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Induction of contraception in some African wild carnivores by downregulation of LH and FSH secretion using the GnRH analogue deslorelin

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The GnRH analogue deslorelin, in long-acting biocompatible implants, was used as a contraceptive in 31 cheetahs (13 females and 18 males), 21 African wild dogs (15 females and 6 males), 10 lionesses and four leopards (three females and one male). A dose of 12 or 15 mg deslorelin was administered to lions, whereas 6 mg deslorelin was administered to the other species. Monitoring consisted of observations, measurement of plasma progesterone and testosterone concentrations, vaginal cytology and evaluation of semen and sex organs. Deslorelin induced contraception in lionesses for 12-18 months, and in female cheetahs and leopards for a minimum of 12 months after treatment. Two male cheetahs had no viable spermatozoa or detectable plasma testosterone 21 months after treatment with deslorelin. Female wild dogs responded less consistently and one bitch conceived 4 weeks after implantation. However, in nine bitches, mating could be postponed until the next breeding season. Male dogs responded consistently and the contraception was effective for approximately 12 months. Although lionesses and cheetahs may become attractive to males for a few days after treatment, mating was not observed. No side-effects or behavioural changes were noted, indicating that deslorelin is a safe drug to use for the contraception of the species described. Males remain fertile for the first 6 weeks after the insertion of implants and should be separated from cyclic females during this period.

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Introduction

Contraception has become a useful tool in population management of wild carnivores in zoos, wildlife sanctuaries and smaller conservancies. The choice of reversible or irreversible methods of fertility control depends on requirements. The main reason for carnivore contraception in southern Africa is to slow down the rate of breeding rather than to produce permanent sterilization. This applies particularly to endangered species, such as African wild dogs and cheetahs. In Namibia, the holding of wild carnivores on private property requires a permit stipulating that breeding of any such animals is not allowed (R E. Stander, personal communication). The main species involved are cheetahs, lions and leopards.

In South Africa, lions are kept on a number of smaller conservancies (1 000-10000 ha) where they are allowed to range freely with prey species. Under such conditions, the lack of competition from other lions and large predators results in an increased cub survival rate. The increased survival rate of young leads to a population explosion and consequently to a depletion of the prey species, which are expensive to replace. For example, at Mabula Nature Reserve it costs R 400-500 000 annually to restock the park with prey species for a pride of lions consisting of four adults, four sub-adults and some suckling cubs. Another example is Thorny Bush where giraffes have raised very few calves successfully over the past few years because of predation by lions. Some of these reserves house valuable species such as sable antelope and disease-free buffalo, which large prides tend to prey on to obtain sufficient bulk. The potential for inbreeding of carnivores on smaller reserves is also increased. Therefore, in an attempt to ameliorate the problem, the rate of reproduction should be slowed down and, for genetic reasons, lionesses should be allowed to breed on a rotational basis.

Selection of contraceptive method

Other than obvious criteria, such as safety to the animal, safety during pregnancy and within the food chain, the main requirement of a contraceptive for carnivores under southern African conditions is reversibility. Remote delivery, although an advantage, is not essential because animals are usually captured to determine their reproductive status or for other management purposes. Further considerations are hormone-dependent characteristics, such as a mane and dominance. For this reason, castration or downregulation of LH release resulting in basal concentrations of testosterone and loss of the mane is not acceptable for male lions. From results obtained in domestic dogs and cats, the GnRH analogue deslorelin acetate released long-term from a biocompatible implant (Peptech Animal Health, Sydney) appears to be an

ideal agent for controlling reproduction (Munson *et al.*, 2001; Trigg *et al.*, 2001). The implants are manufactured by a proprietary method that involves extrusion of deslorelin with matrix consisting principally of low-melting point lipids and biological surfactant (Trigg *et al.*, 2001). Bertschinger *et al*. (2001) reported on the preliminary results of the use of deslorelin in wild carnivores.

