Leopard Population Density in Three Game Reserves of Tanzania, East Africa

(Preliminary Field Work, 2020 Report)

Ph.D. Arturo Caso. Predator Conservation, AC

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Introduction.

The African leopard (*Panthera pardus*) is a cryptic, solitary carnivore for which population-level data are notoriously difficult to obtain. Recently, concerns have been voiced over purported leopard population declines, and the possible negative impacts that legal trophy hunting may be having on leopard populations. These concerns have prompted requests by wildlife management agencies and permitting authorities for updated information on the status of leopard populations, particularly in areas where trophy hunting occurs. Every year Tanzanian authorities welcome sportsmen from all over the world to hunt on authorized game reserves. The leopard being one of the most important and popular game species offered by hunting operators.

In addition to game reserves, Tanzania has different national parks, therefore the country offers a unique opportunity to test the actual leopard population densities in game reserves compared with national parks.

Objective.

The general objective of this project is to measure leopard densities in three Tanzanian game reserves for later comparison with published density data on other areas.

This data will then be utilized to test the hypothesis that sport hunting is not detrimental to the leopard populations within game reserves.

Data Hunters Project.

Data Hunters project (bait cameras set by Professional Hunters) started in 2017 and Dr. Arturo Caso, who is the actual PI of this project, proposed to calibrate the leopard density data obtained from 2017-2019 at bait sites using camera sites in a systematic way. This calibration process is necessary because bait sites are not set in a systematic (grid) pattern and cameras at bait sites are not active for long periods of time, therefore it was necessary to test density results with a scientifically accepted field method to compare (calibrate), both results. Methodology and results on this report preliminary is just related to the calibration grid project and in the future final report, both results (Data Hunter's and the Calibration project's) will be compared.

Study Area.

Originally the study was planned to be performed in 4 Tanzanian game reserves (Selous, Rungwa, Luganzo and Burko), however it was decided to not include Burko in the field work because this game reserve (open area) was too small to make an appropriate camera grid and during an early survey, it was found that the area was crowded with people (Masai) and cattle and there was the latent danger that the cameras may be stolen. Therefore, it was decided that the study would just be conducted in three game reserves (Selous, Luganzo and Rungwa; Fig 1). These three sites also had differences in habitat structure, being Luganzo GR considered a wet miombo area, Rungwa GR a dry miombo area, and Selous GR a combination of both (Foley et al., 2014).

