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Abstract: By the end of 1994, 14 adult cheetahs had been successfully released into the Matusadona National Park (MNP), Zimbabwe. These cheetahs had been captured on commercial ranches in the southern part of the country where they had been reported to be causing stock losses. No feasibility analysis of MNP was carried out prior to the translocation. The park has a relatively high density of lions (0.31/km2) and a density of hyenas of 0.13/km2. Four years after the translocation, 13 adult and four juvenile cheetahs were present in the park (giving a density of 0.035 /km2). There have been five records of breeding and two records of cubs surviving to adulthood since the cheetah were released. The cheetah in the park showed a preference for the ecotone between the woodland and foreshore. The cheetahs utilized the foreshore for hunting and feeding and the woodland for resting and moving through the park. The tree-line was used most often at the same time of the day as most hunting was observed suggesting that it is used prior to a hunt. The thick woodland vegetation of MNP seems to be providing the introduced cheetah with an opportunity to avoid adverse interactions with lions and hyenas and the translocation up to the present date has been a success. There is concern that the behaviour of the cheetahs may limit the size of the population to below that which is viable.

THE MATUSADONA CHEETAH PROJECT: LESSONS FROM A WILD-TO-WILD TRANSLOCATION.

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Abstract: Bt the end of 1994, 14 adult cheetahs had been successfully released into the Matusadona National Park (MNP), Zimbabwe. These cheetahs had been captured on commercial ranches in the southern part of the country where they had been reported to be causing stock losses. No feasibility analysis of MNP was carried out prior to the translocation. The park has a relatively high density of lions (0.31/km^2) and a density of hyenas of 0.13/km^2. Four years after the translocation, 13 adult and four juvenile cheetahs were present in the park (giving a density of 0.035 /km^2). There have been five records of breeding and two records of cubs surviving to adulthood since the cheetah were released. The cheetah in the park showed a preference for the ecotone between the woodland and foreshore. The cheetahs utilised the foreshore for hunting and feeding and the woodland for resting and moving through the park. The treeline was used most often at the same time of the day as most hunting was observed suggesting that it is used prior to a hunt. The thick woodland vegetation of MNP seems to be providing the introduced cheetah with an opportunity to avoid adverse interactions with lions and hyenas and the translocation up to the present date has been a success. There is concern that the behaviour of the cheetahs may limit the size of the population to below that which is viable.

INTRODUCTION

Cheetah are sparsely distributed throughout the Parks and Wildlife estate in Zimbabwe, the latest census (1996) estimating 50 – 75 animals altogether (Heath, personal communication). On commercial ranches in the country cheetah have increased in numbers since 1980 (approximately 5000 in 1996) to the point where they are now considered "problem animals" as they prey on domestic stock[4]. In 1993, in response to requests from farmers in the southern part of the country to remove cheetah from their properties, the Department of National Parks and Wildlife Management, with assistance from local conservation organisations, translocated a total of 21 animals to Matusadona National Park (MNP)[13]. The translocation took place over a period of two years and 14 adults and three cubs survived to be released[16]. Six of the cheetah released were fitted with radio collars which have never been removed.

MNP is situated along the shores of Lake Kariba in Zimbabwe. It comprises two distinct areas, one termed the escarpment and the other the valley floor[15]. The escarpment is dominated by miombo woodland and is characterised by steep-sided valleys. During the dry season there is very little water available in this section of the Park with only a few springs providing water all year round. The vegetation of the valley floor is predominantly *Colospermum (*Mopane) - *Combretum – Terminalia* woodland with little grass production. However, changes in the level of the lake have exposed an area of foreshore that has been colonised by a highly nutritious, productive species of grass, *Panicum repens*[15]. The area of this habitat changes with lake levels and was recorded as 44 km^2 during this study as compared to 102 km^2 during the 1995 study[16]. There is a distinct boundary between the woodland and the foreshore, commonly known as the "treeline".

MNP was chosen for the translocation because it had no resident population of cheetah and the productive strip of grassland along the shores of the lake supports a large prey population[13]. There was no feasibility study carried out prior to the translocation but a population viability analysis was done in 1995. This analysis used population parameters estimated from studies carried out on cheetah in the Serengeti as there were no data available for the introduced population[16]. This study found that prey was unlikely to be a limiting factor but cheetahs would be unlikely to persist in MNP because of the relatively high density of lions (0.2/ km^2) which are known to kill a large percentage of cheetah cubs in other parts of Africa[6].