Experience with deslorelin

Including animals described in the first report, contraceptives have been administered to 31 cheetahs (13 females and 18 males), 21 African wild dogs (15 females and 6 males), 10 lionesses and four leopards (three females and one male) in southern Africa. Monitoring before and after treatment consisted of observations (mostly daily except for leopards), measurements of plasma progesterone and testosterone concentrations, vaginal cytology and evaluation of semen and sex organs. Blood plasma hormone concentrations were measured by radioimmunoassay using commercial kits (Coat-A-Count total progesterone and testosterone kits; Diagnostic Products Corporation, Los Angeles, CA). Plasma progesterone concentrations are typically low (< 1.5 nmol l^{-1}) during anoestrus in wild carnivores, although wild dogs and lionesses with values of up to 5 nmol l^{-1} and 6.73 nmol l^{-1}, respectively, were considered to be in anoestrus in the present study. The majority of the plasma progesterone content in such animals is likely to originate from the adrenal cortex as a result of ACTH stimulation from the stress of capture (H. J. Bertschinger, unpublished). Vaginal cytology (smears stained with Cam's Quick-Stain; Milch, Krugersdorp, SA) was also used to confirm low ovarian steroid activity. Semen was collected by electro-stimulation of anaesthetized males and evaluated as described by Bertschinger and Meltzer (1998) and Meltzer *et al.* (1998). The presence of viable spermatozoa was the only parameter used to assess fertility in males treated with deslorelin. The results for each species are described below.

Cheetahs

This work was out carried in northern Namibia at the Africat Foundation. Male and female cheetahs were housed in mixed groups in camps ranging from 10 to 50 ha. Both male and female cheetahs were treated with a 6 mg deslorelin implant and were observed each day thereafter. Although four of the implanted females attracted males for 5-14 days after treatment (Bertschinger *et al.*, 2001), none of the 13 females was mated and no pregnancies occurred (Table 1). Only one of the 11 females examined within the first 3 months after

deslorelin implantation appears to have ovulated (AJ84, plasma progesterone concentration of 10.29 nmol l^{-1}). Eight of the females were treated in two consecutive years without significant changes in body weight or other side-effects. Two of these females attracted males sporadically during this period but, once again, would not allow mating. Plasma progesterone assays and vaginal cytology indicated an anoestrous status for each of the 13 females at the end of each year.

The results exhibited by six males treated with deslorelin and one male implanted with 50 mg vehicle as a placebo are summarized (Table 2). Spermatozoa were still present in the ejaculate 6 weeks after deslorelin treatment, whereas plasma testosterone concentrations were already undetectable. One year after and, in the case of two animals, 21 months after treatment, viable spermatozoa were still undetectable in the ejaculates and plasma testosterone concentrations were also minimal. Ejaculate volume was either substantially decreased or no fluid could be recovered despite prolonged electro-stimulation. The testes were small and hard, and penile barbs were barely visible at 1 and 2 years after treatment, respectively. In untreated adult cheetahs, penile barbs are particularly well-developed compared with those of lions and leopards. Another 12 males were implanted in February 2001 but, other than the observation that they have not mated, no further results are available.

Hierarchy within groups containing treated male and female cheetahs was unaffected by deslorelin treatment.

African wild dogs

The wild dogs were housed in 0.5 ha camps in pairs or threes of mixed sex at the de Wildt Cheetah and Wildlife Centre. One female was isolated throughout the observation period. The wild dogs are highly fertile, monoestrus and breed once a year from February to mid-April. The dose of deslorelin administered was 6 mg.

The results for 15 females are shown (Table 3). Deslorelin treatment induced oestrus in one bitch after 4 weeks and this bitch gave birth to seven live pups 2 months later (Bertschinger *et al.*, 2001) and conceived again during the 2001 breeding season. The remaining 13 bitches, excluding the isolated bitch, showed signs of oestrus between 3 and 21 months after deslorelin implantation. The mating season was bypassed in nine bitches. Three females, two of which were in pro-oestrus at the time, received only 3 mg deslorelin. Both of the pro-

oestrous animals ovulated after treatment but only one of them allowed mating and became pregnant. The other bitch also ovulated.