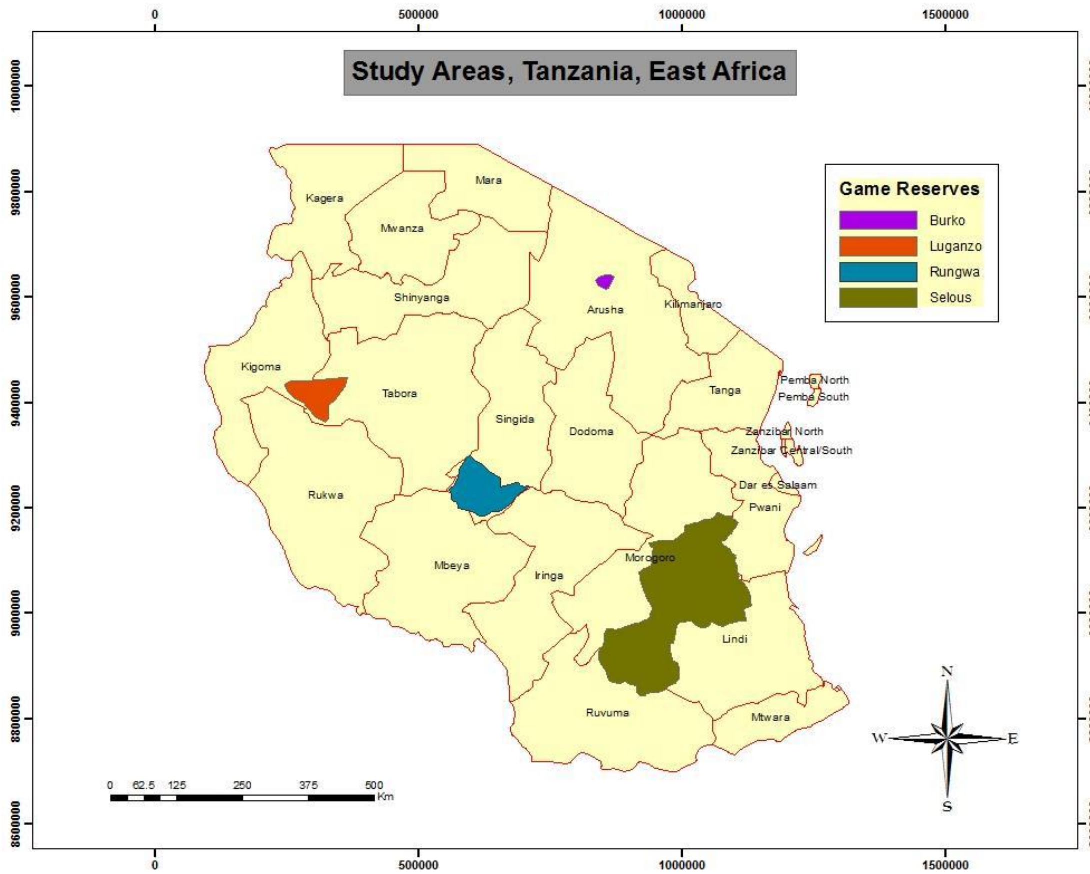

Figure 1. Surveyed game reserves in Tanzania, East Africa.

Methods.

Our methodology consisted in the use of remote-sensing camera traps since this method could be used to address large-scale questions in community ecology by providing systematic data on an array of wide-ranging species (Allen et al. 2020) and it is a suitable method to study elusive animals such as leopards. Ninety-one digital motion-activated white flash cameras (Capture and G-5086 Cuddeback models, De Pere, Wisconsin) were deployed in a grid pattern. These cameras were used to set sixty-three single-camera stations and fourteen double, with a total of 77 camera-stations (Selous 22, Rungwa 25, Luganzo 30; Fig 2). Camera-stations were set on roads and game trails and no attractant (lure or bait) was used to not affect the probability of capture on each camera station. Cameras were attached to trees or wooden poles at a height of 30 to 40 cm depending on terrain and the distance where the leopard was expected to pass, and cameras were set with a delay of 15 s. Separation between camera stations were from 1.5 to 4.5 km to ensure that multiple camera stations were present in an individual's leopard home range and no big gaps would exist between camera stations (Kalle and Quereshi 2011, Strampelli et al. 2018). Camera-stations were active for the 24-h diel and were set for maximum 53 days per site. During the length of the study, no leopards were hunted within or near the camera survey grid, so the assumption of a closed population (no animal will leave or enter the population in the survey period) was accomplished. Additionally, the CloseTest 3 program (Stanley and Burnham 1999) was utilized to test the data for closure. The stations were active, during the dry and part of the wet season (September through November), for a mean of 52 days per site. Each camera has an SD card that stored photographs and short videos and all this material was downloaded to external hard drives and stored for analyses. Photographed leopards were identified visually by their spotting patterns but also with the aid of HotSpotter computer software (Nipko et al. 2020). In some instances, the double camera stations recorded both sides of leopards and this facilitated individual identification. For every leopard photographed and identified, a code, that included camera station, ID number, sex and game reserve, was designated.

For leopard density estimation, independent photographic events (at least 30 minutes between consecutive photos of same individual) were just considered as an independent