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Macnab argued that many ecological hypotheses remain untested despite the numerous opportunities present in natural resource management to test them[9]. The translocation of cheetah to MNP is a case in point where there is an opportunity to test hypotheses about the interactions between the large predators of the Park because of a management decision to manipulate the system. This paper attempts to show that the introduced cheetah population appears to be viable despite the high density of lions in the park. It also suggests that the ecotone between the foreshore and the woodland, and the woodland itself is enabling the cheetah to avoid adverse interactions with the other predators of the park.

METHODS

The number of cheetah present in the park in 1998 was estimated from sightings of cheetah by people using MNP and from personal observations. Sighting sheets were distributed to tour operators, National Parks scouts, houseboat captains and local fishermen because all these groups were likely to see cheetah. On each sighting sheet the location, time of day, activity of the cheetah (walking, resting, hunting and eating), and the habitat type (foreshore, treeline, woodland or riverine) was recorded. In addition the observer was asked to record any identification markings of the animal. The last 20cm of the tail of a cheetah are unique and can be used for identification[16]. This survey was run for a period of six months from February until July 1998. Similar records were kept of personal observations of cheetah during the same period. These records were cross-referenced to estimate the number of cheetah present in the Park. The data from the sighting sheets was also used to determine habitat preferences of the cheetah.

In addition records were used from a continuous monitoring programmed, involving the tour operators and the Parks scouts, which had been set up soon after the cheetahs were released.. This programme provided sighting sheets which recorded the number of animals seen and the location of the animals. It provided a valuable source of information on the number of cubs seen in the park from the time of the translocation until the present date.

The above data was then used to estimate a number of population parameters. It was not possible to estimate litter size at birth because cubs were only observed after they had begun to move with their mother (at an age of about three months). It is this litter size that is estimated in this paper (referred to a "post-emergence" litter size) and therefore the estimate of average litter size is probably less that the actual because it does not take into account deaths during the first three months. Juvenile mortality was estimated by dividing the number of cubs known to have died by the number of cubs known to have survived

The founder population of cheetahs comprised eight males, six females and three cubs (two males and one female). At the end of 1995 all these females had been released. Using the average litter size and assuming that every female bred, had at least one surviving cub and the sex ratio of cubs was unity, it is possible to estimate how many adult cheetah there should be in the Park if no mortality had occurred. By the end of 1995, six females would be breeding, producing 17 cubs of which 7 (four females and three males) would survive to adulthood. By 1997 eleven females would be breeding, producing 31cubs of which 12 (six females and six males) would survive to adulthood. At the beginning of 1998, there should be 22 adult cheetah (11 females and 11 males) and 12 juveniles (six females and six males). By comparing this figure with the number actually present an estimate of adult mortality can be made.

Population viability analysis was then carried out using the simulation software VORTEX (Version 7.0)(IUCN Conservation Breeding Specialist Group) as this was the software that was used in the initial population viability analysis[16]. This computer simulation model is a Monte Carlo simulation of the effects of deterministic forces, as well as demographic, environmental and genetic stochastic events on wildlife populations[5]. It models population dynamics as discrete sequential events that occur according to probabilities that are random variables, following user-specified distributions[5]. It was developed specifically for analysis of long-lived species such as mammals[5]. A number of simulations are run to estimate the mean probability that the population will go extinct. During this study simulations were run 100 times and tested whether the population would persist for 50 years.

Three cheetahs (two males and a female with a cub) were fitted with radio-collars as part of the study to determine the habitat preferences of the introduced cheetah. These cheetah were located on average once a

week. Each time a radio-collared cheetah was seen the location, activity, habitat type and time of day were recorded. The habitat preferences of the cheetah was calculated using preference ratios:

$$PR = U/A$$

where U = the number of sightings in a habitat divided by the total number of sightings and A = the area of the specific habitat divided by the total area[11]. Chi-squared analysis was used to determine if the cheetah preferred specific habitats for certain activities.

RESULTS

Number of cheetah in the Park

There were a total of 28 public sightings of cheetah between February and July 1998. Five of these sightings (three females and two males) recorded tail markings or the presence of collars and the cheetahs could be positively identified. These cheetah were different to the ones radio collared (two males and a female).

In addition to these sightings that recorded identification features, five other adult cheetah are thought to be present in the park; a pregnant female was seen three times in the same area of the park, three cheetah were seen on the same day approximately 60km apart from each other and another adult was seen three times near the southern edge of the park in the foothills of the escarpment and is thought to be locally resident there. This gives a total of 13 adults. Four cubs were seen altogether between February and July 1998.

