Bianco F, Bracchi PG. 2001. Captive bred cheetah behaviour. Annali della Facoltà di Medicina Veterinaria 21:47-60.

Keywords: Acinonyx jubatus/behaviour/captivity/cheetah/husbandry

Abstract: Cheetahs are known as the most difficult cat to breed in captivity. There are three theories as to the source of the cheetah breeding problem: 1) cheetah population had gone through a bottle neck period; 2) most of the male sperm are non functional; 3) low behaviour quality in captivity, it seems that males need to be primed for the mating. The aim of this project is to investigate the behaviour of mother and cubs and male in captivity to evaluate the quality of the husbandry (enclosure, different kind of play distance of the cubs from the mother, vocalisms, pattern of behaviour, similarity to in-situ behaviour). On 1999 eight cubs were born at Marwell zoo (England) after the husbandry of this species was reastablished an year earlier. The specimens studied were a female born 1992 and her eight cubs and the male born 1990 . The female enclosure was divided in eight zones considering the microhabitats available then the behavioural categories to observe were picked up. The male 56 enclosure was split up exclusively on geometrical basis. We used one stop intervals of three minutes for the female and zero one for intervals of three minutes for the cubs, with ad libitum observations from 8 a.m. till 7.30 p.m. reaching a total of 84 h. The male was observed for 35 hours with focal sampling two times a day. The new management adopted by Marwell zoo is an adaptation of the six steps husbandry developed in America that is most of the times impossible to realise in european zoos. This new technique lead to the birth of a record offspring and increased the behaviour of these animals using the same enclosure with minimal economical impact.

CAPTIVE BRED CHEETAH BEHAVIOUR

Bianco Federico[1], Pier Giovanni Bracchi[2]

Introduction

The cheetah (*Acinonyx jubatus* Schreber, 1776) is built for speed, with a deep chest, wasp waist, and proportionately longer limbs than the other big cats (Gonyea 1976). Average adult weight is 43 kg for males and 38 kg for females in the Serengeti (n= 17: Caro *et al* 1987). Flexion of the elongated spine has been measured as increasing, the cheetah's stride length by 11 % at speeds of 56 kph (Hildebrand 1959, 1961). The canines are small relative to other felids: a reduction in the size of roots of the upper canines allows a larger nasal aperture for increased air intake, which is critical for allowing the cheetah to recover from its sprint while it suffocates its prey (P. Leyhausen in Ewer 1973, Kingdon 1977). Its claws remain exposed, lacking the skin sheaths found in most other felids, and thus provide additional traction like a sprínter's cleats. The foot shows several other modifications: the digital pads and also the metacarpal pad are extremely hard and pointed at the front, possibly as an adaptation to sudden breaking, and the palmar pads bear a pair of longitudinal ridges instead of the more usual slight depressions-the functional equivalent of tire treads, serving as anti-skid devices (Pocock 1916, Ewer 1973). The prominent dew claws are used as hooks to trip up fast-running prey. The long tail helps the cheetah's balance as it swerves during a chase. Finally, the cheetah has enlarged bronchi, lungs, heart, and adrenals (Eaton 1974). According to K. Sevrin (pers. comm. in Eaton 1974: 24), a captive cheetah was accurately clocked at 112 kph over a short distance. In the wild, out of 78 chases measured and timed by G. Frame (Frame and Frame 1981: 181), the top speed was 87 kph. Antelopes, the main prey of cheetah, reach top speeds of 80-97 kph (Garland 1983), so peak speeds reached at some portion of a cheetah's sprint probably do exceed the oft-quoted, but seldom documented, 110 kph. Cheetah sprints rarely last longer than 200-300 m, while most antelope can run much further. Heat builds up rapidly during a sprint, and cheetahs have not evolved the evaporative heat release mechanisms of gazelles and goats, even though their energetic cost of running is equivalent (Taylor and Rowntree 1973, Taylor et *al*. 1974). Cheetahs are pale yellow with white underbellies, covered all over with small round black spots. They are readily distinguished from their spotted relatives by their "tear lines"-heavy black

[1] Medico Veterinario, dottorando in Endocrinologia degli Animali Domestici vetfred@libero.it
[2] Dipartimento Prod Anim. Biotec. Vet. Qual. Sic. Alim, Facoltà di Medicina Veterinaria, Università degli studi di Parma

lines extending from the inner corner of each eye to the outer corner of the mouth. Both melanistic and albino cheetah specimens have been reported (Guggisberg 1975), and remarkably pale animals have been reported from desert regions (Draesco-Joffé 1993, P. Gros *in litt.* 1993). A more notorious single-locus genetic mutation (Van Aarde and Van Dyk 1986) produces the blotched tabby pattern of the so-called king cheetah, which was once classified as a separate species (Pocock 1927), and was the subject of a major investigative expedition (Bottriell 1987). This mutation has historically been recorded only from a restricted area in southern Africa centered on Zimbabwe (Hills and Smithers 1980), but there is a recent report of a single skin recovered in Burkina Faso, west Africa (Frame 1992).