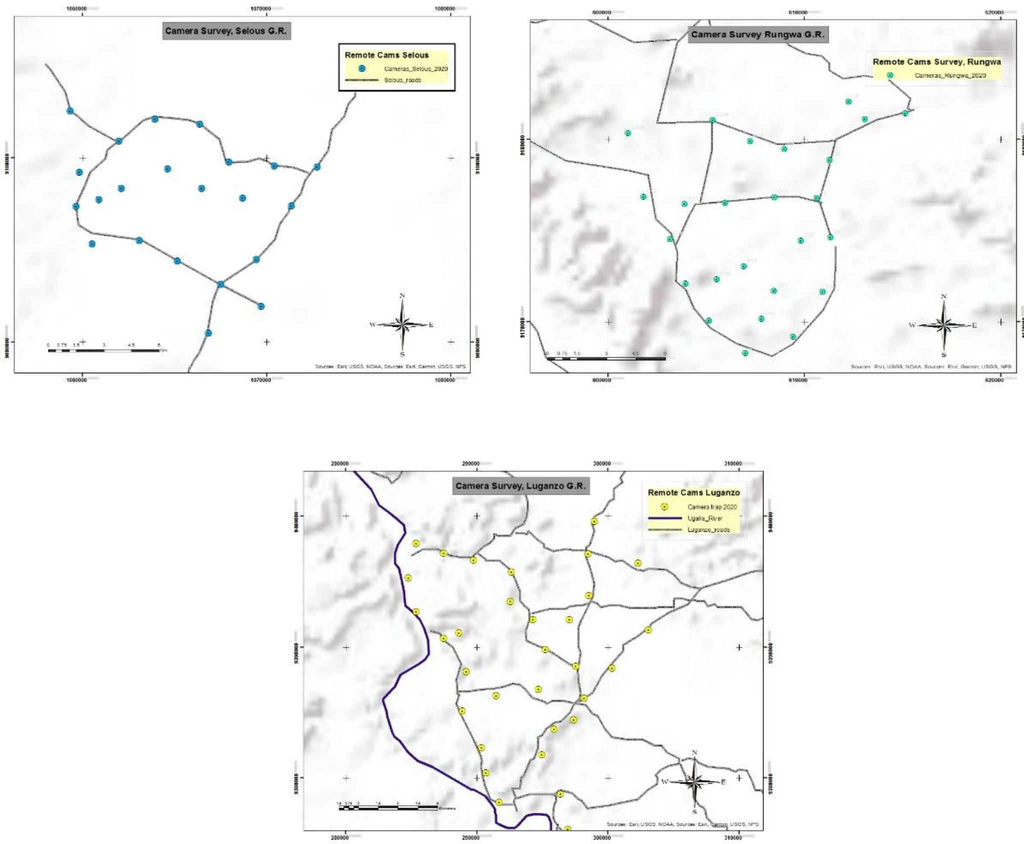

Figure 2. Camera design in Selous, Rungwa, and Luganzo game reserves, in Tanzania, East Africa.

event. Time, moon phase, and habitat type were also recorded for each leopard photo obtained. Camera stations were positioned to create an effective sampling area and camera separation facilitated to run the spatially explicit capture-recapture (SECR) program (Efford, 2016). To estimate leopard density, the "SECR" program (Spatially Explicit Capture Recapture) was used, which is a spatially explicit statistical capture-recapture package (Efford, 2016). The main assumption of this model is that the individuals of the species of interest are distributed independently in space and that they occupy established distribution areas. The mechanism to perform the detection is represented by a mathematical function that describes the decreasing probability of an animal of being detected as its distribution center moves away from a detector.

Results.

During the duration of the field study (September 18 - November 21, 2020), a total of 3,762 trap nights (number of camera stations x nights) were obtained in the three game reserves. We also obtained 113 leopard photos (see Appendix I) and 104 independent events, with 31 individual leopards. (Table 1).

Table 1. Camera and photo results in three game reserves of Tanzania, East Africa.

Game reserve	Camera stations	Nights active	Trap nights	# Leop photos	Ind. events	Individual leopards	Sex ratio
Selous	22 (4D)	52	1,144	24	**21**	**11**	6M ; 5F
Rungwa	25 (5D)	52	1,226	58	**55**	**7**	2M ; 5F
Luganzo	30 (5D)	53	1,392	31	**28**	**13**	7M ; 6F
TOTAL	77	Mean 52	3,762	113	**104**	**31**	15M ; 16F

SECR program suggested to use the null model (M_0), where it assumes all members of the population are equally at risk of capture on every trapping occasion. Buffer width was increased (15,000 m) around the camera sampled area until density was stabilized, assuring that no individual outside the buffer area could be captured (Boron et al., 2016; Strampelli et al., 2018). Leopard density results obtained are shown as number of leopards per 100 km² (Table2). Therefore, our density results were: Selous GR 5.85 (SE ±2.4) leopards/100 km², Rungwa GR 7.18 (SE ±3.7) leopards/100 km², and Luganzo GR of 4.66 (SE ±1.8) leopards/100 km² (Table 2).