The six deslorelin-treated males responded more consistently than the females (Table 4). One month after deslorelin treatment, spermatozoa were still present in the ejaculate but the plasma testosterone concentration was already basal (n = 1). Azoospermia and basal plasma testosterone concentrations were observed in the same dog for 14 months after the deslorelin implant. Reversal of contraception occurred in two dogs, one of which mated successfully 16 months after deslorelin treatment. The other dog had good semen quality and normal plasma testosterone concentrations 12 months after deslorelin administration. Six months after a second implant the testes had atrophied; no spermatozoa were present in the ejaculate and plasma testosterone concentration was basal. The size and structure of the prostate gland is similar to that in domestic dogs and the prostate gland is readily palpable per rectum. Six months after deslorelin treatment the prostate gland was difficult to palpate and measured only 7 mm across each lobe in one wild dog. The placebo-treated dog had a normal plasma testosterone concentration 23 days after treatment.

Lionesses

The results from ten lionesses treated with 12 or 15 mg deslorelin managed under various conditions are shown (Table 5). Deslorelin treatment was able to suppress cyclicity for 12 months in two females treated during dioestrus and for 18 months in two animals treated in anoestrus. Both the females treated in anoestrus were attractive to the male 2 days after deslorelin treatment but did not allow mating (Bertschinger *et al.*, 2001). Recovery of fertility has not yet been proven as two lionesses at Mossel Bay are with vasectomized males and the Mabula pride male is arthritic and azoospermic. The first lioness treated at Mabula has shown signs of oestrus every 2-3 weeks on a regular basis after returning to cyclicity 18 months after treatment, indicating that she has not responded with an induced ovulation. The other six lionesses have not yet undergone oestrus but the period since deslorelin implantation has been only 8 and 10 months, respectively.

Table 1: Adult female cheetahs at Africat housed in mixed sexual groups in 10 to 50 ha camps and implanted with 6 mg deslorelin implants

	Deslorelin implant			Examinations/observations after treatment			
ID	Date	Plasma progesterone (nmol l^{-1})	Treatment-induced oestrus	Interval since first implant (months)	Plasma progesterone (nmol l^{-1})	Interpretation	Return to heat
AJ128[a]	May 99	0.67	None observed	3	0.61	Anoestrus	None after 21 months
				9	0.61	Anoestrus	
AJ240[a]	May 99	0.83	9 days later lasting 2 days	3	0.01	Anoestrus	None after 21 months
				21	0.68	Anoestrus	
AJ5[a]	May 99	0.27	None observed	3	0.21	Anoestrus	None after 21 months
				9	0.09	Anoestrus	
				21	0.81	Anoestrus	
AJ4[a]	May 99	0.62	5 days later lasting 2 days	3	1.11	Anoestrus	None after 21 months
				9	1.01	Anoestrus	
				21	0.25	Anoestrus	
AJ260[a]	May 99	0.23	14 days later lasting 5 days	3	0.48	Anoestrus	None after 21 months
				9	0.01	Anoestrus	
				21	0.49	Anoestrus	
AJ177[a]	May 99	0.54	None observed	3	0.22	Anoestrus	None after 21 months
				9	0.01	Anoestrus	
				21	0.45	Anoestrus	
AJ19[a]	May 99	0.11	5 days later lasting 4 days	3	0.01	Anoestrus	None after 21 months
				9	2.08	Anoestrus	
				21	0.58	Anoestrus	
AJ81[a]	May 99	0.52	None observed	3	0.00	Anoestrus	None after 21 months
				9	0.14	Anoestrus	
				21	0.01	Anoestrus	
AJ84	Feb 00	0.00	None observed	1.5	10.29	Dioestrus	None after 16 months
				12	0.16	Anoestrus	
AJ74	Feb 00	0.07	None observed	1.5	0.39	Anoestrus	None after 16 months
				12	0.64	Anoestrus	
AJ228	Feb 00	0.39	None observed	1.5	0.78	Anoestrus	None after 16 months
				12	1.01	Anoestrus	
AJ82	Feb 00	0.03	None observed	12	0.22	Anoestrus	None after 16 months
AJ244	Feb 00	0.21	None observed	12	0.27	Anoestrus	None after 16 months

[a]These 8 females were given a second 6 mg deslorelin implant 9 months after the first one.