A greater degree of sociality has been observed among cheetahs than for most felids, with the exception of the lion. Male and female littermates tend to stay together for about six months after independence (Caro 1994). Nearly two decades of intensive research in the Serengeti Plains have shown that. While females split off upon reaching sexual maturity, male littermates remain together in coalitions, and sometimes defend territories (Frame and Frame 1984, Caro and Collins 1986). These coalitions, particularly trios, that include unrelated males, with the frequency of this type of grouping estimated at 15% in the Serengeti (Caro and Collins 1986). Males in coalitions are more likely than solitary mates to gain and maintain territories; non-territorial males live a nomadic existence and wander widely (Caro and Collins 1986, 1987a). Territorial males were found to be in better physiological condition and appear to have better access to females during periods of gazelle concentration (Caro and Collins 1987b, Caro *et al* 1989).

In east Africa, the cheetah's main prey is the Thomson's gazelle on the plains (Serengeti: Schaller 1968), and impala in the woodlands (Eaton 1974). In the arid bush land of northern Kenya, G. Adamson (in Hamilton 1986a) identified lesser kudu, gerenuk, and dikdik as major prey. In southern Africa, major prey consists of springbok. Data are scarce for central and west Africa, but cheetahs have been observed to take red hartebeest, oribi, and kob in ManovoGounda-St. Floris National Park in the Central African Republic (Ruggiero 1991). Cheetahs are also known to take smaller prey, particularly hares (Frame 1977, Labuschagne 1979, 198 1), and male coalitions often take much larger prey, such as wildebeest (Dorst and Dandelot 1969, Eaton 1974, McVittie 1979, Caro and Laurenson 1990, Skinner and Smithers 1990).

Biology

Reproductive season: (W) year-round, although birth peaks have been reported during the rainy season in the Serengeti (November-May: Frame 1977, Laurenson *et al.* 1992).
Gestation: (C) 90-98 days (Marker-Kraus 1992).
Litter size: (W) 4.2 (age 1-3 months) on Namibian ranch land (McVittie 1979); 3.5 (age 6-35 days; Laurenson et al. 1992) - 2.6 (age three months; Frame 1977) in the Serengeti; (C) 3.7 (Marker and O'Brien 1989), range 1-8 (Green 1991).
Interbirth interval: (W) 15-19 months (McLaughlin 1970, Schaller 1972). Females readily go into oestrus and conceive after losing a litter. Laurenson *et al.* (1992) found that the interval between the death of the previous litter and the next succes-

sful conception was longer for young (86.3 days, n—3) than adult females (17.8 days, n—9).
Age at independence: (W) mean 18 months (Laurenson et al. 1992), range 13-20 months (Frame 1984) (sub-adults leave mother); 17-27 months (females leave sibling groups: Frame 1980, Laurenson *et al* 1992).
Age at first reproduction: (W) females 24 (n=2: Schaller 1972) - 36 months (n=4: Laurenson *et al.* 1992); males 30-36 months (Caro 1991). (C) females 2-3 years (n=10); males 1-2 years (n=8) (McKeown 1992).
Age at last reproduction: (C) females 10 years; males up to 14 years (McKeown 1992).
Sex ratio: (W) cubs: 1 male:0.95 female (n= 1 17); adults and independent sub-adults: 1 male: 1.9 females (n= 169). This suggests differential male dispersal and mortality (Frame and Frame 1984), although males can be shyer than females and more difficult to observe (Caro and Collins 1986).
Juvenile mortality: (W) Other large carnivores, as well as baboons (L. Marker-Kraus *in litt.* 1993), are known to kill cheetah cubs.
Longevity: (W) 12-14 years (Frame and Frame 1980). However, Laurenson (in press) estimates the mean life expectancy of females reaching three years of age in the Serengeti at only an additional 3.9 years. Territorial males probably live longer, on average, than single males (Caro and Collins 1986, Caro *et al.* 1989). (C) average 10.5 and up to 21 years (L. Marker-Kraus *in litt.* 1993).

Habitat and Distribution

Cheetahs are distributed primarily throughout the drier parts of sub-Saharan Africa (Fig. 3). They are not generally associated with forest habitats and are absent from the Sudano-Guinean forest savannah belt of west Africa (Myers 1975). However, although cheetahs are most frequently observed on open grassy plains (e.g. Schaller 1972, Mills and Biggs 1993), they also make extensive use of bush, scrub, and open woodlands (Myers 1975, Hamilton 1986a, Morsbach 1987). Observations by Eaton (1974) suggest that cheetahs expend more energy hunting in open country than in cover. A mosaic of woodland and grassland is probably preferred. Cheetahs are well-adapted to living in arid environments. They are not obligate drinkers and, in the Kalahari desert, have been estimated to travel an average of 82 km between drinks of water. They were observed to satisfy their moisture requirements by drinking the blood or urine of their prey, or by eating tsama melons (Labuschagne 1979, 1981).

