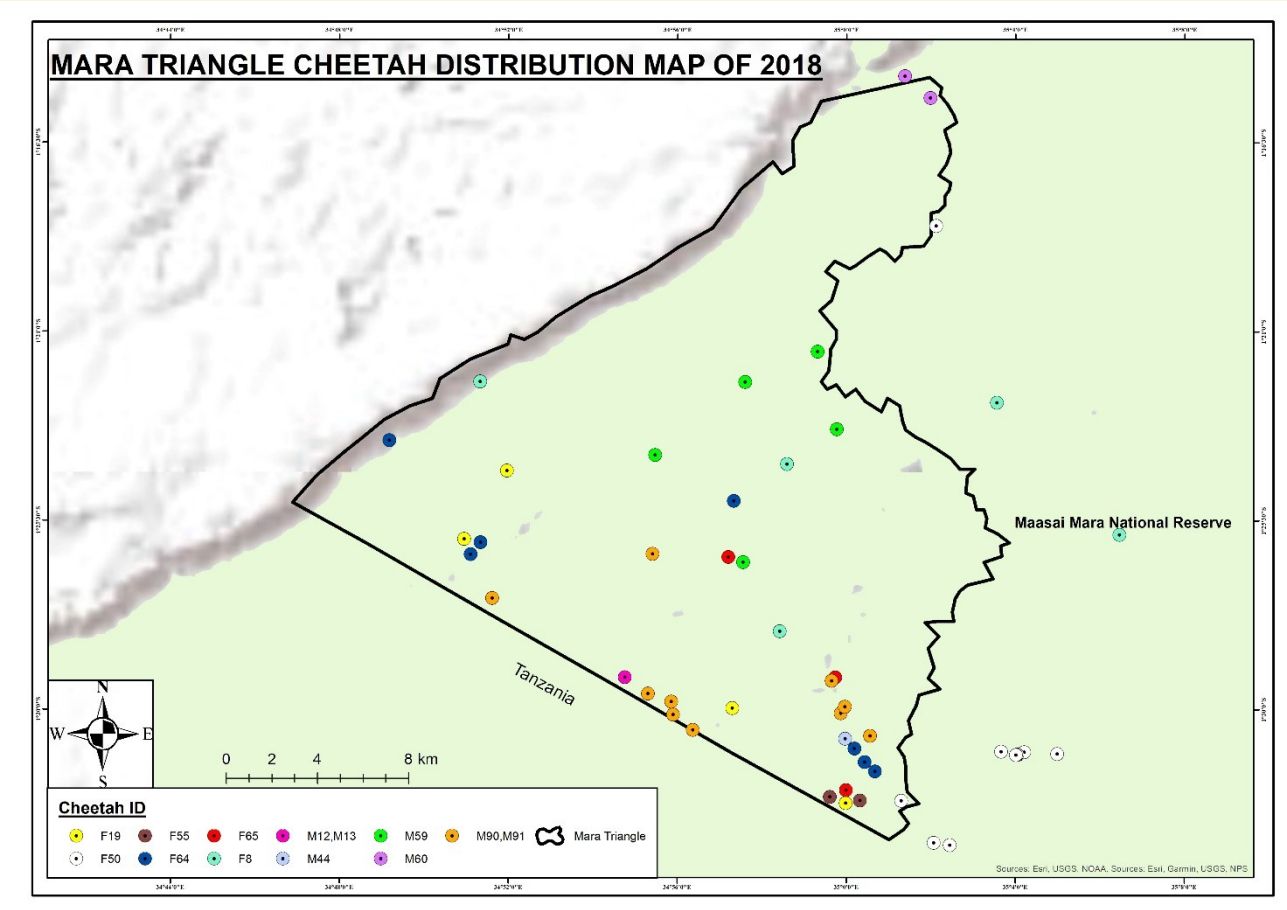
Taking in account the above conditions, radio collaring of a few individuals will provide only data on collared individuals, which cannot be extrapolated to the entire population. Although radio collars provide substantial data on cheetah movements, we should adhere to strict ethical considerations such as the impact of devices on animal behavior and wellbeing and external access to the data to prevent misuse (i.e. cyber poaching). Before deploying any device on cheetahs, researchers must anticipate the possibility of negative effects on the well-being of the study individuals including: numerous immobilizations; insecurity of drop-off mechanisms due to extra weight added to the collar and triggering prematurely or not at all; failure of the collar, and correlate it with the potential outcome of the proposed study. Taking in account vulnerability of the species, radio collar shall be used only if the risk from it will not exceed a significant contribution to the conservation of the species and that particular individual

1.9. Cheetahs of the Mara Triangle. In 2017, out of 63(32.31) adult cheetahs of the Mara, 10 (6.4) have been observed in the Mara Triangle. In 2018, out of 64(32.32) - 10(5.5) were in Triangle, in 2019, out of 71 (42.29), 10(5.5) were in Triangle. In 2017-2019, 16 different individuals – 9 males and 7 females have been seen in the Triangle, but their total number per year did not exceed ten, probably due to a limited carrying capacity of the area. Additionally to the counted wild cheetahs, two adolescent littermates (1.1) have been released in the Triangle in July 2019. After exploring different areas of the conservancy, they moved to the area at the Tanzanian border and spent significant time in the northern Serengeti. That also could be linked to the limited carrying capacity of the conservancy' territory.



Pic.21 Cheetah distribution on the Mara Triangle in 2017

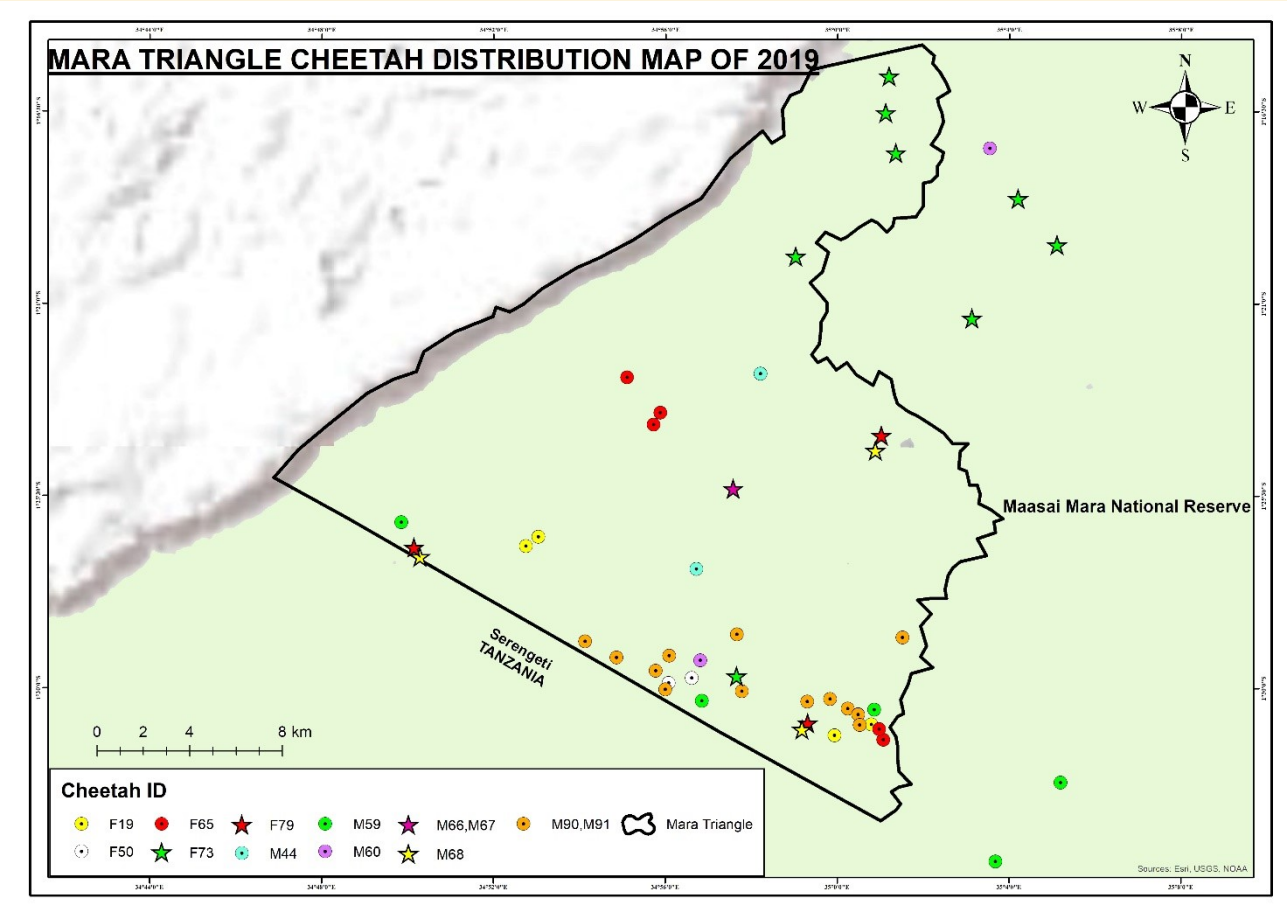
Apparently, the territory of the Triangle can sustain only one coalition of males. Coalition of two males – **Oloololo Brothers** (M4,M5) used Mara Triangle from early 2011 to 2013, when they moved to the Mara North Conservancy and later, to the Maasai Mara National Reserve. Early in 2013, a coalition of three males born in Naboisho Consevancy, later called **Border Boys** (M12,M13,M14), came to the Triangle from Ol Kinyei Conservancy. By March 2014, they lost one member (M14). The Border Boys have been dominating large area of the Mara Triangle from 2013 till February 2018, when they were spotted last time. They were replaced by a coalition of two males named **Lemai Boys** (M90,M91). When these males were spotted in the Triangle at the Tanzanian border first, in February 2016, there coalition consisted of three shy males. By the time they started visiting Triangle more often, they have been often confused for the Border Boys due to the similar size and good physical condition. Lemai Boys dominate Tanzanian border area since August 2018 to the end of 2019, until one of them got lost While coalition held particular territory close to the Tanzanian border, single males - **Serena Male** (M59) and **Olope** (M60) covered the entire territory of the Triangle. Obviously, both strategies give opportunity for all males meet with different females, who roam the Triangle. Interestingly, that in addition to **Rani** (F8), who was born in 2008 in the Triangle and over the past two years has become a frequent visitor in the Triangle, in March 2018, a 5 year old female **Karembo** (F55) visited the Triangle. She was born from Amani (F3) in the Reserve but raised in the Mara North Conservancy. Amani's area of operation covers Reserve from the Sand River through Lookout area, across Talek River to Rhino Ridge and through Olare Orok to the Mara North Conservancy (Pic.9). Unlike other females, who typically stay within their mother's territories, Karembo moved to the remote areas and spends most of the time in the Serengeti with seldom visits to the Reserve.