Table 2: Adult male cheetahs at Africat housed in mixed sexual groups in 10 to 50 ha camps and implanted with 6 mg deslorelin implants

	Deslorelin implant			Examinations/observations after treatment			
ID	Date	Plasma testosterone (nmol l^{-1})	Semen	Interval since implant (months)	Plasma testosterone (nmol l^{-1})	Semen	Mating and result
AJ70	May 99	1.41	Spermatozoa present	3	ND	No spermatozoa	None after 24 months
				9	0	No spermatozoa	
				21	0	Few dead spermatozoa	
AJ79	May 99	0.31	Spermatozoa present	3	ND	No spermatozoa	None after 24 months
				9	0	No spermatozoa	
				21	0	No spermatozoa	
AJ302	Feb 00	0.79	Spermatozoa present	1.5	0	Spermatozoa present[a]	None after 12 months
				12	0	No sperm	
AJ303	Feb 00	11.33	Spermatozoa present	1.5	0	Spermatozoa present[a]	None after 12 months
				12	0	No spermatozoa	
AJ9	Feb 00	2.05	Spermatozoa present	12	0	No spermatozoa	None after 12 months
AJ18	Feb 00	4.85	Spermatozoa present	12	0	Few dead spermatozoa	None after 12 months

[a]Small ejaculate volume with a high concentration of spermatozoa.
ND: no data collected.

Table 3: Adult African wild dog females at de Wildt Cheetah and Wildlife Centre housed in mixed pairs or threes and treated with deslorelin implants

	Deslorelin implant					Examinations after treatment			First oestrus after treatment	
ID	Date	Dose (mg)	Plasma progesterone (nmol l^{-1})	Stage of oestrus cycle	Treatment induced heat	Interval since implant	Plasma progesterone (nmol l^{-1})	Stage of oestrous cycle	Interval since implant	Result 2 months after mating
F139	Feb 99	6	3.74	Anoestrus	None	80 days	3.77	Anoestrus	12 months	6 pups
F144	Feb 99	6	3.79	Anoestrus	None	1 month 3 months 9 months	3.94 2.83 4.62	Anoestrus Anoestrus Anoestrus	13 months	Whelped but number unknown
F59	Feb 99	6[a]	4.75	Anoestrus	None	3 months 9 months 21 months	16.31 3.57 1.45	Dioestrus Anoestrus Anoestrus	Contracepted male after 21 months	No pups to date
F143	Feb 99	6[a]	2.34	Anoestrus	None	1 month 3 months 9 months	54.52 3.08 2.71	Dioestrus Anoestrus Anoestrus	Sold 12 months after implant - NP	No further information available
F142	Feb 99	6	2.72	Anoestrus	None	1 month 3 months 9 months	7.91 2.81 2.87	Dioestrus Anoestrus Anoestrus	Sold 12 months after implant - NP	No further information available
F177	Nov 99	6	1.96	Anoestrus	None	12 months	1.96	Anoestrus	Contracepted male after 12 months	No pups to date
F166	Nov 99	6	4.05	Anoestrus	None	None	ND	ND	16 months	10 pups
F104	Nov 99	6	3.56	Anoestrus	None	None	ND	ND	Died 18 months after implant	No pups before she died
F178	Nov 99	6	3.60	Anoestrus	None	None	ND	ND	3 months 15 months	7 pups 8 pups (second litter)
F72	Nov 99	6	2.74	Anoestrus	4 weeks later	None	ND	ND	4 weeks 14 months	7 pups Pregnant (second litter)
F211	Nov 99	6	ND	ND	None	None	ND	ND	No male present	No further information available
F75	Jan 00	6	3.33	Anoestrus	None	None	ND	ND	7 months	6 pups
F157	March 00	3	8.43	Pro-oestrus	Not mated	1 month	19.96	Dioestrus NP	11 months	Whelped but number of pups unknown
F161	March 00	3	8.06	Pro-oestrus	Mated	1 month	77.71	Pregnant 2.5 weeks	± 2 weeks	Whelped but number of pups unknown
F162	March 00	3	2.72	Anoestrus	None	1 month	34.95	Dioestrus NP	None after 15 months	