Population Status

Global: Category 3(A). Regional: Category 2(A). IUCN: Vulnerable. The total number of cheetahs in sub-Saharan Africa has been variously estimated at 15,000 (Myers 1975), 25,000 (Frame 1984), and 9,000-12,000 (Kraus and Marker-Kraus 1991), and a wide-ranging survey is in progress to develop a better grasp of the cheetah's current status (P. Gros, in prep.). The two largest metapopulations of cheetah are now believed to occur in east Africa (Kenya and Tanzania) and southern Africa

(Namibia, Botswana, Zimbabwe and Zambia) (Kraus and Marker-Kraus 1991, Gros 1990 and *in litt.* 199 1).

Density and abundance vary widely according to environmental conditions, especially the occurrence of suitable prey and other large predators (Laurenson in press). In the Serengeti Plains ecosystem, cheetahs concentrate seasonally in association with migratory movements of Thomson's gazelle (Durant *el al.* 1988).

Estimating cheetah density is complicated by their unusual social organization. Both solitary male and female adults are semi-nomadic, having large, overlapping home ranges of the order of 800-1,500 kM2 (Frame 1980, Morsbach 1987, Caro 1994). Coalitions of males, on the other hand, have been found (in the Serengeti) to defend small territories of the order of 12-36 kmq, but up to 150 kln2 (Bertram 1978, Frame 1980, Caro and Collins 1986). These territories periodically hold big numbers of Thomson's gazelle, the favoured prey of female cheetahs, and females were often observed in the males' territories (Caro and Coffins 1987b).

Protection Status

CITES Appendix I. An Appendix 1 quota system was established under CITES in 1992 for live animals and trophies, with annual quotas allocated as follows: 150 (Namibia), 50 (Zimbabwe), 5 (Botswana). National legislation: fully protected over most of its range. Hunting prohibited: Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Ethiopia, Ghana, Kenya, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire. Trophy hunting permitted: Namibia. Zambia, Zimbabwe. No information: Chad, Sudan (IUCN Environmental Law Centre, 1986; Kraus and Marker-Kraus 199 1).

Principal Threats

Genetic homogenicity: Genetic research has demonstrated that both captive and free-ranging cheetahs exhibit a very high level of homogeneity in coding DNA, on compared par with inbred strains of laboratory mice (O'Brien *et al.* 1983, 1985, 1986, 1987a), the cheetah appears to have suffered a series of severe population bottlenecks in its history, with the first and most significant occurring possibly during the late Pleistocene extinctions, around 10,000 years ago (Menotti-Raymond and O'Brien 1993). The factors which would have led to these ancient population bottlenecks are not clear, but both their causes and consequences could be of significance to cheetah conservation today.

It has been argued that lack of genetic diversity may render the cheetah an exceptionally vulnerable species (O'Brien *et al* 1983). Genetic variation is thought to be essential to the long-term adaptability and persistence of populations by providing sufficient genetic options on which natural extinction can operate in response to environmental change. The evidence for cheetahs being compromised by their genes arises mainly from captivity, where epidemics of infectious disease have occurred with high mortality (O'Brien *et al* 1985, Evermann *et al.* 1988). Increased susceptibility to disease has been linked to genetic monomorphism (O'Brien and Evermann 1988).

Zoos have had difficulty in breeding cheetahs. Captive female cheetahs conceive infrequently, and when they do, cub mortality is relatively high (28-36%) (Marker and O'Brien 1989; Marker-Kraus and Grisham 1993), although these rates are similar to those of other felid and carnivore species kept in captivity (Loudon 1985). Finally, both wild and captive male cheetahs have high levels of abnormal sperm (71-76%: Wildt *et al.* 1987a), and success with *in vitro* fertilization using cheetah sperm is relatively low compared to other felid species (Donoghue *et al.* 1992).

Vulnerability in Protected Areas: Many observers have commented on the cheetah's vulnerability to interspecific competition with other large carnivores, and this is now the primary focus of the long-term cheetah study in the Serengeti (S. Durant, pers. comm. 1 993). The chief mechanism by which more powerful carnivores-lions, leopards. and hyenas-limit cheetah abundance is by killing cheetah cubs (Laurenson in press), but these species, as well as (sometimes) jackals, baboons, and vultures, also drive adult cheetahs off their kills.