Pic.22 Cheetah distribution in the Mara Triangle in 2018

In 2017 and 2018, she gave birth in the Reserve and lost both litters within the first three months. In 2018, she visited Triangle for the first time. In 2019, 4 other cheetahs – two males **Mugi** (M44) and **Olope** (M60) and two females – **Imani** (F50) and **Busara** (F73) started exploring the territory of the Mara Triangle. They all crossed the Mara River in different points from the Reserve. Lowering the water level in the rivers facilitates crossing. For Imani it was not the first visit. In early October 2013, three months after Anani had left her cubs (Imani, Hodari and his brother), siblings crossed the Mara River and started exploring the Triangle. Since that time, **Hodari** (M30) used to visit Triangle once in a few months, while Imani was roaming in the Reserve, surrounding Conservancies and northern part of Serengeti.

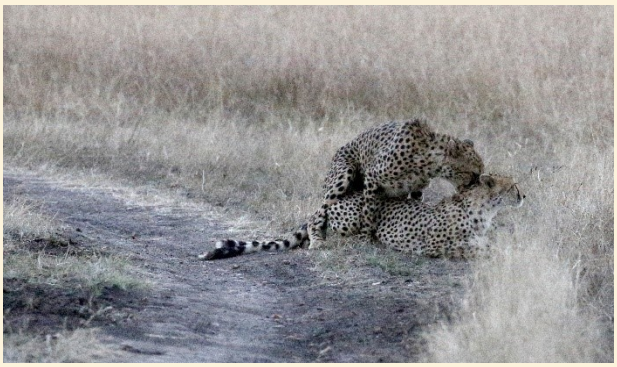
One of the reason for cheetahs travelling to the Triangle is a competition with conspecifics for available resources. The largest cheetah male coalition in Mara, the Tano Bora (Fast Five), expels singletons from their territories, limiting their ability to hunt and mate successfully. Perhaps that is why single males and females begin to look for new partners outside Tano Bora's area of control. For example, in the end of January 2019, we observed Imani (daughter of Amani, born in 2012) in the Triangle with two **Lemai Boys** (M90,M91), and in March 2019, another adult female Busara (daughter of Amani, born in 2016) have been observed actively exploring the Triangle for two weeks, including the top of the Escarpment. Five-year old male **Mugi** (Miale's son born in 2014) crossed to the Mara Triangle on 6 March 2019, in 10 days after been attacked by one male of the **Tano Bora** coalition in the Reserve. Although brothers known to form life-time unions, Mugi (M44) separated from his brother **Mukiri** (M45) in 2017 (the reason remains unknown). **Mukiri** (M45) was subsequently seen in the Triangle until the end of 2017.



Pic.23 Cheetah distribution in the Mara Triangle in 2019

1.10. Cheetah movements. Cheetahs intensively use roads at any time of the day not only for walking, but also for resting, feeding, following in courtship and even mating. During light hours, resting individual or group sometimes cause a traffic jam, but playing on road cubs can cause a road accident. The behavior of animals is unpredictable. Some cheetah mothers settle for rest at the edge, where their cubs become more vulnerable. In addition, the young often start catch-up games and run from one side to the other ignoring sounds of approaching vehicles. At twilight hours, when visitors rush to the gates of the park, cheetahs' games on roads especially on the bends can cost them their lives. When giving talks and in the field, we urge guides not to overspeed and pay attention to the roadsides - cubs can jump out onto the roadway at any moment.

Pic. 24,25 Cheetahs travel by roads

Pic.26,27 Cheetah coalition rests (left) and mate (right) on the road

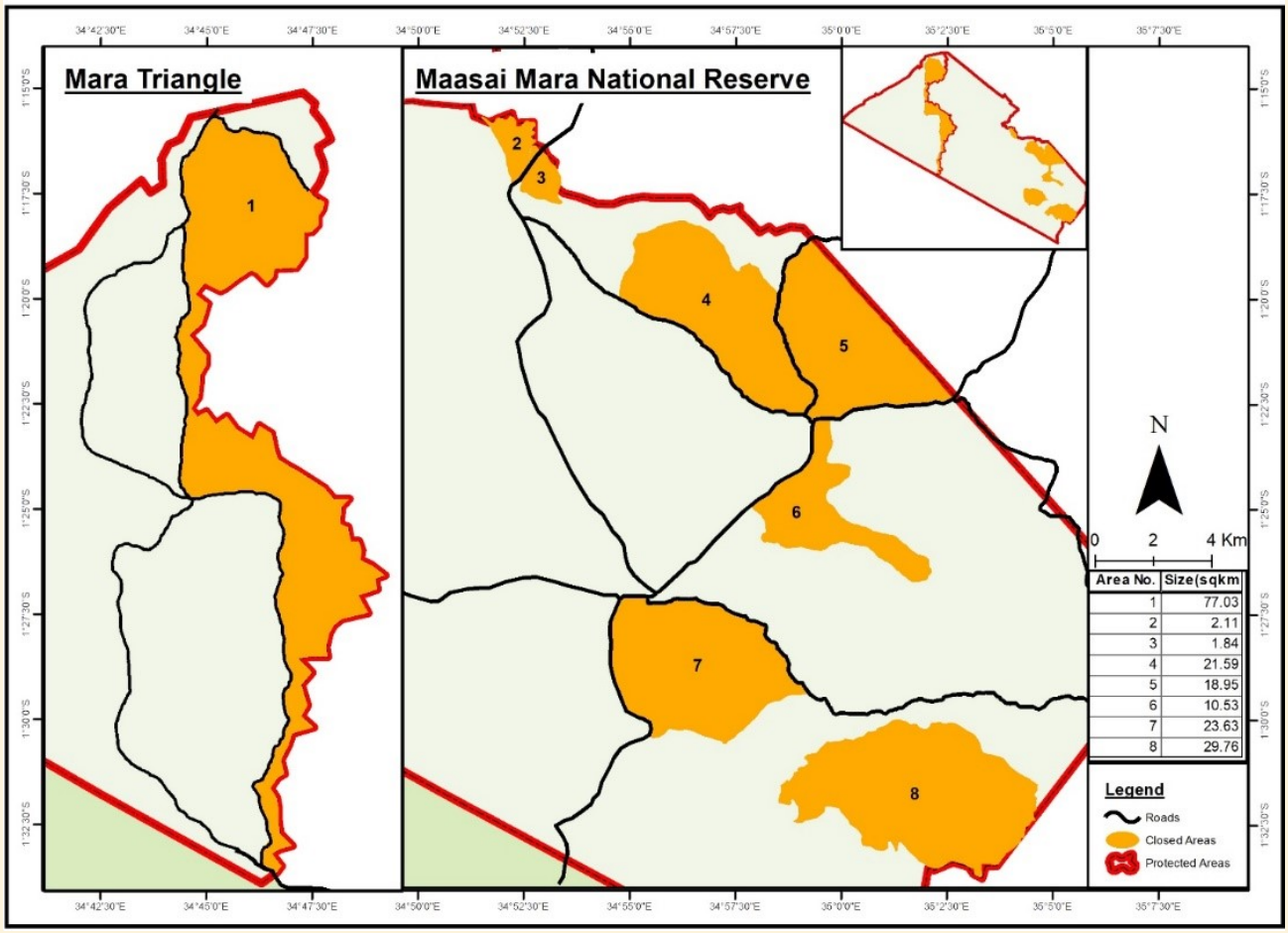
Pic. 28 Female rests on the roadside while her cub is at the verge (below)

Pic.29 Female (sitting) and three cubs playing on the road in the evening twilight

1.11. Closed areas of the Reserve – refugee zones. Certain parts of the Maasai Mara National Reserve and The Mara Triangle (The Mara Conservancy) are permanently closed to tour vehicles. The size of closed areas in the Mara Triangle is 14% of its territory, and in the Reserve – 11% of its territory (Pic.30). These areas play significant role in preserving wildlife, especially vulnerable species like cheetahs. Closed areas provide suitable environment with variety of the prey species and absence of disturbance from the visitors to:

* New cheetahs from outside the Mara, e.g. from unprotected areas and neighboring Serengeti NP, who are extremely shy and do not let cars approach closer than 100 meters. Such animals use closed areas as refugee zones, where they hide while exploring the Mara and develop tolerance to tour vehicles;
* Females, who are raising small cubs. Before delivery, females search for secure areas and give birth in hard-to-reach places: dense bushland, ravines or rocky areas with shrubs, where vehicles cannot reach the den. Such areas are naturally closed for visitors, hence excluding human interference and disturbance of females and offspring. Female also can give birth in the open field in the patch of tall grass, but in places remote from the car tracks. Some females setup dens in the savannas of closed areas. All cheetah females who raise cubs in the Reserve, actively use closed areas. When heading for hunt, females nurse cubs and leave them sometimes in the patch of grass in the open field. Absence of cars excludes the possibility that the car will wake up the cubs by turning on the ignition or inadvertently run over them.
* Cheetahs who are experiencing increased attention from tourists (i.e. famous individuals) and fail resting and/or hunting because followed throughout a day by numerous tour vehicles. Single individuals and coalitions actively use closed areas for resting and hunting when followed by the vehicles.

Therefore these areas in the Reserve play a role of refugee zones, and it is important to keep them closed to public permanently.



Pic.30 Closed areas of the Mara Triangle (left) and MMNR (right)

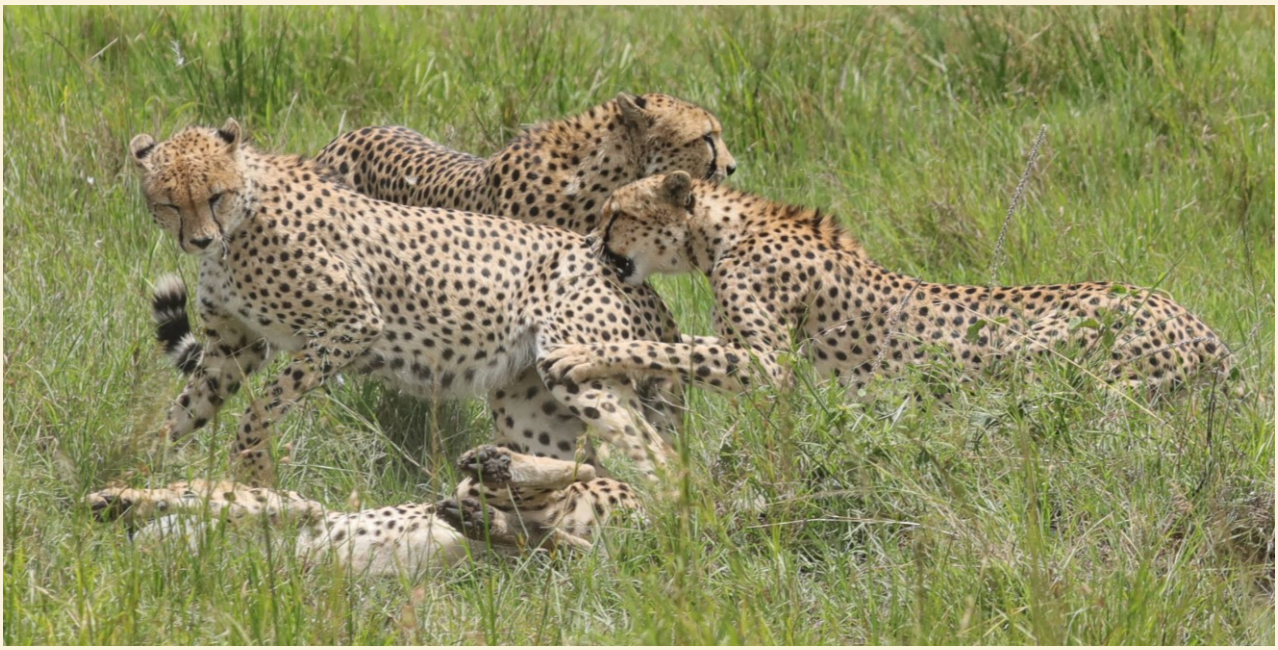
2. FIELD ACTIVITIES AND BEHAVIORAL OBSERVATIONS

In 2018, the research team spent in the field 292 days (1545 hours) and covered 19,198 km.
In 2019, we spent in the field 287 days (1970 hours) and covered 19,541 km. Field work included scouting for cheetahs and cheetah behaviour observations. In 2018, we collected behavioral data on 55 adult cheetahs (28 males and 27 females with and without cubs) and 2019 - on 55 (34 males and 21 females with and without cubs) adult cheetahs in the Reserve and surrounding Conservances. Data on the most significant events affecting survival of the species, as well as behavioral adaptations contributing to the survival of the groups and individuals, and data on new cheetah observed in the Mara, sets out below.