There have been eight records of cubs, which were conceived after the release of the cheetah into the park (Table 1). Some of these sightings were of the same litters, but six separate litters were identified giving an average litter size of 2.8 cubs (number of cubs seen with a female divided by the number of females)

Table 1: Sightings of cubs during the period July 1995 to July 1998.

Date	Number of cubs	Location
April 1995	3 cubs seen with uncollared female	Kemurara
28/6/96	3 cubs seen without adult	Chifudze
1/8/96	4 cubs seen with adult female	Fothergill
10/8/96	3 larger cubs seen with different female	Kemurara
22/8/97	2 subadults and 1 adult *	Kemurara
16/11/97	1cub seen with female	Fothergill
18/12/97	3 cubs seen with female	Kemurara
14/2/98	1 cub seen with female	Fothergill

*Reported as adult in September 1997. In January 1998 two young adults seen on their own in the Jenge area. These may be the surviving cubs of the litter observed in August 1996

Two of these litters were observed until the cubs became independent. One cub survived from the litter of four seen in August 1996 and one cub survived from the litter of one seen in November 1997. This gives an estimate of 60% post-emergent juvenile mortality.

The total number of cheetah observed in the Park was 13 adults and four juveniles. Comparing this figure to the total that should be present if there had been no mortality gives an annual adult and subadult mortality rate of 20.45%

It is known that one of the original males collared was snared in the Omay communal lands before the end of 1995, and that a male was found dead in a tree in 1997 (Tour operator sighting). Two females released with radio collars are known to move out of the park but it is not clear if they have left the park completely

because up until June 1996 there were seen periodically in the Park. Since then the collars have stopped working and they have not been located with any degree of certainty.

Habitat preferences

The cheetah showed a very strong preference for the ecotone between the woodland and the foreshore both in analysis of data collected from public sightings (PR = 16.39) and radio-tracking of collared cheetah (PR = 11.29). The foreshore was preferred over the woodland in both the public (PR(F) = 4.65 and PR(W) = 0.35) and collared (PR(F) = 1.42 and PR(W) = 0.82) analyses although the difference is more pronounced in the public data analysis.

The foreshore was used predominantly for hunting and feeding, the treeline for resting and the woodland for resting and walking (Chi-squared test of association: n = 62, $\lambda^2 = 15.433$, df = 6. $0.025 > P > 0.01$) (Table 2)

Table 2. Number of cheetah activities observed in different habitats (collared cheetah)

ACTIVITY	Resting		Walking		Hunting		Eating		Total	
	Obs	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**	**Obs**	**Exp**
Habitat type										
Foreshore	2	*2.58*	2	*5.32*	2	*0.81*	4	*1.29*	10	*10*
Treeline	0	*1.81*	6	*3.73*	0	*0.56*	1	*0.90*	7	*7*
Woodland	14	*11.61*	25	*23.95*	3	*3.63*	3	*5.81*	45	*45*
Total	**16**	***16***	**33**	***33***	**5**	***5***	**8**	***8***	**62**	***62***

The treeline was used at the time of day when most hunting was observed (Figures 1 and 2). The woodland was used during the middle part of the day when the cheetahs were resting or moving through the park (Figures 1 and 2).

Vortex simulation

It was assumed that the population existed in isolation and there was no migration into and out off the park. Cheetahs are polygamous, with females breeding at two years of age and males at four (although some may breed younger than this)[1]. All males were assumed to be in the breeding pool. Male cheetahs appear to adopt two strategies to find mates, either holding a territory or roaming over a large area looking for mates[2]. It can be assumed, therefore, that most males will find and mate with at least one female. Average age at the time of death in MNP was eight (observations made during this study). There is usually an even sex ratio at birth[8] and the average litter size recorded in MNP was three cubs. Reproduction was assumed to be density independent but variation in reproduction was correlated with variation in survival due to changes in the environment. No inbreeding depression was incorporated as cheetahs are known to be inbred. All females were assumed to breed with 3% producing one cub, 9% producing two cubs and 88% producing three cubs (estimated from observations of litters sizes in this study). Juvenile mortality was entered as 60% and adult mortality as 20.5%. From observations of the cheetahs in the Park, the population was estimated to consist of three females and one male below the age of two (juveniles), five females and three males between the ages of three and five, and two females and three males between the ages of six and eight. The carrying capacity of the park was assumed to be 45 animals, calculated from the average equilibrium density of 0.1cheetahs/km^2 in areas under 500km determined by East[3].