[a]Treated simultaneously with 150 mg proligestone (Bertschinger *et al.*, 2001). ND: no data collected ; NP: not pregnant.

Table 4: Adult African wild dog males at de Wildt Cheetah and Wildlife Centre housed in mixed pairs or threes and treated with 6 mg deslorelin implants (n = 6) or 50 mg placebo (n = 1)

	Deslorelin treatment				Examinations/observations after treatment				
ID	Date	Plasma testosterone (nmol l^{-1})	Semen	Testis size (mm)	Interval since first implant	Plasma testosterone (nmol l^{-1})	Semen	Testis size/ prostatic lobe (mm)	Mating and result
M141	Feb 99	1.87	ND	ND	1 month 3 months 9 months 14 months	0.27 0 0 0.02	ND ND ND ND	ND ND ND Small and hard	One bitch mated 3 weeks after implant – no other bitches mated for at least 14 months[a]
M54	Nov 99	0.32	ND	ND	ND	ND	ND	ND	Had not bred by 13 months when he died
M173	Nov 99	3.39	Spermatozoa present	ND	19 months	10.69	Spermatozoa present	L: 37x19 R: 38x20	Bitch mated after 16 months - pregnant
M130	Nov 99 Nov 00	1.63	Spermatozoa present	ND	12months 18 months	5.40 0	Spermatozoa present No spermatozoa	L: 46x29 R: 49x29 L: 31x19 R: 28x18	No mating occurred
M 56	Nov 00	5.2	ND	L: 52x23 R: 50x23	6 months	0	ND	L: 33x17 R: 34x16	No mating occurred
M176	Nov 00	5.7	Spermatozoa present	ND	6 months 7 months	0 0	No spermatozoa ND	L: 28x17 R: 29x16 Prostate: 7	No mating occurred
M107 Placebo	May 01	5.26	Spermatozoa present	L: 44x23 R: 43x27	23 days	7.25	ND	Prostate: 22	Not with cycling female

[a]Dog with three untreated bitches (Bertschinger *et al.*, 2001).

ND: no data collected; L: left testis; R: right testis.

Table 5: Adult lionesses treated with deslorelin implants at various locations

	Location		Deslorelin implant					Post-treatment observations	
ID	Name	Management	Date	Dose (mg)	Plasma progesterone (nmol l^{-1})	Stage of oestrous cycle	Treatment-induced oestrus	Interval since implant	Results of mating
40	Mabula	1 400 ha[a]	Dec 98	12[b]	5.47	Anoestrus	2 days later lasting 2 days	18 months	After first oestrus, 12 heats 2-3 weeks apart. Dominant male examined and found to be infertile
26	Mabula	1 400 ha[a]	Nov 99	12	ND	Unknown	2 days later lasting 2 days	18 months	Mating observed; too early for result but with same male as no. 40
38T	Mossel Bay	65 ha[c]	Nov 99	12	170.8	Dioestrus	None	12 months	Mated by vasectomised male. Second oestrus after 1.5 months; then at 3 week intervals
E6T	Mossel Bay	65 ha[c]	Nov 99	12	125.1	Dioestrus	None	12 months	Mated by vasectomised male. Second oestrus after 1.5 months; then at 3 week intervals
C6T	Thornybush	10 000 ha[a]	Aug 00	15	4.11	Anoestrus	None	10 months	Oestrus not observed
33T	Thornybush	10 000 ha[a]	Aug 00	15	3.13	Anoestrus	None	10 months	Oestrus not observed
46T	Thornybush	10 000 ha[a]	Aug 00	15	1.02	Anoestrus	None	10 months	Oestrus not observed
5CB	Pretoria Zoo	0.75 ha[d]	Oct 00	12	2.51	Anoestrus	Separated from male for 3 months	8 months	Oestrus not observed
2B3	Pretoria Zoo	0.75 ha[d]	Oct 00	12	14.44	Late dioestrus	Separated from male for 3 months	8 months	Oestrus not observed
Elsa	Doman Namibia	10 ha[e]	Jan 01	15	6.73	Anoestrus	Separated from male for 3 weeks	5 months	Oestrus not observed