3. CHEETAH BIOLOGY and BEHAVIOR

Pic.31 Two males fight

3.1. Social interactions within male coalitions. Membership in a coalition provides cheetah males with significant benefits. Social animals in the group have a hierarchy with a linear or near linear ranking and with expressed leadership of one of the members. In well-maintained coalitions, which consist of brothers-littermates, males share responsibilities, and the level of affiliative behaviors is high while the level of aggression between members is low. However, by living in a group with unrelated members, cheetah males meet challenges. In such groups, leadership is held by brothers, but unrelated males compete to earn a higher rank. In the Tano Bora coalition, one male has no relatives. In most cases, the dominance hierarchy is relatively stable and members usually step aside when confronted by the leader. However, if the leader weakened by injury, disease, or senility, the shift may occur and the individual with the highest rank will move downward to the lowest position. In **Tano Bora** cheetah male coalition, which consists of 5 males, **Olpadan** was the group leader for 2 years since the formation of the coalition in December 2016. He started losing his leading position in the beginning of 2019, and completely lost it on 18 March, after the surgery when one of his injured testicles was removed.



Pic.32 Member of a coalition Winda attacks the leader Olpadan

Within 4 months prior to the injury, he was attacked by other members several times. In two cases, the fight was conducted during the courtship with different females. During intraspecific fights, cheetah males target anogenital area of rivals. There are known cases when males have bitten and cut off the testicles of intruders, and often a fight led to the death of a wounded male. We have observed such fights between members of this coalition, when two males – **Winda** and **Leboo** were attacking their leader **Olpadan**. Most likely, their fight led to **Olpadan's** testicle injury in March 2019. Dr. Limo (KWS, David Sheldrick Foundation) performed a surgery and removed injured and infected testicle. The male recovered well from anesthesia and joined his coalition-mates. The meeting was not friendly, two males rushed to the cured male, and one of them attacked him. The ex-leader had to act as a submissive member in order to reduce aggression. After a 6-hour rest in the shade, all the males went to the Talek River and crossed it immediately after sunset.

Pic.33. Olpadan (the leader of a coalition) attacked by the coalition-mates (above) and Pic.35 Surgery orchiectomy (below)

After the surgery, the leadership has been shared mostly by **Olarishani, Winda** and **Olonyok**. Being the lowest-ranking male in the group, **Olpadan** often followed the group at the end of the chain and was the last to start eating. Interestingly, **Olonyok**, whom **Olpadan** had attacked before, demonstrating reverse aggression, in 2019, was the one who allows **Olpadan** eating next to him and who was engaged with ex-leader in mutual grooming after eating.

Pic.36 Winda and Olarishani (left) approaching Olpadan (right) after the surgery

Pic.37 Olpadan approaching his coalition–mates.

3.2. Social interactions between coalitions. Cheetah social life is complex – unrelated males form alliances and keep bonds as long as it benefits all members of a group. Probably, under certain circumstances, one of the members may start looking for the alternative group to join. In 2019, we observed interesting behavior of a male who was trying to join unrelated male coalition. On 19 February, on their way to Talek river, **Tano Bora** (coalition of 5 males) spotted two males: **Mkali** and **Mwanga**. Fortunately enough, two males spotted the biggest Mara cheetah coalition and rushed towards the river, followed by five sprinters. For some time, all 7 were making sounds indicating aggressive and defensive behaviors deep inside the bushes on the slope of the river. After a few hours, only three individuals remained on the spot: **Mkali, Mwanga** and **Olpadan** (ex-leader of the Tano Bora coalition), while four others left. For several hours, **Olpadan** was following two coalition-mates without any attempt to harm them, but trying to sniff young males and rest nearby (Pic.36). In return, two males displayed defensive behaviors, and often **Olpadan** was displaying submissive behavior (sat with the back towards the males). Probably, after losing his leading position among his group members, he attempted to join younger males. Next morning, **Mkali** was in 1.5 km, calling for his coalition-mate. At the same time, **Olpadan** was calling from under the same tree where **Mkali** and **Mwanga** were resting the previous day. When in the afternoon three out of 5 males (**Leboo, Winda** and **Olonyok**) appeared in the area, **Olpadan** did not attempt to approach them. Sitting in the shade, he was watching them and calling several times. None of the males responded. In over an hour, after unsuccessful hunt and joint rest in the bush in 300m, they slowly approached **Olpadan**, who was not confident in the beginning. It is interesting, that if one of the males leaved coalition for a day or two and then returned to the group, **Olpadan** met him aggressively. This time, three males accepted him peacefully. By the evening of 20 February, two males were still missing – **Olarishani** from the Tano Bora coalition and **Mkali** – coalition-mate of **Mwanga.** The latter re-united with his coalition-mate next day.

Pic.38. Olpadan (waling) approaches two males from another coalition

3.3. Breeding Behavior.

3.3.1. Courtship with a single female. Cheetah males and females' territories overlap, allowing individuals meeting for courtship. Cheetahs in heat cover vast areas leaving scent marks on the elevated objects for the possible partners. These "messages" pass information about their reproductive status and encourage males to look for the mate if the female is in estrus. If female in heat jumps on the roof of a tour vehicle and leaves the scent mark, it will never reach males. This is one of the reasons to prevent cheetahs climbing vehicles.

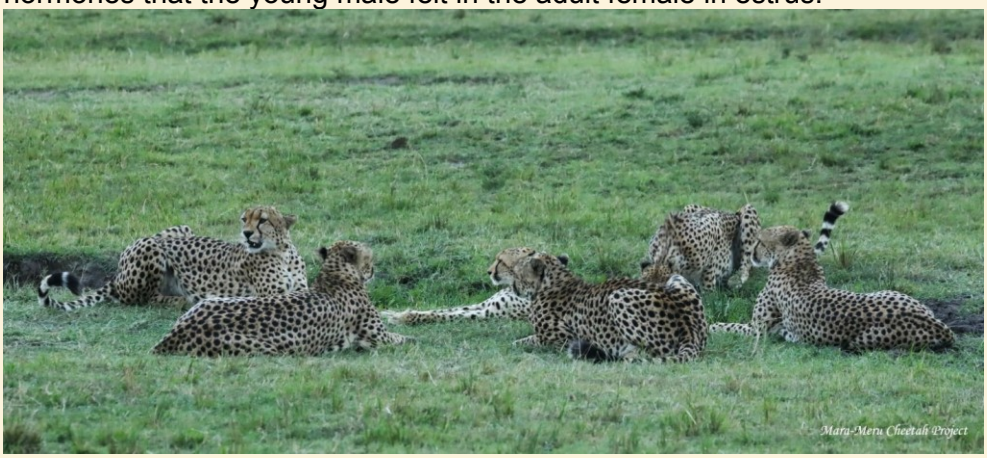
Pic.39 Lemai Boys following female Imani (standing in the middle) and chasing Olope (below)

Encounters with the males induce estrus in cheetah females, and even if the first encounter would not end up with mating, the next one might be successful for the partners. Sometimes, males in a coalition compete for a female in oestrus, and one of them dominates getting opportunity to mate.

In the end of January 2019, two **Lemai Boys** encountered Imani, who had crossed the river to the Triangle side for the first time since October 2013. Males were holding Imani trapped for two days. It is not known if they mated with Imani, but if she was not in heat at that time, she might have come into estrus soon or was in estrus before meeting a coalition and therefore mated with another male – **Olope**, whose territory covers a part of the Reserve and the Triangle. The morning female escaped from the male coalition, **Olope** was running feverishly at the same area calling intensively until he attracted attention of **Lemal Boys**. After chasing him far away, they started marking trees indicating their presence in the territory they control. Behavior of **Olope** could indicate that he had met Imani and possibly had mated with her and then lost her or he found her scent marks and was looking for her. As Imani was not seen with cubs this year, it is impossible to say if any mating occurred in January 2019.

Pic.40 Lemai Boys)one featured on the right) chasing Olope (left)

3.3.2. Courtship with a female with sub-adult cubs. Females with sub-adult cubs come into estrus and can mate with a single male or with multiple partners. Cheetah females are induced ovulators, i.e. they need external incentive to stimulate estrus. Meeting the male conspecifics and their interest is one of the strongest stimuli. Amani – the most successful cheetah female in the Mara has been raising the third litter in the Mara North and Lemek conservancies. In order to acquaint her cubs with different types of environments, prey and competitor species, Amani takes each litter through the Ecosystem, including the Maasai Mara National Reserve. In the beginning of September of 2019, **Amani** (F3) brought her thee cubs into the reserve for several days, and then appeared again in the middle of September. At that time, she came across the male coalition **Tano Bora**, who have been holding her hostage for three days. Amani's cubs were hunting in 1-2 kilometers. Shortly before noon on the third day, when the males have lost interest in the female, and one by one left her to hunt, Amani slipped away and began to search for her offspring, calling them. She went to the area where she had last seen them. Seven hours later, she finally teamed up with her cubs. The male cub was keep trying to mount the mother a few times like cubs act when meeting their lost siblings. This behavior could be triggered by the release of hormones that the young male felt in the adult female in estrus.



Pic.41 Two of the Tano Bora males near female Amani (above)

Pic.42 Tano Bora males lie around Amani

3.3.3. Mating behavior. To avoid competition for females, males in coalitions sometimes split, and by that, increase chances for successful mating. Some cheetahs demonstrate a preference of partners for mating. For example, **Leboo** – a male of the **Tano Bora** male coalition, not for the first time left the group while courting **Miale**. Usually, after spending two days with the female, he rejoined the group. Males in coalitions do not stay together all the time; they might split for a few hours or days. There are a several reasons for that: simultaneous hunting on different prey, especially in the areas with large hyena numbers (in case of one kill taken by hyena, coalition-mates can feed on the other one); attack of other carnivores, which separate males from each other, and courtship behavior. The latter became one of the most common reasons for splitting of the **Tano Bora** males. More often, it was **Olonyok**, who left the others, but in 2019, **Winda** joined him. Males hunted and rested together, and after the mission was over (or was not successful), they started looking for the other members of a coalition. In the beginning of September 2019, we observed two males – **Winda** and **Olonyok**, reuniting with the other three members: **Olpadan, Leboo** and **Olarishani.** The two travelers had to cross the Talek River, which was full, so sometimes males completely disappeared under the wave. **Olpadan** met **Olonyok** with an attack on the other shore, as he commonly used to.