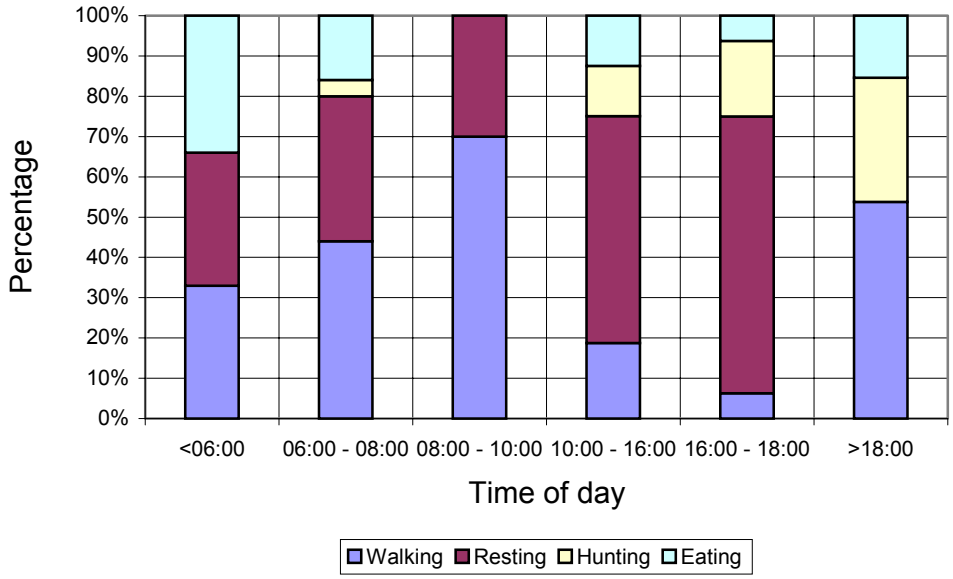

Figure 1: Cheetah activities during the day

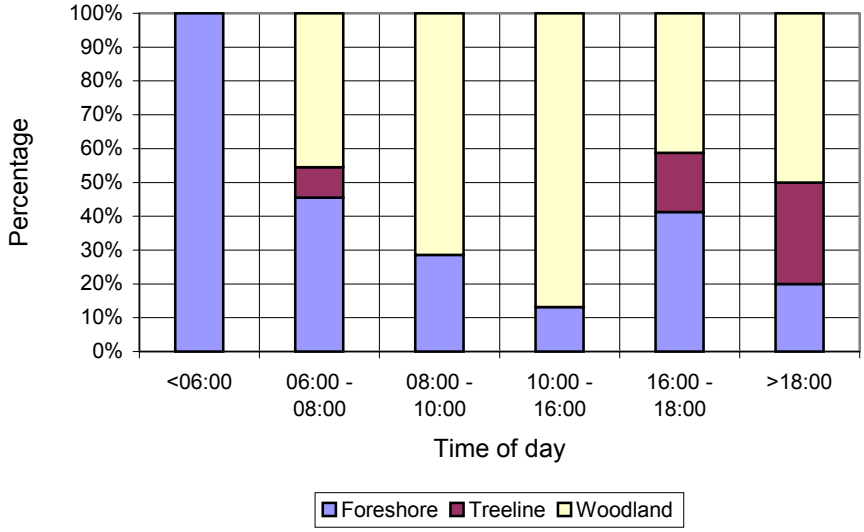

Figure 2: Habitat use by cheetahs during the day

The results of the VORTEX simulation suggests that there is a 100% chance that the population will be successful. However, a carrying capacity of 45 individuals is the maximum possible and the reality may be much lower than this. If the carrying capacity of the park is reduced to less than 30 individuals, but all other parameters are the same, simulations of VORTEX suggest that the population would no longer be viable (probabilities of extinction in a hundred years increases to 10%).

DISCUSSION

The population parameters for the Matusadona cheetah appear to be different from that which would be expected with such a high density of lions (0.31/km^2, 1998 estimate). The average post-emergence litter size (2.8 cubs) was higher than the Serengeti population (2.2 cubs)[6]. In the Serengeti ecosystem lions kill about 58% of cubs before they emerge from the lairs[7] although the density of lions in the Serengeti ecosystem is only 0.1/km^2[2, 14]. The litter size (post-emergence) of 2.8cubs as was recorded in this study suggests that the cheetahs are able to avoid predation of cubs in the first three months to a large extent. However, in areas of Africa where cheetahs are the terminal predator the average litter size appears to be closer to 4 cubs[10, 12]. This suggests that some cubs are lost in Matusadona but whether this is due to predation or to other factors is unknown.