[a]Free-ranging lions kept with prey species.

[b]Treated simultaneously with 3mg norgestomate implant – examination 3 months later revealed late dioestrus (Bertschinger *et al*., 2001).

[c]Two lionesses with 2 adult vasectomised males in a camp where they are fed.

[d]Two adult lionesses with one male and two sub-adults in a camp where they are fed.

[e]Lioness with male and 6-month-old cubs in camp where they are fed.

ND: no data collected.

Leopards

At the Africat Foundation, two females, each housed with a male in a 20 ha camp, were treated with 6mg deslorelin. Neither female became pregnant within the subsequent 12 months. A third female was implanted with the same dose of deslorelin in the Lowveld of South Africa and has not become pregnant within 18 months. A single male housed with a female in a 10 ha camp was also implanted at Africat. Only 4 months have passed since then and so far no mating has been observed.

Discussion

For wild carnivores, the selection of a contraceptive that is both safe and suits the specific requirements of the region is extremely important. In the present scenario, the most important requirement was reversibility with accompanying good fertility. From the point of view of safety, long-term use of progestagens, which have been associated with complications, such as cystic endometrial hyperplasia (CEH), pyometra, mammary and endometrial cancers are inappropriate (Munson and Mason, 1991; Munson, 2001). The reversibility of the pig zona pellucida (PZP) contraception in wild carnivores remains questionable. In domestic dogs PZP has been shown to produce permanent infertility (immuno-sterilization) as a result of destruction of ovarian follicles (Mahi-Brown *et al.*, 1985; Fayrer-Hosken *et al.*, 2000). Munson (2001) described hypercalcaemia leading to renal failure and cardiomyopathy in felids vaccinated with PZP in Freund's adjuvant. In addition, immunocontraception of 27 felids and four canids with PZP yielded variable and sometimes disappointing results (J. F. Kirkpatrick and K. M. Frank, personal communication). Continued cyclicity and the resulting management problems were also deemed undesirable. For this and other reasons, consideration was not given to the use of anti-progestins, which have been used successfully in captive bears (Göritz *et al.*, 2001). The efficacy of immunocontraception using peptide hormones or their receptors as antigens (Meloen *et al.*, 1994; Remy *et al.*, 1996; Thompson, 2000) must be tested properly in domestic carnivores before attempting to use them in valuable wild carnivore species.

In the present study, deslorelin was found to be an effective contraceptive for lionesses and female leopards, and for male and female wild dogs and cheetahs. Apart from the females attracting males for a short period after treatment, no side-effects were observed. The use of progestagens to suppress such behaviour in a lioness or ovulation in two wild dogs after

deslorelin treatment was unsuccessful (Bertschinger *et al.*, 2001). These results are not comparable with the work of Wright *et al.* (2001) in domestic dogs, as these workers used the oral progestagen megestrol acetate, and started treatment before deslorelin implantation. As pre-treatment of wild carnivores with progestagens in whatever form is highly impractical and may be dangerous with regard to induction of CEH, the practice was not pursued in the present trials. The possibility of mating during the first 3 weeks after implantation can be avoided by separating the female from the untreated males if possible.