Aim of the project

The project was born by chance because the birth of the eight cubs was unexpected as the husbandry Management at Marwell zoo was changed just en year earlier. In fact until 1998 the cheetahs kept at Marwell a male and a female used to be bred in the same enclosure that is now dedicated exclusively to the female. In fact most of European zoos have a unique enclosure where male and female are kept together and no significant differences concerning number of births were observed between those that kept the specimens together and those that split them. Just recently in the United States a particular management has been studied for cheetahs consisting in different enclosures of male and female located far from each other within the zoo. Just at the beginning of the mating season the male is approached to the female by 6 steps that prime him before mating and that has given very good results. Most of the time this schedule is unbearable in European zoos because of the economical impact this would have but similar techniques have been experimented in different zoos with contrasting results. The aim of my project was to evaluate the behavioural quality of both male and female in term to establish whether the enclosure was correct or if behavioural enrichment was needed. Because of the chance to observe such a record birth most of the attention was focused on the relationship between mother and cubs also considering the differences between the in-situ behaviour recorded in literature. Unfortunately a reintroduction program in not likely to be carried out because of the TSE (transmissive spongiform encephalopathy) that is affecting cheetahs in british zoos because it would be a dangerous risk to spread this syndrome in the wild, for the same reason these animals cannot be exported to other foreign zoos to enrich the genomic status of the captive population.

The study on the male was lead in order to put out some distress pattern.

Materials and Methods

The collection of all the data available on the animals studied has been the first thing I did, then followed two days of pilot study that have been useful to draw the

enclosure and decide how to split them in zones to consider then general observation to pick up the behaviours to consider and the sampling method to use.

The specimens studied were:

Sex: female
Birth: 29 April 1992
Place of birth: Belfast
Int. Studbook #: 2703
Reg. Studbook #: 349
Familiar name: F21 Joolz
No births in Belfast
26 Jan 1999, Pretoria (male) access to Joolz
23 April 1999, Pretoria split from Joolz
12 May 1999, First day she went out to feed

Sex: male
Date of birth: 5 March 1990
Place of birth: Pretoria, South Africa
Int. Studbook #: 2355
Reg. Studbook # :——
Familiare name: M25 Pretoria

13 November 1998,		donation from Pretoria to Whipsnade
21 January	**1999**,	donation from Whipsnade to Marwell
26 January	**1999**,	Pretoria with Joolz
23 April	**1999**,	Pretoria split from Joolz

Cubs
Date of birth: 10 May 1999
Place of birth: Marwell
4553 male, 4554 male, 4555 male, 4556 male, 4557 male, 4558 female, 4559 female, 4586 female

The second step has been the study of the enclosure, to this purpose the enclosure has been brawn considering all the trees, bushes dens and plains to consider the different microhabitats available in it (see fig 1). The same has been done for the male with the only that the division of the area has been done exclusively on geometrical basis (see fig 2).

The third objective of the pilot study is to pick up the behavioural displays to observe and the sampling method to use
Sampling method picked up:
Female:

- sampling ad libitum
- 8.30 – 19.00
- one stop
- intervals 3 minutes
- total observation time: 85 h

Fig. 1 female enclosure

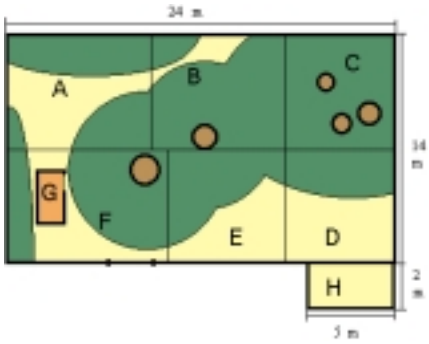


Fig. 2 male enclosure

Fig. 3 cub holding a tool in his mouth

Fig. 4 female nursing

Cubs:

- sampling ad libitum
- 8.30 – 19.00
- one – zero
- intervals 3 minutes
- total observation time : 85 h

Male:

- focal sampling
- 11.30 – 12.30 and 15.00 – 17.00
- one – zero
- intervals 5 minutes
- total observation time: 35h