For Luganzo GR we ran CAPTURE program since the standard error was too big using SECR program (Table2). CAPTURE program has been widely used by previous wildlife camera studies (Bouliner et al, 1998) and this program suggested to use jackknife model (M_h) as an estimator for leopard density. Jackknife model incorporates heterogeneity and assumes that each individual has a unique capture probability. To establish an effective area of sampling, a buffer (circle) for this program was calculated using the maximum mean distance moved (MMDM) of each individual photographed at two or more stations (Silver et al., 2004). Buffers were created around each camera station and were combined to obtain the final effective sampling area (Silver et al., 2004; Balme et al., 2009).

Table 2. Estimated leopard density in three game reserves of Tanzania, East Africa.

Game Reserve	Program	Buffer Area	Model	Estimated Density Leopards/100 km²	Standard error (SE: 95% CI)	Effective Area (km²)
Selous	SECR	15,000	Null model (M_o)	**5.85**	2.4	141.26
Rungwa	SECR	15,000	Null model (M_o)	**7.18**	3.7	141.67
Luganzo[1]	SECR	15,000	Null model (M_o)	**2.42**	7.97*	197.37
Luganzo[2]	CAPTURE	80,000	Jackknife model (M_h)	**4.66**	1.8	664.7

* Extreme standard error

Discussion.

It is important to mention that this study was one of a kind since no other project had surveyed three study areas in such as small period. We set the camera stations in one area and then continued to the next and then to the third, so the three areas were surveyed almost at the same time. The objective was to set the camera stations for at least 60 days on each game reserve but because the rains came earlier and there was the danger of not being able to pick up cameras, the study was shortened to 52 days per area. The shorter sampling time, however, makes results more strict and therefore more reliable (Karanth et al., 2006).

Leopard density results in the three game reserves (Table 2) indicated that at least during the length of the study period (dry season), the leopard density was alike (with similar methodology), or even higher except for Luganzo GR, to the recent publication about leopard density at Serengeti national park, where the authors report 5.41 (SE ±3.2) leopards/100 km² (dry season) and 5.72 (SE ±3.3) leopards/100 km² (wet season) leopards/100 km² (Allen et al., 2020).

For Luganzo GR, even that the number of photos and individuals were not small (Table1), cameras were set in a bigger area (Table 2) and therefore this may have caused the extreme standard error obtained with SECR program (Table 2). However, with CAPTURE program and with the estimator (Jakknife) suggested by this program, density results were not low compared to other African leopard studies, such as Srampelli et al., 2018 where they report 2.96 (SE ±2.4) leopards/100 km² in Mozambique and 1.0 (SE ±0.7) leopards/100 km² in Waterberg Plateau Park, Namibia by Stein et al., 2011. Although our study was done for just one season, our results may show that the leopard population in these three game reserves is in carrying capacity and therefore, sport hunting has not been detrimental for the leopard populations.

As stated, these results are just about the field grid study done from September 18 - November 21, 2020, and they will be compared in detail later with what has been obtained for the Data Hunters project (cameras at bait sites) as it was proposed as a long-term population survey. However, a preliminary comparison shows that probably bait camera's results are under-valued, because grid camera results showed higher leopard densities as they were obtained with bait cameras. For example, four leopard bait camera results at Selous GR showed a mean density of 3.1 (SE ±0.24) leopards/100 km^2, while in this grid study, we obtained a density value of 5.85 (SE ±2.4) leopards/100 km^2 in the same game reserve (Table 2). However, further analysis is needed for the other game reserves sampled in both studies.

The IUCN has made the statement that it is imperative that leopard populations should be monitored throughout its range to know their actual status (Stein et al., 2020). However, scientific field work requires time and funding, so this initiative to support this field project by hunting organizations speaks out of the great interest of hunters on preserving the species in their hunting areas.

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Vita.

Dr. Arturo Caso has a M.S. in Range and Wildlife Management and a Ph.D. in Wildlife Ecology from Texas A&M University-Kingsville. For over 25 years, Dr. Caso has conducted field studies over different carnivores in the U.S. and Mexico including the jaguar, ocelot, mountain lion, and black bear. In addition, he did a leopard study in Tanzania, using GPS collars, from 2001 to 2003 and he was the first scientist to use this methodology in wild leopards. Also, Dr Caso did a lion and leopard population camera survey in 2011. Dr. Caso is a member of the IUCN Cat Specialist Group and he has worked as a Research Associate for the Caesar Kleberg Wildlife Research Institute. Today, Dr. Arturo Caso is the President of NGO Predator Conservation, A.C.

Appendix I. Example of leopard photos obtained at three game reserves of Tanzania in 2020.