Pic.43. Male Leboo (M70) mating with Miale (F7) on 20 October 2019

Frequently encountered mating partners know each other, because their home ranges overlap. In the Maasai-Mara NR, both sexes visit hotspots, where they explore and leave scent-marks on the certain trees and elevated soil structures (murrams). Males check such places regularly, while females in heat visit them occasionally and stay for 3-4 days at these areas. During this time coalition-mates sometimes split up and one or two members follow a female for 2-3 days depending on her receptivity, and then re-unite with their coalition. It is extremely difficult to witness mating as cheetahs are shy and although they display courtship behavior during the day time, the actual mating takes place at night. Since 2011, we have witnessed only five cases of actual mating during the light hours documented by photos and video. Interestingly, that each member of the Tano Bora coalition have been documented mating with different females: Olpadan with Rani, Olarishani with Nora, Leboo with Miale, Olonyok with Nashipai.

3.4. Encounters of females with cubs and males. Raising cubs is not an easy task for cheetah females – they have to regularly hunt and feed the young, train them to hunt and protect their prey on their own. And most importantly, females have to protect their cubs from various predators, including conspecifics. There are cases when males not only attack females, but also kill their offspring. Mating with several males reduces the risk of male killing young during unexpected encounters of partners.

Pic.44. Four males of Tano Bora with Nora (left) December 2017

On 19th December 2017 in the Maasai Mara National Reserve 4 males of Tano Bora a coalition of 5, encountered a female **Nora**, and one male **Olarishani** used his chance when other members went for hunting and started copulation. Other three males returned to the spot and started mounting the mating couple (Pic.44). In 14 months, on 25 February 2019, Tano Bora encountered Nora with her single two-month-old female cub. Although the males attacked Nora, they did not touch her cub, who was defending herself from approaching males by howling loudly, hissing and growling at them. After investigating reproductive status of the female, all males lost interest and left her. Most likely, mating with one male and attempts of other coalition members to mount her (but in fact mounting another male), helped prevent an attack on the cub.

Pic 45 Tano Bora males with Nora and her cub on 25 February 2019

The same case was observed with another female – Rani, who mated with one of the Tano Bora male (Olpadan) while two more males were making attempts to mount her on 4 March 2018. In 15 months, on 21 June 2019, all Tano Bora coalition encountered Rani with her 4 months old single cub. Males were interested in the female and did not attack the cub, who was making loud sounds.


Pic.46,47 Three males of Tano Bora surround Nora (sits) and one male approaches her cub

3.5. Cheetah lairs. Females give birth in the patches of grass in savanna, under bushes in the rocky areas or in the bushland, and in ravines. If the lair found by guides/rangers in the area, which is accessible by tour vehicles, we close the area together with the County rangers with warning road posts «AREA CLOSED» and «TRACK CLOSED». When necessary, together with rangers, we monitor the area from a distance of 200-400m in order to eliminate the anxiety of the female and the cubs especially during the time when the female leaves for hunting. The area where female raised offspring opens after the cubs emerge from the den and begin following the mother in movements around the area, but with monitoring the family to avoid disturbance/harassment.

Pic.48 Female with cubs – lair in the field

Pic.49 Lair in ravine

Pic.50 Ranger installs restricting road post (left above) Pic.51 Lail in the patch of grass in the field Pic.52 Nursing female in the closed area (left)

3.6. Number of cubs in the litter. It is impossible to tell how many cubs are born. Rare sightings of blind cubs in the dens revealed that number of cubs in one litter vary from 2 to 7 (Pic.53,54). It the beginning of November 2019, 4-year old female Siligi (F63) was spotted in the closed area with 7 cubs approximately 2 months old. It was the first documented case of 7 cubs not only born but emerged from the den in the Mara. It was her second known litter (the first one she lost). Having 7 cubs, female had to hunt at every opportunity, sometimes making two kills a day. She started teaching cubs hunting by introducing alive antelope's fawns to her cubs, when they reached the age of 3-months, which was the earliest age recorded for teaching cubs. Unfortunately, within next 2 months, Siligi lost 5 cubs.

Pic 53. Siligi with 7 cubs

Pic.54 Siligi with 7 cubs December 2019

3.7. Lifespan of the cheetah families. In the Masai Mara, mothers spend from 12 to 23 months with their litters. The average age of independence the Mara is 16.9 months, n=28 litters. (See Table 2), which is similar to Serengeti where it is 17.1 months (Kelly et al., 1998).The difference made by two litters where mothers left at the age of 12 and 13 months.

After separation from the mother, littermates stay together for up to six months perfecting their hunting skills. When females reach sexual maturity at approximately two years of age they leave their brothers and start their solitary life. Males-littemates remain together for the rest of their lives in groups called "coalitions", which may consist of up to 5 individuals. Male cubs move from the mother's territory while cubs females usually establish terrotories (home ranges) within their mother's home range. If females (sisters) raise cubs in the same area, one of them can adopt sister's cub/cubs (see Chapter 3.9).

Table 2. *Lifespan of cheetah families*

№	Lifespan of a Family (months)	Number of Cubs	Sex of Cubs	Cheetah Female ID
1	23	2	1.1	F13
2	21	2	0.2	F9
3	21	2	2.0	F13
4	20	2	1.1	F16
5	19	1	0.1	F4
6	19	5	1.4	F19
7	19	3	1.2	F3
8	18	3	1.2	F26
9	18	3	1.2	F8
10	18	1	1.0	F7
11	18	3	1.2	F51
12	17	2	0.2	F3
13	17	3	3.0	F59
14	17	3	2.1	F78
15	17	3	2.1	F53
16	17	2	2.0	F7
17	16	3	2.1	F50
18	16	1	1.0	F13
19	16	4	3.1	F67
20	15	1	1.0	F42
21	15	1	1.0	F5
22	15	2	2.0	F40
23	15	1	0.1	F3
24	14	1	1.0	F24
25	14	1	1.0	F1
26	14	3	2.1	F3
27	13	1	0.1	F26
28	12	6	4.2	F6

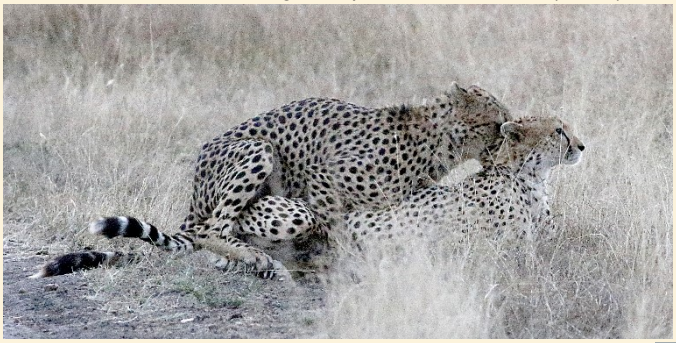
3.8. A case of abandoned cub. Females abandon cubs when disturbed at the lair or cannot take care of offspring due to absence of milk. Before abandoning the lair, mothers sometimes commit infanticide. In 2018, a 3-year old female Nashipai (F69) killed her 6-days old cub and left it being unable to nurse it due to absence of milk.

Nashipai (F69) was born in June 2015 from the female Rani. On 18 June 2017, while hunting an impala in the bushy area of te Reserve, she crashed at full speed into a tourist car, which quickly drove off-road through the bushes. We found female lying on the ground with bleeding shoulder and right side of the forehead, with unstable gait and shaking while walking. On 19 June, she was treated by the KWS veterinarian Dr. Limo, but remained unstable for several days,

Pic.55-56 Nashipai hunting (above) and after accident (right)

during which she was closely monitored. She did not make any attempt to hunt, and on the sixth day after an accident, she moved into the Olare-Motorogi Conserancy. By that time, she has not eaten for 8 days.

Pic.57 KWS vet team treating Nashipai on 19 June 2017 (above) *Pic. 58 Nashipai mates with Olonyok (left) and Pic.59 Nashiai after she left the cub (below)*



The female recovered by 14 August, when she successfully hunter the fawn of the gazelle and was first spotted after the accident. She had been observed pregnant in February 2018, but lost her litter in the conservancy. On 9 August 2018, we observed Nashipai mating with the male Olonyok (M73 from the Tano Bora coalition). In three months, she gave birth around 9 November 2018 in the Reserve.

On 13 November 2018, Mara guides reported to us a female nursing two newborn cubs under a Croton bush in 6-7m from the main road Sekenani-Keekorok. On 13 November, from the main road, we could see two cubs' heads; cubs were blind. The female looked tired and was asleep. Cubs were quiet. According to the reports from the guides, that day the female tried hunting but failed. On 14 November, only one cub was spotted at the same location at 17.00. Nashipai looked disturbed when the cub was trying to suckle, and walked into the filed for 60-70m. On 15 November, at 7.00, we found Nashipai in 3 km from the previous day location. Within the next 3 hours of observation from the distance of 300-400 m, she tried hunting Thompson gazelles twice, but failed. The female looked relaxed and spent significant time resting under the shade. She was moving towards the Naboisho conservancy and at 10.01 entered the thick bush at the border of the Reserve. At 10.45, we arrived with the ranger from the ranger outpost near Simba lodge, to the area where female had her cubs. From the main road, we could hear loud sounds produced by a cub. Hoping that the female will hunt successfully and will come back, and to avoid attracting attention to the area with a cub, we left the area. According to the Mara guides who have been passing by the place later that day and next morning, the mother did not come to that place.

Pic. 60 Wounded dead cub November 2018

On 16 November, at 9.00, there was no sign of a female and cubs at the area they were located previously. No other predators were spotted in the area. The Reserve authorities checked the place, where the cub was making sounds on the previous day. One cub was found dead with two injures on both sides of the body. His intestine was empty. Tissues (heart, liver and part of intestine) and one tick have been placed into tubes with 100% Ethanol for the genetic analysis at the KWS Forensic and Genetic Laboratory.

The fact that on 14 and 15 November cubs/cub were/was making sounds with the female lying with them and also alone when the female was hunting, could indicate that the female had insufficient amount of milk possibly due to a lack of food after giving birth. Pregnant females hunt small prey: hares and fawns of ungulates to reduce the energy costs. Female defecated on 15 November.