Although acceptable, the results were more variable in female wild dogs. This finding may have been due to the social interaction, which is totally different from that of the other species treated in the present study. Previously, it has been observed that, when new packs of dogs are formed by mixing animals from different sources, oestrus may be induced in all the females of the new pack (H. J. Bertschinger, unpublished; M. Hofmeyr, personal communication). The other difference observed in dogs (body weight 23-26 kg) is a much shorter contraceptive period compared with that in cheetahs (34-45 kg) when the same dose of deslorelin was used. It is possible that the contraceptive period can be attributed to different sensitivities of species like the domestic dog and cat to the same dose of deslorelin (Munson *et al.*, 2001; Trigg *et al.*, 2001). However, African wild dogs are extremely hyperactive compared with cheetahs, indicating a much higher metabolic rate. The daily energy requirement of 15.3 MJ in free-ranging wild dogs is almost double the requirement for working border collies (Gorman e*t al.*, 1998). A dose of 3 mg deslorelin was ineffective in suppressing oestrus and mating in a bitch that was already in pro-oestrus at the time of treatment. Two other bitches, one in pro-oestrus and one in anoestrus, also ovulated after treatment with this low dose; however, ovulation may also have occurred with treatment with 6 mg deslorelin. Safety during pregnancy was demonstrated in one wild dog that conceived 4 weeks after deslorelin treatment and later delivered seven live pups (Bertschinger *et al.*, 2001).

An added advantage of long-term contraception in carnivores using deslorelin appears to be a decreased risk of developing CEH and pyometra. The relationship between advancing age and CEH-pyometra is well established in domestic dogs, particularly if they have not produced a litter (Dow, 1957).

As a contraceptive and in the formulation used, deslorelin is highly effective in male wild dogs and cheetahs once spermatozoa are no longer present in the ejaculate. In addition, the duration of contraception appears to be longer in males than in females. As in females, male

dogs recover fertility much earlier than cheetahs after they have received the same dose of deslorelin. Male lions on display (free-ranging or in zoos) should not be treated with deslorelin, as they are likely to lose their testosterone-dependent manes. In cheetahs, decreased semen volume was a constant feature of deslorelin contraception, probably as a result of reduced formation of dihydrotestosterone required for the androgen-dependent secondary sex glands (Shasin, 1998). Androgen dependency of the secondary sex glands could be verified by the fact that the prostate gland of a wild dog showed marked atrophy after deslorelin treatment.

Another encouraging aspect of the present trial using deslorelin was the absence of side-effects, including behavioural changes. Although there was no objective measurement of behavioural interaction, all animals, with the exception of the leopards, were observed each day. No hierarchical alterations were noted and scent marking in male wild dogs continued despite undetectable plasma testosterone concentrations. Testosterone is converted to oestradiol in the brain, which, according to Bahsin (1998), is responsible for this behaviour in dogs. Perhaps the behaviour becomes imprinted earlier, in fetal life or at about the time of puberty.

Conclusions

In conclusion, the deslorelin implant offers a safe and reversible method of contraception for small numbers of captive and free-ranging wild carnivores. Continued cyclicity of females, as observed with PZP vaccine (J. F. Kirkpatrick and K. M. Frank, personal communication), weight gain and increased incidence of uterine and mammary tumours, or endometrial hyperplasia as observed with progestagen implants (Munson and Mason, 1991; Munson, 2001), seem unlikely sequelae to deslorelin treatment. The contraceptive results in males are more reliable if they are not exposed to oestrous females for the first 6 weeks after deslorelin treatment. In wild dogs treated with 6 mg deslorelin, contraception is effective for 9-14 months. In cheetahs treated with the same dose, lionesses treated with 12 mg deslorelin and in leopards treated with 6 mg deslorelin, contraception was effective for approximately 2 years, 12-18 months and > 12 months, respectively.

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