The post emergence mortality recorded for the Matusadona population is less than that expected where lions and hyenas and hyenas are present. Post emergence mortality in the Serengeti is very high (83.3%) with spotted hyenas accounting for 41.7% and lions for 33.3%[6]. The relatively low density of hyenas in the valley floor of MNP (0.13/km^2, 1998 estimate) may be one reason why the mortality recorded in Matusadona is less (60%) than that of the Serengeti ecosystem where the density of hyenas is 0.4/km^2[2, 14]. The presence of thick vegetation may enable females to effectively hide cubs and allow cubs to disperse and hide themselves if attacked by another predator. During this study period a female with an eight month old cub was observed being chased by two lionesses. She and the cub separated, disappeared into thick bush and the lionesses gave up the chase. However, some cubs must be lost to predation or other factors in Matusadona , as studies of cheetah were other predators are absent record a 85% success rate in raising cubs to adulthood[10, 12] whereas only 40% of cubs in MNP reach adulthood (estimate recorded during this study).

The preference shown by the cheetahs for the open foreshore for hunting and eating and the woodland for resting and moving through the park, also support the hypothesis that the habitats available in Matusadona are enabling the cheetah to avoid adverse interactions with the other predators. Cheetahs can take advantage of the open habitat for killing prey but can use the treeline to stalk. This situation is ideal for cheetahs who cannot maintain a chase for long and require cover to stalk[1]. The woodland provides a refuge where the cheetahs can remain undetected while they are resting or moving around. Studies in the Serengeti have shown that male cheetahs set up territories in areas where cover is available as this is an important resource for females[2]. Similarly when cheetahs were introduced into Suikerbosrand reserve they were observed to use the ravines and gullies for hunting rather than the open grassland[12]. In Kruger National Park, cheetahs showed a very strong preference for the open grassland and hunted in the late morning and early afternoon[11] but this could be a response to the threat of kleptoparasitism in this park where hyenas were recorded to take 14% of cheetah kills. In MNP, no cheetah kills were observed to be stolen by hyenas.

Population viability analysis of the MNP population with a relatively low mortality rate and a high carrying capacity illustrates that the population will persist (100% chance of success). However, the viability of the cheetah population in MNP may not be dependent on the mortality rates of cubs but on the mortality rate of young adults the effect of which has yet to be determined as the cheetah were only introduced 4 years ago. In Kruger National Park the most significant mortality was that of subadults and young adults who were forced by already established cheetahs, to disperse into suboptimal habitat (Mills, personal communication). In the Serengeti ecosystem, 50% of adult males are lost due to intraspecific competition over access to territories[8]. Although territorial systems in cheetah are not properly understood it is known that they will avoid contact with each other, resulting in a "time-plan" territorial system where scent marking is used to warn other cheetah[12]. This behaviour may limit the number of cheetah that are able to use an area reducing the carrying capacity. In MNP, subadults and young adults may be being forced out of the park into the surrounding communal lands by the adult cheetah already established in the park. At present this effect is minimal as the cheetah are still expanding into the park. The records of a cheetah towards the southern part of the park in the foothills of the escarpments provide some evidence that the cheetahs in the park may have used up all the available land. If the amount of suitable land within the park limits the population below a carrying capacity of 30 individuals then VORTEX population would not be viable. This effect will only become noticeable in the near future.

CONCLUSION

The translocation of cheetah to MNP has provided some useful data in that it seems that cheetahs are not always adversely affected by lions and hyenas if the available habitat enables them to avoid adverse interactions. Caro[1]argues that cheetah display all the characteristics of species that adapt well to translocation; toleration of a wide variety of habitats, a broad range of prey species, exploratory and amenable to behavioural changes. The MNP translocation provides evidence that cheetah adapt quickly to new environments and use the available resources to their advantage. Conservation of cheetahs in areas where other predators are present may not be the lost cause that previous studies have argued[6, 1]. Different environments seem to affect the intensity guild interactions and each potential cheetah re-introduction programme must bear this in mind. The other interesting question which arises form the MNP translocation is whether the behaviour of cheetahs has the potential to limit the size of an introduced population to below that which is viable. The MNP translocation suggests that it is important to understand how a translocated population uses its new environment, not only immediately after release but also in the long term as behaviour patterns may affect the success of the introduced population.

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