Pic. 61,62 Intestine of the cub – empty inside

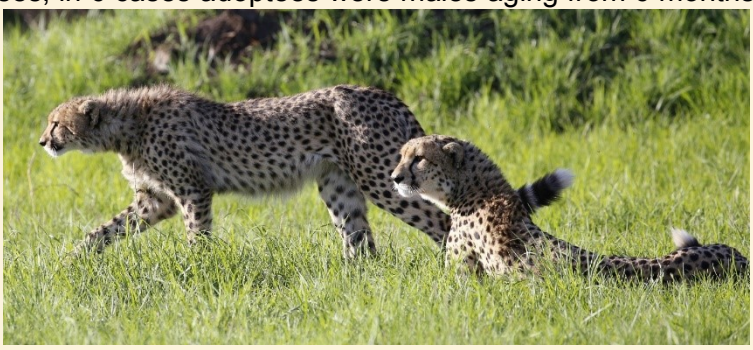
According to Nashipai's feces small quantity, hard texture and high conten of hairs of the prey, the female has eaten approximately 4 days prior defecating. The possible reason for leaving the cub most likely was absence or insufficient amount of milk. In captivity, when leaving abandon cubs, mother bites them across the body. It is most likely that wounds on both sides of the cub's body resulted from the bite by a female prior living the cub. After that accident, we observed Nashipai in courtship and pregnant several times, but since 2018 case, she had never been spotted with cubs. If that trauma caused apogalactia or hypogalactia, this female is lost to the population due to inability to reproduce. *Apogalactia* (complete absence of milk in female after delivery) or *hypogalactia* (decreased function of the mammary glands, which can manifest itself in a violation of the processes of lactopoiesis, lactogenesis or milk flow, as well as in a reduction in lactation over time). Although such disorders can be congenital, there is a possibility that severe stress in a collision with a vehicle and a head (brain) injury caused disorders in the production of hormones that trigger milk production.

Sex of the cub – male; **age** – 5-7 days, blind, **weight** – 495 g
Body measurements of the cub:
Body length (from the tip of a nose to the base of a tail) – 33.0 cm; Tail – 13.3 cm
Length of the front limb – 12.0 cm Length of the hind limb – 14.0 cm
Belly girth – 19.0 cm Head girth – 16.5 cm
Muzzle girth – 11.0 cm Distance between ears – 4.4 cm
Height of ears – 1.53 cm (right) and 2.0 cm (left)
Paws measurements:
Left front length – 23.4 cm; width – 22.27 cm Left hind length – 24.5 cm; width – 20.36 cm
Right front length – 23.4 cm; width – 20.28 cm Right hind length – 26.6 cm; width – 20.0 cm

The consequence of this event was the introduction of a new Park rule in the Maasai Mara National Reserve following our recommendation: ***"Do not drive whenever animals are hunting. Perpetration will be equated to the animal harassment".***

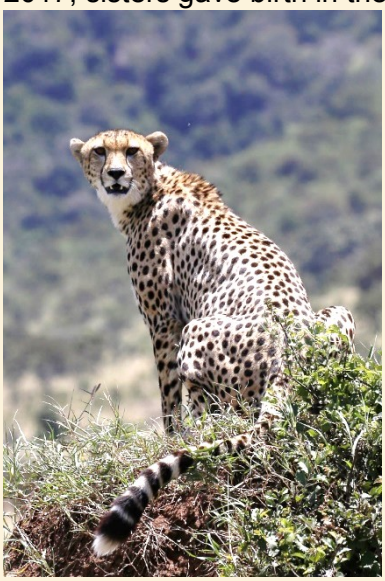
3.9. Maternity Behavior and Adoption of Cubs. High level of sociality and strong maternity instinct altogether allow cheetah females adopt cubs of different ages. In captivity, cheetah females accept small cubs (from 1 day old) and allow them nursing together with biological cubs, when the cub/cubs are put in a den with cubs in the absence of their mother. Such event is man-initiated. In case of a female "coalition", where both females have cubs, they raise all cubs together, voluntary nursing them and sharing meals with them. (Chelysheva E.V. 2006. Specifics of Social Behavior of the Cheetahs (*Acinonyx jubatus*) in the Wild and in Captivity: on the Issue of the Optimization of Keeping Conditions. // *CARNIVORES AND MARINE MAMMALS IN CAPTIVITY* – Eurasian Regional Association of Zoos and Aquariums. 2006: 32-62 (*in Russian*).

In the wild, adoption of cheetah cubs documented in the Serengeti where the youngest adoptee was 4 months old. (Caro, T.M. Cheetahs of the Serengeti Plains: Group living in an asocial species. – Chicago: University of Chicago Press, 1994. – Pp. 89-92). In 9 recorder cases, mothers had 2-4 own cubs aging from 4 to 12.5 months. Out of 9 cases, in 6 cases adoptees were males aging from 6 months to over 12.5 months, who were staying with the family from 3 days to over 11 months. Interestingly, that males adoptee were staying significantly longer with the family which contained at least one male, and the longest time spent was 337 days. (Caro 1994). By joining families, cubs who lost their family/mothers, increase their chances for survival by getting an access to food and possibly protection.



Pic. 63 Naretoi with her son (24 March 2018)

In 2018, we documented a case of adoption of a 15 months old male cub by his "aunt" – sister of his mother. Two sisters – Naretoi (F64) and Naserian (F65) have been raised by their mother Kakenya (F19) in the Mara Triangle, but spent significant time in the neighboring Serengeti National Park. In 2017, sisters gave birth in the Mata Triangle: Naretoi in June and Naserian in September.



By 24th of March, Naretoi lost one of her three cubs, and by May 2018, lost one more cub. On 17th of August 2018, her remaining son was spotted alone in the Triangle. He was 14 months old at that time. On 7 September, Naretoi visited Triangle been pregnant. Most likely, that could be a reason for leaving the cub. On 24 October, she was with one 1.5 months old cub, who she lost by 16 November. On 16 November, she was found sick (Pic.65) Dr. Limo (KWS) examined her on 16 November and treated her on 20 November, but on 26 November she died.

Pic. 64,65 Naretoi pregnant (left) and sick (right)

Naserian left for Serengeti soon after her cubs started following her, and appeared in the Mara Triangle on 4th of June 2018 with the only remaining male cub (8,5 months old), who was very shy like majority of cheetahs who have been raised in Tanzania.

After a short visit, Naserian disappeared for several months. In the end of August, Mara Conservancy rangers spotted on the Tanzanian side female with a big cub. By that time, Naserian had one big cub. When she showed up in the Triangle again on 13th of October 2018, she already had two healthy male cubs – her own son and Naretoi's son. Therefore, adoption occurred between the beginning of September and beginning of October, when Naretoi's son was 14-15 month old. Possibly both females with litters could meet in the Triangle and in Serengeti, and their cubs could have known each other. Meetings of unrelated females with cubs are usually peaceful, and end up with all the cubs following one female who called them (Caro,1994). We observed such case in the Mara in 2001.

Pic. 66 Naserian (right) with her biological cub male M99 (left) an adopted cub male M98 – her sister's son (middle)

By joining the family, cubs who lost their mothers gain by getting an access to food as at the age of one year they are still not efficient hunters. At the time of observations, Naserian's cub male was shy and noticeably smaller than Naretoi's son, who was more confident and occupied the space near his stepmother, demanding her attention. Such behavior correlates with described by Caro (1994). Although both males were friendly to each other, during plays, one male displayed dominance by mounting another one. Although, Caro (1994) pointed out that adoptees competed for food and were stealing food from the cubs of their adoptive mother, Naserian and both cubs have been sharing the kills peacefully.

Pic. 67 Naretoi's son is mounting Naserian's son

Pic 68. Naserian's son is mounting Naretoi's son

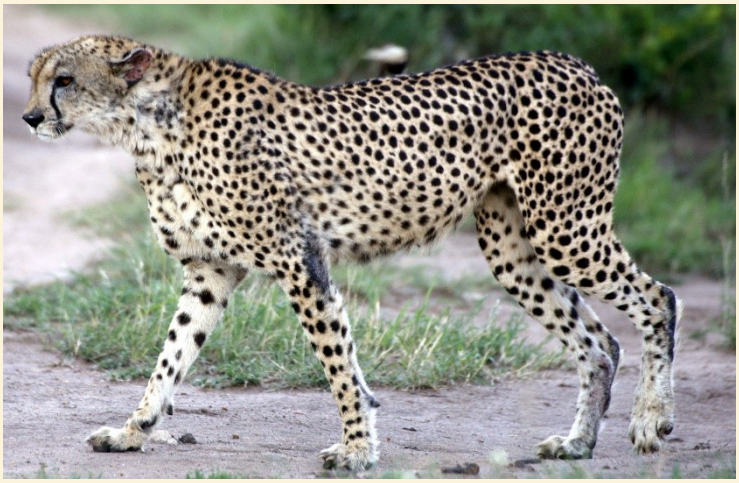
By 20th of December 2018, both cubs were still with Naserian, observed in the Triangle, however on 24th of March 2019, she was seen with her own son (M99). On 23rd of July 2019, adopted cub (M98) was spotted in the Serengeti alone. At that time he was 2 years and 1 month old. Whichever reason for separation was (for example, female in estrus chased a male), time spent with Naserian's family

provided Naretoi's son with necessary resources and was definitely beneficial for the young male. To date, it was the first documented case of cheetah adoption in the Mara.

4. HEALTH MONITORING

Following one of the Project objectives (i.e. *Identification of major threats to the cheetah population including health problems*) the research team performs cheetah health monitoring by direct observations and collecting photographic materials from the rangers and guides. Because of the regular monitoring of cheetahs, we have clearly identified who needed medical attention, reported to local KWS veterinary unit and assisted them in locating these individuals who required treatment.

4.1. Sarcoptic mange. Sarcoptic mange is a highly contagious mite infection caused by *Sarcoptes scabiei* burrowing under the skin of domestic and wild mammals. It has been reported from 10 orders, 27 families and 104 species of domestic, free-ranging and wild mammals, including cheetahs. Cheetahs acquire it via direct contact with infected prey species or conspecifics. Clinical symptoms of mange depend on the immune status of the respective host. At the latest stages, the skin becomes extensively thickened, greyish in colour, there is amarked eosinophilia throughout the epidermis and dermis (the skin becomes red in colour) and often almost complete alopecia. The skin cracks, dries and exfoliates exposing the unprotected tissues. Treatment of infected individuals in the field has been successful.



Pic.69 Cheetah male with mange, 2019

From 2012-to date, 29 (14.13.2) cheetahs were spotted with different stages of mange, of which 9 (4.3.2) were treated by the Veterinary Units, and 4 (1.3) recovered by themselves. In general, there is positive dynamics in the cheetah health: In 2012, 22 (10.10.2) cheetahs (29%) were spotted with different stages of mange, of which 8 (3.3.2) were treated by the Veterinary Units, and 3 (1.2) recovered by themselves. in 2014-2015 there were 10(3.6) adult cheetahs spotted with mange, or 13% of the Mara cheetah population; in 2016, 5(3.2), which was 8.5%, in 2017, 4 (2.2) with mange, i.e.5.4%, in 2018, 2(1.1) -3.5%, both spent most time in serengeti; and in 2019 – 5(3.2) or 7% adult cheetahs, out of which 2 males spent most time in Serengeti. In 2019, two young cheetahs (1.1) have been treated by the KWS Vet Unit and one female recovered by herself.

We documented two sources of mange in cheetahs: prey (feeding on infected Thompson's gazelle) and another cheetah (contact with infected individual during courtship).