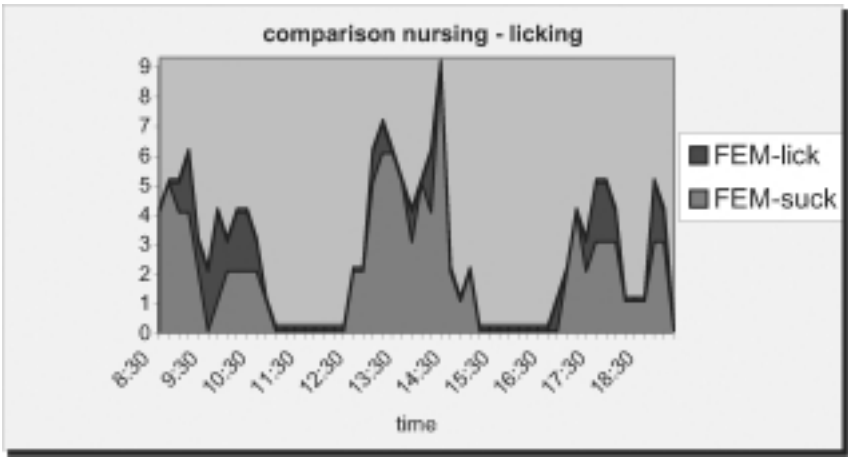
Discussion

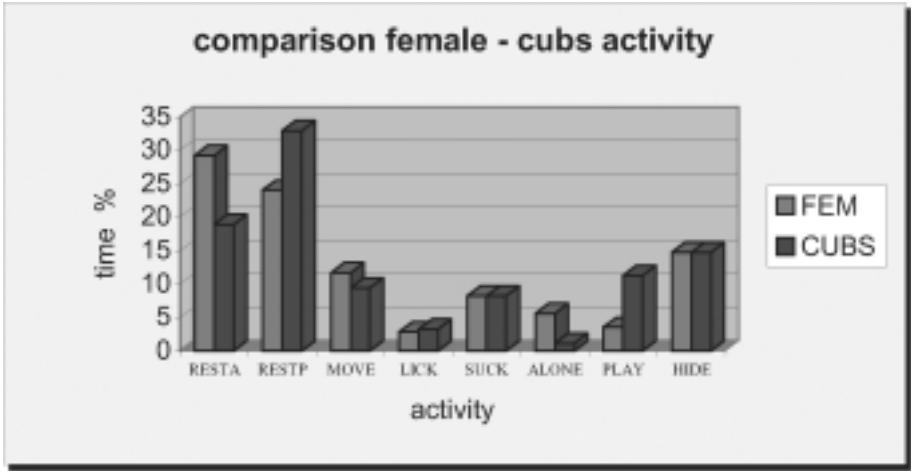
The data collected were transformed in to graphs thus to try and find out a pattern of the different behaviours through out the day. I considered separately the behaviour of the female then of the cubs the interactions between them. An important role in the behaviour is played by the enclosure and I carefully studied the way they used it. Another object of the study considered the way the cubs played.

The female appeared to be very attentive to all the cubs did even though for a high percentage of the day she isolated jumping on a den not giving attention to the cubs. That one was her first offspring but she had very good skills. The graphs show that all that her behaviour was always subordinated to the activity of the cubs passing from resting to immediate patrolling depended on what they did. On the other hand the activity of the cubs was very difficult do study for this reason I picked up a special way to observe them first of all the behaviours selected were the one observed in a specific moment using a one stop sampling method. As I had to observe eight cubs I used to put down on the paper what at least more then 3 cubs did in order to get good results. The cubs passed very rapidly from resting to playing and even playing was a very frenetic activity as long as the play took place it could stop very rapidly with a cascade effect starting from one cubs involving then all of the others. I had the chance to observe a particular way to play displayed by a couple of cubs that used to pick up a piece of wood from the ground and use it as a tool while playing, activity never recorded before in literature (fig. 3). They spent a great part of the day nursing and in particular I found out that there were three period of the day dedicated to nursing (fig. 4). At the same time of nursing the cubs were licked by the mother, this activity very important in most of the felids, known as grooming, plays a role in strengthening the relationships between individuals but was seldom seen out of the time of nursing.

At the time of study the cubs were three months old and depended a lot on mother they used to spend most of the day at a short distance from the mother (1-5 meters) with a very low percentage of far distance (over 10 m).

Comparing the activity of the female and the cubs the only main difference detectable concerns the time spent resting or in activity, the first is much higher in the female compared to the cubs and vice versa.





The use of the enclosure was satisfactory using all the areas but one (for unknown reason may be they felt too exposed to the public put there. In the enclosure there were 4 dens available and I carried out nocturnal observations to find out which den they used at night and in fact the mother changed den every 3-4 nights, attitude displayed in nature in order to avoid the possible incursion of predators. During the observation periods we recorded a behaviour known in the wild but never seen in captivity known as Mobbing. The mobbing is displayed between cheetahs and prey species, the latter approach the cheetah and expose itself intimidating the predator as its main hunt strategy consists on the embushment. The cheetah enclosure shared a part of the net with the sable antilopes one and the latter at eve used to get closed to the net and stare at the cheetahs that were always very scared of it and run away, in fact the cheetahs are among the big cats the most delicate and could be often killed by their prey species if they didn't surprise them in the chase.

The study carried out on the male showed that his enclosure was not adapt to his needings has he often displayed stereotipied movement like circling, back and forth and so on.