4.2. Injuries of the body. Since we started monitoring cheetahs in 2011, we have seen several cases of injured individuals. In most of the cases, it is difficult to reveal the cause of injury. One we spot an injured cheetah, we immediately repot to the KWS Veterinary Unit based in the Mara and local authorities in the area of operation (i.e. conservancy CEO and rangers) and monitor the injured individual in order to see if it can hunt successfully and take care of itself or seeks veterinary and rangers' assistance. In 2018 and 2019, apart from small injuries observed in several adult and sub-adult individuals, who have recovered by their own, severe injuries have been observed in three adult cheetahs (two males and one female), who required veterinary assistance.

Pic.70, Male M5 (Martin) and Pic. 71 M58 (Olpadan)

In one case 9-year old male Martin (M5) was found on 1st August with numerous injuries all over the body and a head, with missing third part of a tail and skinned inner part of a hind leg. He received veterinary assistance and supplementary feeding on 1st August, and made a kill of a wildebeest calf on 4th August. After that, he was spotted twice, and disappeared by the middle of the month.

In the second case, on 11 March 2019, we received first information about Olpadan (M58) – one of the Tano Bora coalition, with bleeding testicle. In the morning of 18 March, Tano Bora males came to the MMNR from adjacent Olare-Motorogi conservancy, and it was clear that Olpadan was unwell. One of the testicles was infected. We reported to the KWS Vet Unit and Park authorities, who responded fast. During the surgery, left testicles was removed. The male joined his coalition-mates after recovering from anesthesia and we have been closely monitoring him.

Pic.72. Dr. Limo performs orchiectomy

Pic.73. Dr. Chelysheva collects ectoparasites

4.3. Disease. In 2018, one cheetah (female Naretoi) died in the Mara Triangle of a condition, identified by the KWS Veterinarian as Hypoglycemic Encephalopathy – a brain injury, resulted from prolonged or severe hypoglycemia (low blood sugar). Her symptoms were similar to those of another female Malkia, who died in the Reserve on 29 July 2017, been pregnant with 2 cubs. Both females were weak and had unsteady gait. Additionally, Naretoi lost weight noticeably (Pic.65).

5. COOPERATION with the MARA COUNTY COUNCIL, CONSERVANCY RANGERS and TOUR FACILITIES

5.1. Monitoring cheetahs. Since the beginning of the project in 2011, we recognize the strong impact of the Citizen science in facilitating of the data collection and in conservation activities, and actively involve local representatives into data collection. Our research team is closely working with all Narok County Government rangers teams in the Maasai Mara National Reserve and several surrounding conservancies, with the guides, managers and guests of the tour facilities in the areas of operation, and collaborates with the other projects' research teams. As a part of colaboration work, we provided each field team with the Cheetah ID Catalogues with photographs of the body profiles of all known individuals, and with compact water- and shock-proof digital photo cameras (Nikon Coolpix AW100, 110 and 120 with built-in GPS) for facilitating field data collection and monitoring of valuable species. On the regular basis, we receive information on suspected cases of sick, dead, injured or lost individuals. We exchange with rangers' teams updated information on the cheetah movements, health and reproductive status, and provide them with the road signs ("TRACK CLOSED", "AREA CLOSED" and "RANGERS ONLY") for a limitation of tourists accessibility to the areas of cheetah dens. To date, over 170 road signs were delivered to the Park authorities. They are also used for closing areas for a vegetation recovering.

Pic.74 Cameras for rangers of the Lemek and Olchorro conservancies (left) Pic 75 Practical lesson of identification of cheetahs spotted in Enonkishu Conservancy (right) and conservancy team after a Cheetah workshop (17 December 2019) Pic.76 MMCP team with Conservancy wardens and rangers (below)

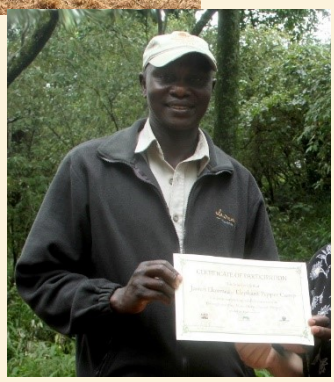
5.2. Conducting Workshops for local stakeholders. In 2018 and 2019, Project team conducted numerous workshops for the Mara guides in different tour facilities in the MMNR and surrounding and remote conservancies. By the invitation of the conservancies' authorities, we conducted workshops with the PowerPoint presentations and lessons on cheetah identification for the conservancies' rangers, camp guides and spotters. We have been also exchanging data with conservancies' stakeholders on cheetah movements, health and reproductive status. This long-term mutually beneficial collaboration is vital for species conservation work performed by the rangers and researchers on the ground, and plays significant role in facilitation of research and conservation efforts by the Project.

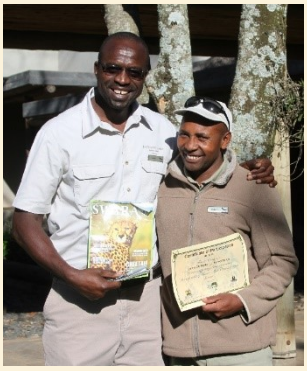
Pic. 77 Cheetah female is exploring the road sign at the area of the den with cubs (left).
Pic.78 Closing the area of a cheetah den

In order to encourage Mara guides to participate in wildlife conservation, Project team produced Certificates of Participation (Pic.79), signed by the Kenya Wildlife Service and Narok County Government officials.


Certificate of Participation
No. 0001
This is to Certify that
.....of.....
Has been supporting wildlife conservation
Through assisting Mara - Meru Cheetah Project
Granted
31/March/2014
REPUBLIC OF KENYA
KENYA WILDLIFE SERVICE
Director
Project Manager

Pic 79. Certificate for the guides





Pic 80 Certificate issued to the head guideof Elewana collection guide (left) and Pic.81 Kichwa Tembo Camp guide (right)

Criteria for the selection of a guide is based on active support of thIn e Project by providing information on cheetah sightings for cheetah monitoring, photographs for building Mara Cheetah Pedigree and adherence to the set Conservancy/Park Rules and Regulations. From 2014 to date, 95 Certificates were awarded to the most dedicated Mara representatives from different camps/lodges of the Maasai Mara National Reserve and neighboring conservancies.

5.3. Educational talks. In 2019, Dr.Elena gave several talks to groups of international students from different Universities with the PowerPoint presentations on various topics including Biology and conservation of vulnerable species and Human-Wildlife conflict in the Mara. Together with Jackson Otuke (Senior Research Assistant), Dr. Elena conducted workshops for the rangers and guides in the Mara, including the workshop for the members of Mara Guides Association (MGA). On April 26, by invitation of the Kenya Professional Safari Guides Association (KPSGA) administration, Dr. Elena gave a talk at the Safari Walk conference hall of Nairobi National Park for over 50 the guides from different travel companies and shared with them updates on the biology and behavior of the cheetah, discussed various problems faced by cheetahs and guides. Applying scientific data from behavioral observations in the field, personal tourist experience, and opinion of the guests, Dr. Elena presented the way of tour guiding and animal sighting where animals are not getting disturbed and clients get full satisfaction from the game drive. The meeting was very productive and guides got the opportunity to ask the researcher any question of interest to them.

Pic. 82 Dr. Elena (Project founder) gives a lectue for the tour guides at KPSGA

5.4. Human-Wildlife Conflict Workshop in the Mara. On April 23-27 of 2018, Dr. Elena participated in the HWC Workshop held at the Mara Sarova Game Camp, organized by the Kenyan Wildlife Service and WWF Kenya, and dedicated to solving problems between wild animals and humans. Dr. Elena gave a presentation on the data collected by the MMCP on the HWC and gave suggestions for mitigation of the HWC. The seminar was attended by representatives of major projects studying various animals in the Mara, including hyenas, cheetahs, leopards, lions, vultures and elephants. For 3 days, we all productively discussed the most important conservation issues and strategies, shared our experience and research results, planned further joint work to resolve conflicts and save animals in the Maasai Mara. It was nice to meet friends, colleagues and a former volunteers of our project, who over the years have deepened their experience and knowledge and made a significant contribution to the seminar.

Pic. 83-84 Dr.Elena with particiants of the HWC Workshop at Sarova Camp

Pic.85 Discussion with participants of the Workhop

LEOPARD SURVEY
Maasai Mara

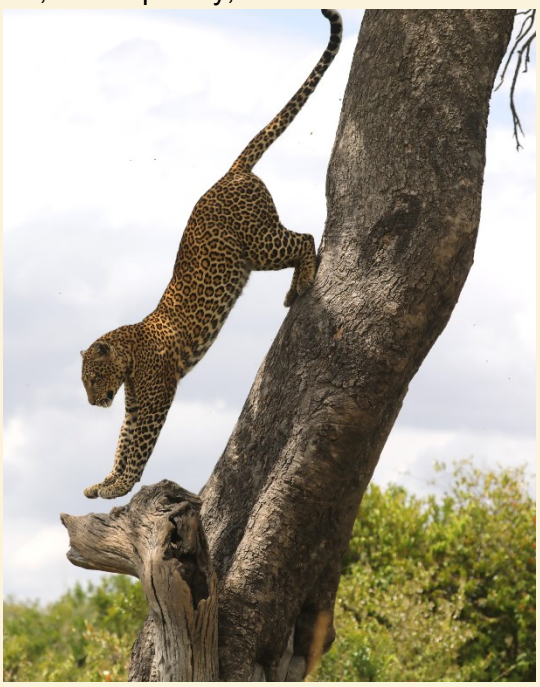
INTRODUCTION

Leopards (*Panthera pardus*) are declining across majority of their range due to habitat and prey loss, and exploitation thus considered as "Vulnerable" by the IUCN and are listed in CITES Appendix 2cd (Stein et al. 2016). The African leopard has lost over half of its former range in recent decades, with national parks and reserves maintaining vital source populations, particularly in East Africa. Protected areas are increasingly acting as critical refugia for wildlife, serving as protection for extensive ecological processes and ecosystem functions. Due to increasing human encroachment into the remaining habitat of large predators, there is an urgent need to understand the underlying processes which drive co-occurrence among apex predators. Camera traps are increasingly being used to determine relationships between sympatric mammals and environmental characteristics, often with a view to inferring interspecific interactions.

Leopards are one of several large predators associated with recognised trophic cascades and are known to have a cascading influence on ecosystems and ecological communities (23). Indeed, where leopards and lions occur sympatrically they exert control on mesopredators. For example, an increase in the abundance of baboons (*Papio anubis*) in West Africa, was linked with declines in these predators relative to other explanatory environmental factors that might explain range use and abundance of baboons. This is important because among large mammals baboons pose a significant threat to crops and livestock. Indeed, in certain areas it is common for children to be kept out of school to protect crops from baboon raids (23).

The leopard's ability to adapt to changing environments and to varying habitats, has enabled them to survive in regions where other large felids have been eradicated, or severely isolated (31, 32). However, this adaptability has not habituated the leopard against all levels of threat (33). Leopards,

like many large carnivores that are in decline (34), face a number of significant and ongoing threats, which aside from habitat loss and prey base depletion, include human-leopard conflict, poaching for skins and body parts, unregulated trophy hunting and retaliatory killing (35-40).
The African leopard exists within an intact guild of terrestrial predators, within which interspecific competition is fierce. As such, the leopard serves as a valuable ecological case study on the question of how competitors might coexist under conditions of forced proximity (14). Until recently, leopards were assumed to be resilient to interspecific competition and, consequently, have been omitted from research that is focused on interspecific competition (15). However, evidence now suggests that dominant competitors – such as lions do in fact pose a threat to leopards (16, 17). Enforced proximity with dominant competitors could influence leopard behaviour and impact reproductive success. Their survival is important from an ecological perspective because intact predator guilds are essential for optimal ecosystem function (18).



Protected areas may be key to the leopards' survival because outside of these areas they suffer higher mortality rates (19). Therefore, it is important to understand the factors that enable coexistence between leopards and their competitors inside protected areas (9). Beyond caching their prey in trees, not much is known about the mechanisms that facilitate co-occurrence between the leopard and its competitors (20, 21).

The leopard is a solitary and reclusive felid that despite being one of Africa's most widespread large cats, have lost between 63 – 75 % of their historical range (41) (Table 1). Following a recent up listing, the International Union for the Conservation of Nature (IUCN) and the Convention of International Trade in Endangered Species (CITES), classify the leopard as Vulnerable (33, 42). The IUCN recognises nine subspecies (43, 44) (Table 3).
Robust population estimates and demographics and a greater understanding of the threats facing the leopard requires more research (33). With the exception of the Phinda Game Reserve, South Africa (45), long-term data on leopard populations is almost entirely absent (33). While the leopard attract considerable interest from researchers and conservationists, some regions and subspecies are studied with greater intensity than others, thus more comprehensive research efforts should be prioritised (33).

Table 3. IUCN classification and range estimates for leopard subspecies. Subspecies are listed in order of least extant range to most. Values in bold indicate greatest threat. Source: *Jacobson et al. (33)*

Common name	Panthera pardus subspecies	IUCN classification	% Range loss	% Remaining range
Amur leopard	*Panthera pardus orientalis*	Critically Endangered	97 - 98	< 5
Arabian leopard	*P.p. nimr*	Critically Endangered	98	< 5
Javan leopard	*P.p. melas*	Critically Endangered	84	< 5
Sri Lankan leopard	*P.p. kotiya*	Endangered	63	< 5
Chinese leopard	*P.p. japonensis*	Near Threatened	96 – 98	< 5
Indochinese leopard	*P.p. delacouri*	Near Threatened	93 – 96	
Persian leopard	*P.p. saxicolor*	Endangered	72 – 84	10 – 15
Indian leopard	*P.p fusca*	Vulnerable	70 - 72	< 5
African leopard	*P.p. pardus*	Vulnerable	63 – 75	15 - 20

Numerous studies on leopard behaviour and ecology have been conducted in Southern Africa (Bailey, 2005; Swanepoel, 2009), Kalahari Desert (Bothma & Le Richie, 1984); in the Serengeti National Park (Cavallo, 1991); in Kenya (Hamilton 1981), including Sangare Ranch Conservancy (Svengren 2008), ranch in the Lolldaiga Hills in Laikipia (Mizutani & Jewell, 1998) and in Nairobi National Park and Silole Sanctuary (Yamane 2006). To date, there has been no research carried out on the Maasai Mara leopard population. With top carnivores facing increasing pressures due to loss of habitat, illegal trade in skins and body parts, and human-predator conflict, more research which encourages and promotes viable wildlife conservation practice is needed (Pitman, 2012), if the future of one of the world's most enigmatic apex predators is to be secure.

The leopard is arguably the least studied of all African guild members and this is a likely consequence of the difficulty in collecting data on a species that is elusive, solitary and wide-ranging - and thus difficult to observe directly (48). Furthermore, for a species that, until recently, was of low conservation concern (33, 42), the high costs associated with acquiring ecological data, particularly with the use of GPS radio collars - a tool often used to obtain data on cryptic species (75), may have led to resources being directed towards species perceived to be of greater conservation concern (48). However, advances in digital photography and infrared sensor technology has led to a cost-effective, non-invasive, means of gathering reliable information on elusive species, with the use of camera trap methodology (76, 77). Following the recent up-listing of the leopards conservation status this is a timely opportunity to acquire the knowledge urgently required in order to implement effective conservation actions, where needed (48).

Interviewing local communities around the Maasai Mara National Reserve, conducted by our research team in 2012-2015 indicated that 89% of local pastoralists confuse leopard for a cheetah, thereby mistakenly persecuting both species for livestock depredation.

Following a show of interest by the KWS in understanding the status and threats facing leopards in Kenya, we conducted the leopard study within the Mara-Meru Cheetah Project (MMCP) in partnership with the Mara Conservancy. Study conducted by Eve M. Hills (Brighton University, UK) with assistance of Jackson M. Otuke (MMCP Research assistant), using non-invasive methods: camera trap study and Facebook photo survey. The key reason for this study was to assist in the formulation of wildlife management policies in the Mara, using scientifically gathered and recorded data. It is essential that management practices be established to address the issues that surround the conflict between people and predators.

Camera trapping. A variety of techniques have been developed to study and monitor large mammals such as leopards. Techniques that include the use of the presence of signs, such as prey availability (20); kill sites and spoor (78); interviews with local people (79); and more direct survey techniques, for instance, the collaring of individuals within a population (80, 81). There are limitations to all these techniques and, in particular the collaring of animals which is constrained by the small number of individuals that can be tagged simultaneously, the ambiguity of how many untagged individuals are present within the population, and the high costs and ethical issues associated with collaring animals (82). Over the past two decades camera traps have considerably advanced our ability to study rare and elusive species (83). They have the advantage of being non-invasive and

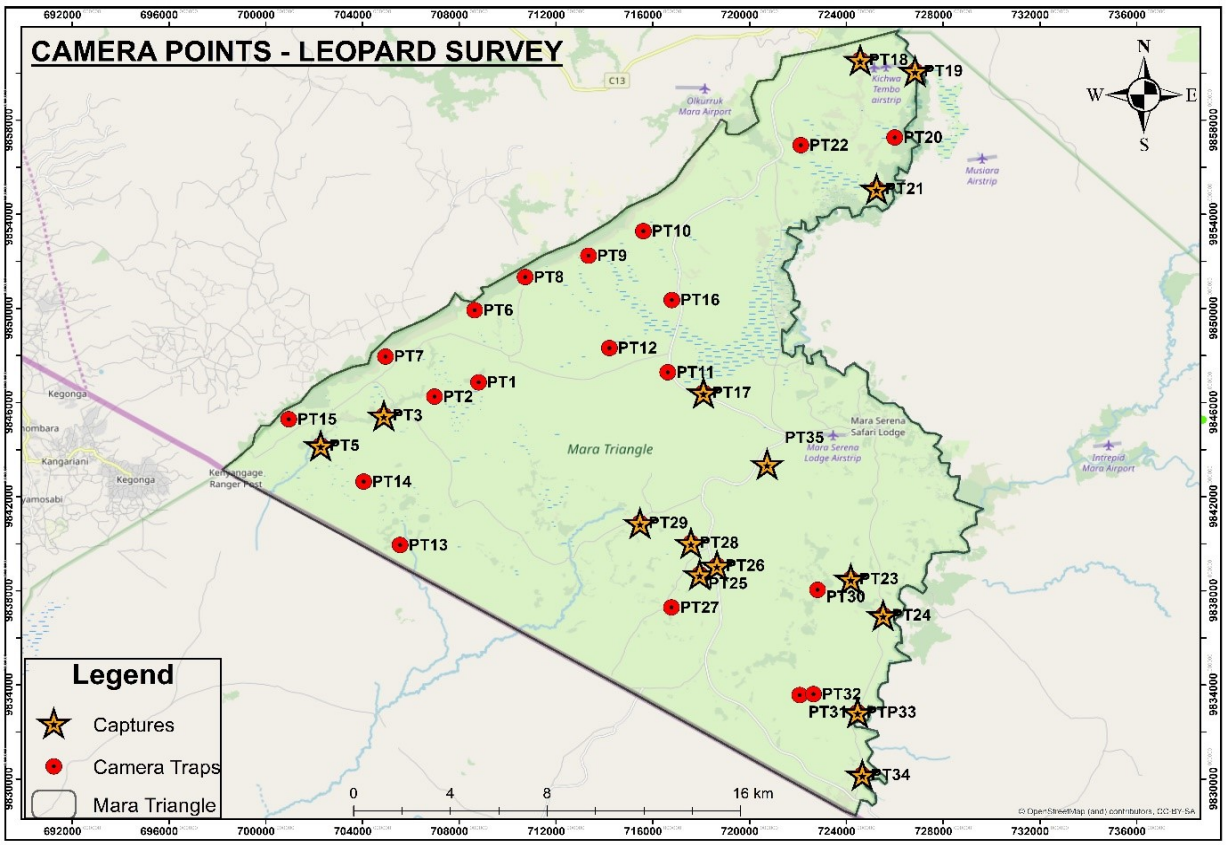
appropriate for use over large areas with relatively minimal effort (84) and expertise. Where species have uniquely identifiable coat patterns or markings, for example bobcats (*Lynx rufus*) (85), tigers (Panthera tigris) (86), ocelots (*Leopardus paralis*) (87), jaguar (Panthera onca) (88), and leopard (89), capture-mark-recapture (CMR) models can be used to estimate population densities using camera trap data (90). Today camera trapping is also used to study various aspects of wildlife ecology including species inventory, distribution, population structure, habitat use and behaviour (91).

This study, for the first time, used camera trapping to assess the influences of leopard occurrence in the Maasai Mara National Reserve (MMNR), Kenya. Two main questions are addressed: (1) do leopards choose certain habitat types in which to hunt and, if so, (2) what factors determine whether an area is preferred or avoided? For instance, do leopards select habitats where prey species richness/category (i.e. prey weight) are optimum? Or, do they select habitats which increase the probability of prey capture, such as semi-open habitats which provide a level of concealment. Furthermore, does the presence or absence of intra-guild competitors (e.g. lions, hyeanas) drive whether an area is selected by leopards?

Habitat loss and human conflict have led to the unprecedented decline of large predators. The function of apex predators on ecosystem structure and regulation is well-known. This study will use camera trap technology to investigate the factors (e.g. habitat type, prey species richness and interspecific competition) influencing leopard occurrence in the Maasai Mara National Reserve.