Conclusion

In conclusion I can say that the behaviour of the female and the cubs appear to be very good, most of the time very similar to that of the wild cheetahs, and no particular changement in the enclosure is needed nor any behavioural enrichement. On the other hand that of the male is need to be improved either changing the enclosure or modifying the existing one adapting it to the needs of the animal.

Key words: cheetah, ex-situ conservation
Parole chiave: ghepardo, conservazione ex-situ
Mots clé: guépard, conservation ex-situ

RIASSUNTO: Il ghepardo è uno dei felidi più difficile da allevare in cattività. Ci sono tre teorie che tentano di spiegare le ragioni di questo insuccesso. La più accreditata vuole che il problema vada ricercato in una maggiore sensibilità agli stress manageriali. Per questo motivo molti zoo americani hanno sperimentato con successo una nuova tecnica di allevamento detta a sei stadi molto costosa e difficile da applicare per la maggiorparte degli zoo europei. Presso lo zoo di Marwell è stato applicato una adattamento di questa tecnica alle strutture già esistenti. L'esperimento ha avuto successo è nel 1999 si è assistito alla nascita di otto cuccioli. Lo scopo del mio studio era quello di stabilire in base ad uno studio sul comportamento della femmina dei cuccioli e del maschio se la tecnica di allevamento si adattasse bene a questo animale e se fosse possibile in qualche modo incrementare la qualità comportamentale dei soggetti. Mentre lo studio effettuato sulla femmina e sui cuccioli ha dimostrato un'ampia variabilità comportamentale ed un soddisfacente utilizzo del recinto, la situazione del maschio è ben diversa. Quest'ultimo manifestava infatti comportamenti stereotipati usando solo una minima parte del recinto a sua disposizione, per questo motivo è stato suggerito da cambiare recinto e di trasformare il preesistente adattandolo alle esigenze dell'animale.

SUMMARY: Cheetahs are known as the most difficult cat to breed in captivity. There are three theories as to the source of the cheetah breeding problem: 1) cheetah population had gone through a bottle neck period; 2) most of the male sperm are non functional; 3) low behaviour quality in captivity, it seems that males need to be primed for the mating. The aim of this project is to investigate the behaviour of mother and cubs and male in captivity to evaluate the quality of the husbandry (enclosure, different kind of play distance of the cubs from the mother, vocalisms, pattern of behaviour, similarity to in-situ behaviour). On 1999 eight cubs were born at Marwell zoo (England) after the husbandry of this species was reastablished an year earlier. The specimens studied were a female born 1992 and her eight cubs and the male born 1990 . The female enclosure was divided in eight zones considering the microhabitats available then the behavioural categories to observe were picked up. The male

enclosure was split up exclusively on geometrical basis. We used one stop intervals of three minutes for the female and zero one for intervals of three minutes for the cubs, with ad libitum observations from 8 a.m. till 7.30 p.m. reaching a total of 84 h. The male was observed for 35 hours with focal sampling two times a day. The new management adopted by Marwell zoo is an adaptation of the six steps husbandry developed in America that is most of the times impossible to realise in european zoos. This new technique lead to the birth of a record offspring and increased the behaviour of these animals using the same enclosure with minimal economical impact.

Bibliography

1. Bottriell, L.G. 1987. King cheetah: the story of the quest. EJ Brill, Leiden.

2. Caro, T.M. 1994. Cheetahs of the Serengeti plains: group living in an asocial species. Univ. Chicago Press, Chicago.

3. Caro, T.M. e Collins, D.A. 1986. Male cheetahs of the Serengeti. Nat. Geog. Res. 2:75-86.

4. Caro, T.M. e Collins, D.A. 1987a. Male cheetah social organization and territoriality. Ethology 74:52-64.

5. Caro T. M. 1993, Behavioural Solutions to breeding cheetahs in captivity: insights from the wild. Zoo Biology 12: 19-30

6. Donaghue, A.M., Howard, J.G., Byers, A.P., Goodrowe, K.L., Bush, M., Blumer, E., Lukas, J., Stover, J., Snodgrass, K. and D.E. Wildt. 1992. Correlation of sperm viability with gamete interaction and fertilization in vitro in the cheetah (Acinonyx jubatus). Biol. Reprod. 46:1047-1056.

7. Dorst, J. and Dandelot, P. 1969. A field guide to the larger mammals of Africa. Collins, London.

8. Dragesco-Joffé, A. 1993. La Vie Sauvage au Sahara. [Wildlife in the Sahara]. Delachaux et Niestlé, Lausanne (Switzerland) and Paris (in French).

9. Durant, S.M., Caro, T.M., Collins, D.A., Alawi, R.M. and C.D. FitzGibbon. 1988. Migration patterns of Thomson's gazelles and cheetahs on the Serengeti Plains. Afr. J. Ecol. 26:257-268.