Objectives of the study:

1. Determine whether there is a correlation between habitat type and leopard occurrence
2. Determine whether species richness is related to leopard occurrence.
3. Determine whether sympatric carnivore occurrence is related to leopard occurrence

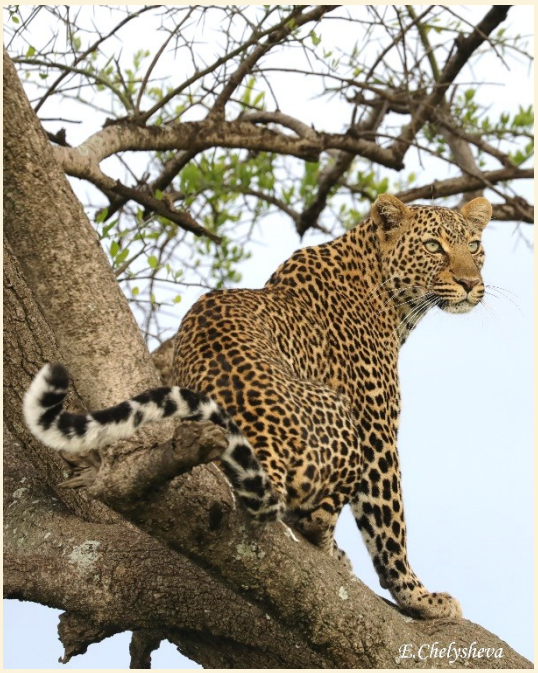


Pic. 86 Red circles indicate camera trapping locations and gold stars indicate where leopards were photo-captured. Map produced by Jackson Otuke Map source: ArcMap 10.6.1

METHODS

With the assistance of local rangers, a preliminary survey was conducted in the study area to identify sites where there was evidence (or prior knowledge) of leopard presence or activity, including, spoor, scratch marks (103), existing photographic record, and places where leopards might be expected to pass. Animal trails leading towards, or near to permanent water, drainage lines and potential cache/marking trees were selected as potential camera points. Thus, ensuring that sampling effort covered all habitat types and areas where leopards were likely to be present (104). Both old and recent leopard signs were recorded to help gauge the likelihood of capturing the focal-species at each point (105). Spacing between potential points during the preliminary survey was measured using a handheld GPS unit. In agreement with a MC management request, camera-traps were not placed in areas where they would be easily seen by visitors to the Reserve. Consequently, although leopards are known to utilise road networks (90, 105-107) camera traps were not placed on roads during this survey. Camera trap survey in the Mara Triangle was conducted in April through June 2019. 70 camera traps have been placed in 34 stations.

RESULTS



725 leopard images have been obtained from the camera traps.

Out of 13 photo-captured individuals:
males = 6 (3 unknown – not in current database)
females = 7 (4 unknown – not in current database)
The Facebook/photo Survey yielded total of 97 (42.55) individuals. Combined survey (Camera trap and FB) results for individuals identified in the Maasai Mara National Reserve and 6 in conservancies - 99 (43 males, 56 females), out of which:
In the Reserve = 44 (21.23)
In the Triangle = 33 (15.18)
In the conservancies (Facebook photos of sightings in Naboisho, OMC, MNC, Ol Chorro, Lemek, Ol Kinyei) =22 (7.15).
Camera trap study revealed 8 new leopards - 4 males (including 1 male from the pilot in Sopa area), 4 females (including 1 juvenile).
Three males are presumed to have died, 1 male is definitely deceased (based on public knowledge or age of individual at the date of last photo). Two males are known to have dispersed from the Reserve to the Triangle (1 possibly now deceased), 3 males are known to have dispersed from the Reserve to other conservancies, while 1 conservancy male was observed challenging a male for territory inside the Reserve. Five females are presumed to have died, 5 females are definitely deceased. One female is regularly sighted inside the Reserve but is also seen in the Triangle, while 1 Triangle female has been sighted inside the Reserve. Only individuals known to have died have been removed from the final totals (n = 6).

This study aimed to investigate the environmental factors influencing leopard occurrence from photographic data collected

across 34 camera stations, over a single season, in the Masai Mara National Reserve, Kenya. Logistic regression modelling indicated that leopard occurrence was significantly influenced by the presence of spotted hyeanas (*Crocuta crocuta*) (Wald X2 (1) = 6.526, p = 0.011). These findings suggest that lion presence, prey, and habitat did not have a strong influence on the occurrence of leopards. Lions (*Panthera leo*) and hyeanas pose a threat to individual leopards, yet, relatively little is known of the processes facilitating co-occurrence between carnivore guild members, particularly leopards.

Preliminary results of the study:

1. There was no correlation between prey species and the presence of leopards.
2. There was no correlation between the presence of lions and the presence of leopards.
3. Leopard occurrence was most strongly influenced by the presence of spotted hyenas
4. Site selection by leopards was not influenced by habitat type.

Further research should investigate how resilient leopards are to the effects of intra-guild competition, particularly in areas used intensively by leopards and hyeanas. Understanding intra-guild interactions is key to conserving one of last intact carnivore guilds in the world, within the boundaries of one of Africa's most outstanding protected areas.

Table 4. *Relative abundance index (RAI) of leopard capture success rates (number of leopard captures per 100 camera-trap events) across the study area.*

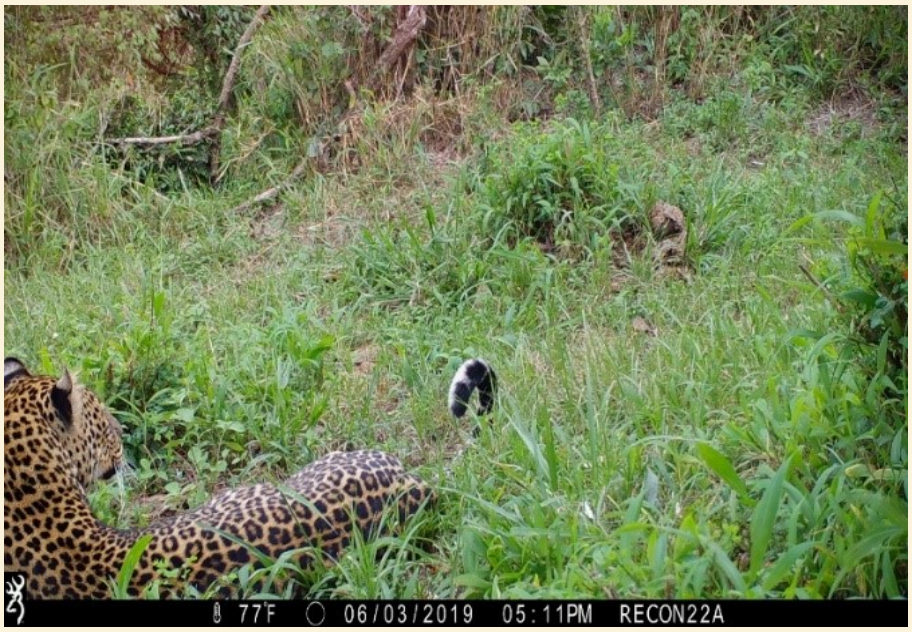
Sampled area	Survey duration (mean no of trap days)	Camera trap stations	Camera trap nights	Total leopard pictures	Identified leopards	Capture rate (%)
Northern Triangle	60	18	1,075	58	3	5.3
Southern Triangle	54	16	863	667	10	77.2
Average	57	17	969	362.5	6.5	41.25
Total	-	34	1,938	725	13	

CONCLUSIONS

Results from this study raise the question of whether interactions with hyeanas are having a negative effect on the population of leopards. While caution should be given before drawing inferences about the patterns of behaviour observed from the data. It is important to note that a recent study by Green et al. (145), indicated that populations of lions and hyeanas within the Reserve were changing in opposite directions, suggesting that the large predator guild inside the Reserve is being severely disrupted (165). In other parts of Africa, both lion and leopard populations are declining due to widespread habitat loss, poaching, retaliatory killing, prey depletion and poorly regulated trophy hunting (38, 166-169). A lack of data on the Reserves leopards' hinders the chances of identifying trends in the status of leopards inside the Reserve. However, if we hope to preserve the MMNR as an iconic sanctuary for large predators, we need to perform a rapid and accurate assessment of the leopard population, examine in greater detail the changes that are happening within the large predator guild and their underlying causal factors, and evaluate the impacts of this altered predator community on ecosystem function (145). Protected areas in sub-Saharan Africa are fast becoming isolated land masses bordered by degraded rangelands and expanding human populations (170). The future preservation of large predators depends on the efficiency of sanctuaries to protect species, like leopards, that are particularly sensitive to loss of habitat and at high risk of persecution by people (19, 171). Effective community conservation programs can help alleviate conflicts outside of protected areas (172), and is crucial to long-term conservation of large predators (145). However, if sensitive species are allowed to decline within protected areas, not even the most resourceful conservation initiatives outside of them will be able to sustain large predator populations into the future (143).

Pic. 88 Images captured from one of the camera trap locations: one of 7(3.4) unknown leopards

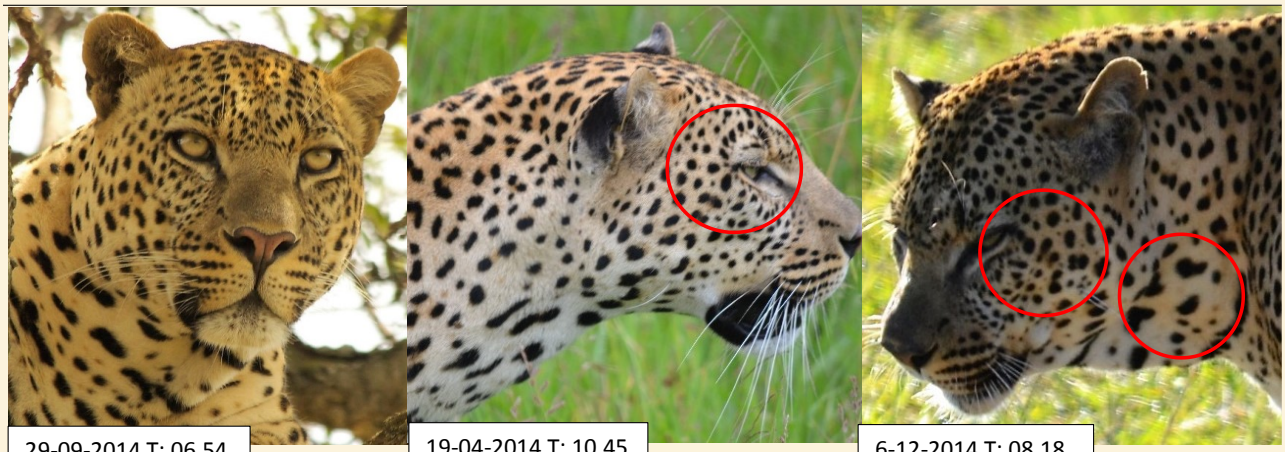
Pic. 89 Female with a juvenile female cub is relaxed in the presence of the camera. Some tall vegetation in front of the camera have been cleared unwittingly providing her with a resting area



MARA LEOPARD DATABASE

Leopards sighted from 2010 to date are presented in the current database. The Database was formed by Ms.Eve M. Hills using the photographs taken by the ongoing cheetah research' team (Mara-Meru Cheetah Project), and obtained from the Maasai-Mara tour guides, visitors and volunteers. Research to date; over 10000 photographs have been processed, and 112 leopards (47 males, 63 females, 2 sex unknown) have been identified. Each individual has been given a code, e.g. M1 for a male, F1 for a female. Leopards from the Mara Triangle and conservancies have IDs M5T, M6MNC (Triangle, Mara North Conservancy) etc.

ID: **M001R/**Name **Keekorok male**



29-09-2014 T: 06.54 | 19-04-2014 T: 10.45 | 6-12-2014 T: 08.18

17-08-2018 T: 17:38

21-12-2014 T: 09.55

Born: appr. 2010
Estimated age: 7-9
Mother: Unknown
Area: Keekorok

Pic. 90 Example of the Database page: Leopard male with known name M001R, where R-Maasai Mara National Reserve

ID: **M002**

Most recent sighting**: 10 June 2016**

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