10. Eaton, R.L. 1974. The cheetah. Van Nostrand Reinhold, New York.

11. Evermann, J.F., Heeney,J.L., Roelke, M.E., McKeirnan, A.J. and S.J. O'Brien. 1988. Biological and pathological consequences of feline infectious peritonitis virus infection in the cheetah. Arch. Virol. 102:155-171.

12. Ewer, R.F. 1973. The carnivores. Cornell Univ. Press, Ithaca, New York.

13. Fitz Gibbon, C.D. 1990. Why do hunting cheetahs prefer male gazelles? Anim. Behav. 40:837-845.

14. Fleetwood AJ, Furley CW, 21 Aprile 1990, Vet Rec 126(16): 408-9

15. Frame, G.W. 1977. Cheetah ecology and behaviour. Pp 74-87 in the 1976-76 Annual Report, Serengeti Research Institute, Arusha.

16. Frame, G.W. 1980. Cheetah social organization in the Serengeti ecosystem, Tanzania. Paper presented at the Animal Behavior Society, Fort Collins, Colorado.

17. Frame, G.W. e Frame, L.H. 1984. Cheetah male cooperation: test of a mutualism model. Paper presented at Animal Behavior Society, Cheney, Washington.

18. Garland, T., Jr. 1983. The relation between maximal running speed and body mass in terrestrial mammals. J. Zool., Lond. 199:157-170.

19. Gonyea, W.J. 1976. Adaptive differences in the body proportions of large felids. Acta. Anat. 96:81-96. con

20. Goodrowe, Karen L. ; Crawshaw, Graham J. ; Mehren, Kay G., 1 Marzo 1991, Stimulation of ovarian activity and oocyte recovery in the caracal and the cheetah, Journal of zoo and wildlife medicine, pag 42

21. Graham, A. 1966. East African Wild Life Society cheetah survey: extracts from the report by wildlife services. E. Afr. Wildl. J. 4:50-55.

22. Gros, P. 1990. Global cheetah project Phase I: Cheetah status in southern Africa. Unpubl. report., Univ. of California, Davis.

23. Guggisberg, C.A.W. 1975. Wild cats of the world. David and Charles, London.

24. Hamilton, P.H. 1986a. Status of the cheetah in Kenya, with reference to sub-Saharan Africa. Pp 65-76 in Miller, S. and Everett, D., eds. Cats of the world: Biology, conservation and management. National Wildlife Federation, Washington D.C.

25. Hildebrand, M. 1961. Further studies on locomotion of the cheetah. J. Mammal. 42:84-91.

26. Hills, D.M. e Smithers, R.H.N. 1980. The “king cheetah”: a historical review. Arnoldia 9(1):1-23.

27. Howard, Jogayle; Donoghue, Ann M.; Barone, Mark A., 1 Settembre 1992, Succesfull induction of Ovarian Activity and Laparoscopic Intrauterine Artificial Insemination in the Cheetah, Journal of zoo and wildlife medicine, pag 288

28. IUCN Environmental Law Centre. 1986. African wildlife laws. IUCN Environmental Policy and Law Occasional Paper no. 3. IUCN, Gland, Switzerland and Cambridge, UK.

29. Jeffrey M, Wells GA, Settembre 1998, Vet Pathology; 25(5): 398-9, Lasswade Veterinary Laboratory, Midlothian

30. King Simon 1 Gennaio 1998 Cheetahs and tourist cars – a recipe for disaster? Not necessarily, BBC wildlife

31. Kingdon, J. 1977. East African mammals: An atlas of evolution in Africa, Vol. 3(A). Carnivores. Academic Press, New York.

32. Kraus, D. and Marker-Kraus, L. 1991. The status of the cheetah (Acinonyx jubatus). Unpubl. data sheet, IUCN/SSC Cat Specialist Group, Bougy-Villars, Switzerland.

33. Labuschagne, W. 1979. [A bio-ecological and behavioural study of the cheetah, Acinonyx jubatus jubatus (Schreber, 1776).] M.S. thesis, Univ. Pretoria, Pretoria (in Afrikaans).

34. Labuschagne, W. 1981. Aspects of cheetah ecology in the Kalahari Gemsbok National Park. Paper presented at Internat. Union of the Directors of Zoological Gardens, Washington D.C.

35. Laurenson, M. Karen, 1995, Cub growth and maternal care in cheetahs, Behavioural Ecology, pag 405

36. Laurenson, M.K. 1992. Reproductive strategies in wild female cheetahs. Ph.D. thesis, Univ. of Cambridge, Cambridge.

37. Laurenson, M.K. 1993. Early maternal benaviour of wild cheetahs: implications for captive husbandry. Zoo Biology 12:31-43.

38. Laurenson, M.K., Caro, T. and M. Borner. 1992. Female cheetah reproduction. Nat. Geog. Res. 8(1):64-75.

39. Lindburg, D.G., Durrant, B.S., Millard, S.E. and J.E. Oosterhuis. 1993. Fertility assessment of cheetah males with poor quality semen. Zoo Biology 12(1):97-104.

40. Marker-Kraus, 1997, History of the cheetah Acinonyx jubatus in zoos 1829-1994, Internation zoo yearbook v35, 27

41. Marker-Kraus, L e Daniel Kraus, 1997, Conservation strategies for the long-term survival of the cheetah, International zoo yearbook

42. Marker-Kraus, L. and Kraus, D. 1991. 1991 Annual Report. Unpubl. report, Cheetah Conservation Fund, Windhoek.

43. Marker-Kraus, L. and Grisham, J. 1993. Captive breeding of cheetahs in North American zoos. Zoo Biology 12 (1): 5-18.

44. McKeown, S. 1992. Joint management of species cheetah breeding programme. Pp 78-88 in P. Mansard, ed. Cats: proc. conference/workshop held at Chester Zoo on October 10, 1992 by the Ridgeway Trust for Endangered Cats and the Association of British Wild Animal Keepers. Ridgeway Trust for Endangered Cats, Hastings, East Sussex.

45. McLaughlin, R. 1970. Aspects of the biology of cheetahs Acinonyx jubatus (Schreber) in Nairobi National Park. M.S. thesis, Univ. of Nairobi, Nairobi.

46. McVittie, R. 1979. Changes in the social behaviour of South-West African cheetah. Madoqua 2(3):171-184.

47. Menotti-Raymond, M. and O'Brien, S.J. 1993. Dating the genetic bottleneck of the African cheetah. Proc. Natl. Acad. Sci. 90.

48. Mills, L. Scott, 1 Aprile 1996, Cheetah extinction: genetic or extrinsic factors?, Conservation Biology pag 315

49. Mills, M.G.L. 1990. Kalahari hyaenas: the comparative behavioural ecology of two species. Unwin Hyman, London.

50. Mills, M.G.L. e Biggs, H.C. 1993. Prey apportionment and related ecological relationships between large carnivores in Kruger National Park. In N. Dunstone and M.L. Gorman, eds. Mammals as predators. Proc. Symp. Zool. Soc. Lond. 65. Clarendon, Oxford.

51. Morsbach, D. 1984-1986. [The behavioural ecology and movement of cheetahs on farmland in Southwest Africa/Namibia.] Annual progress reports submitted to the Directorate of Nature Conservation and Recreation Resorts, Govt. of Namibia, Windhoek (in Afrikaans).

52. Myers, N. 1975. The cheetah Acinonyx jubatus in Africa. IUCN Monograph No. 4, Morges, Switzerland.

53. O'Donovan, Declan; Hindle, Joanne E.; O'Donovan, Sean, 1992, Effects of visitors on the behaviour of female cheetah and cubs, Internation zoo yearbook pag 238

54. Peet PL, Luglio 1992, Aust Vet 69(7): 171

55. Pocock, R.I. 1927. Description of a new species of cheetah (Acinonyx). Proc. Zool. Soc. London Pt. 1:245-251.

56. Rosevear, D.R. 1974. The carnivores of West Africa. British Museum (Natural History), London.

57. Ruggiero, R.G. 1991. Prey selection of the lion (Panthera leo L.) in the Manovo-Gounda-St. Floris National Park, Central African Republic. Mammalia 55:23-33.

58. Schaller, G.B. 1968. Hunting behaviour of the cheetah in the Serengeti National Park, Tanzania. E. Afr. Wildl. J. 6:95-100.

59. Schaller, G.B. 1972. The Serengeti lion. Univ. of Chicago Press, Chicago. leosub jubsub parsub mgt res

60. van Aarde, R.J. and van Dyk, A. 1986. Inheritance of the king coat colour patterns in cheetahs Acinonyx jubatus. J. Zool. 209:573-578.

61. van Dyk, A. 1991. The cheetahs of DeWildt. Stuik, Cape Town.

62. Wildt, D.E., O'Brien, S.J., Howard, J.G., Caro, T.M., Roelke, M.E., Brown, J.L. and M. Bush. 1987a. Similarity in ejaculate-endocrine characteristics in captive versus free-ranging cheetahs of two subspecies. Biol. Reprod. 36:351-360.

63. Wild, D.E.; Roth, Terry L.; Swanson, William F., 1 Marzo 1995, Enhancing Zona Penetration by Spermatozoa From a Teratosperimic Species, the Cheetah, The journal of experimental zoology, pag 323.

64. Wildt, David E.; Grisham Jack, 1993, Basic research and the cheetah SSP Program, Zoo Biology pag 3.