Infertility/Subfertility In The Southern White Rhinoceros *(Ceratotherium simum simum)* and the evaluation of their reproductive parameters as to other related species

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Fertility

The optimum reproductive performance targets for Southern White Rhinoceros are assessed as:

Average age to produce first calf: 5-7 years
Inter-calving interval: 2-3 years
Live calves produced/lifetime: 6-7
Birth rate/total population/year: 5-7%

results below these targets are considered as being sub-fertile or infertile.

Background

Extensive research studies along with clinical observations and actual fertility results of Southern White Rhinos in captivity, serve to confirm that this species exhibit a number of classic symptoms of infertility or subfertility that are commonly displayed by others in the Perissodactyla order, especially the horse and ass, and by the herbivorous species such as the bovine. These symptoms can be summarized as being:

acute and chronic anoestrous
irregular oestrous cycles
silent heat (oestrous)
ovulation failure
conception failure
absorptions/abortions

The herd reproduction parameters as reported for fertility in the wild do not indicate similar problems being experienced under natural environmental conditions. Reduced fertility may occur as the result of varying seasonal conditions (droughts, stress and disease) but overall the fertility rates of captive animals (wild born and captive born) are significantly reduced. With the identification of the symptoms, the major challenge is to diagnose the underlying causes precipitating the observed signs of abnormal reproductive events. Once clearly diagnosed it may be possible to significantly improve the fertility success of captive-bred females or even achieve the optimum targets achieved in the wild.

Based on experience in horses, cattle and other species, we do not consider it appropriate to adopt artificial procedures to stimulate or induce the reproductive cycle. Generally this will fail if there are underlying basic problems affecting the natural physiological status.

Reproductive Physiology

Normal reproduction function and fertility depend on the maintenance of the animal's optimum internal status (metabolic, health, nutritional) which will result in a balanced physiological state (hormone levels, enzymes, vitamins, minerals, fluid, *et cetera*).

Table 1 - Basic Hormone Status - outlines the major hormones, their interaction and external factors likely to influence their balance within the female.

Should the critical balance or production of these hormones be affected by such factors as nutritional deficiencies or imbalance, abnormal social relationships, captive management, confinement, environmental or disease condition, then the first changes likely to occur will be to the animal's hormone balance which can undoubtedly result in a lowering of fertility or even infertility in both the female and the male.

Nutrition affects reproduction (Celi, P. *et al* 1998), partly through the neuroendocrine control of gonadotrophin secretion and partly through gonadotrophin-independent pathways. Endogenous opioid peptides also control gonadotrophin secretion through effects that appear to depend on intracellular calcium status and metabolic changes.

Examples of this occurring have been clearly identified in the horse, cow, dog, sheep, et cetera. and relate to:

stress (environmental, management, social relations) results in an increase in cortisone levels, hence an increase in prolactin which then depresses FSH and LH levels; or

nutritional imbalance or deficiencies (proteins and amino acids required for hormone production) result in a decline of GNRH releasing hormone and a concurrent decline in the release of pituitary hormones i.e. FSH, LH, Thyroid and Growth Hormone; or

nutritional deficiencies/toxicity (e.g. the minerals-copper, iron and selenium) result in a decrease in conception rates even with optimum ovulation rates. There are also possible abortions with low selenium levels; or finally

recent research in Canada/Alaska (Bowyer, T. *et al* 1998) has shown that with changes in population densities and reduced habitat the grazing pattern of the Moose (*Alces alces*) has significantly altered. Moose normally are year-round browsers, now, with these changes, they have had to resort to grazing behaviour. These nutritional changes have resulted in abnormal digestive metabolic processes, e.g. changes in levels and concentrations of fatty acids. These may account for the recorded higher levels of infertility.

Experience in the Czech Republic (Vahala J, 1998) suggests that the major factor leading to infertility in White Rhino relates to management factors thereby creating behavioral disorders and hormone abnormalities. The observations related to sufficient space, not numbers in a breeding group. Observations at Werribee Park, Australia, fail to support this as the pair retained there has a large and fully accessible grazing reserve.

These are but a few examples that result in physiological changes that can lead to anoestrous, anovulation cycles, silent heats, irregular cycle lengths or conception failures. The genetic make-up of the Southern White Rhino may be more sensitive to external influences than other Rhino species when maintained in captivity, a factor not determined.

Species Comparison

Considering the reproductive parameters of the related 4 species of the family Rhinocerotidae, the Black Rhino (*Diceros bicornis*), the Indian (*Rhinocerous unicornis*), the Javan (*Rhinocerous sondaicos*) and the Sumatran (*Dicerorhinus sumatrensis*) along with others of the order

Perissodactyla, the horse, ass and zebra (*equidae*), and of other herbivorous species such as the bovine; in the wild, in captivity or under domestication, these may have some relevance in the diagnosis, treatment or prevention of subfertility or infertility of the Southern White Rhino, but it is considered to be of little significance. The wide variation of captive management conditions, such as ages of the animals, holding facilities, limited numbers, nutrition, social interaction *et cetera*, highlights the difficulty of formulating any significant diagnosis or appropriate recommendation to improve breeding performance of all the species.

A comparison of the cycling hormone profiles (oestrogen and progesterone) of the Indian, White and Black (Hindle, J. 1990) highlights the species variation during oestrus and in relation to mating, figure 1.

Table 2 presents a summary of the reproductive parameters of the Black and White Rhinos held in captivity in Australia. (Thorne, A. 1998; Lynch, M. 1998)

The social interaction and behavioral characters within captive groups present conflicting pictures. Within the Whites, it is generally accepted that pairs fail to produce, but likewise the same applies to bigger mixed groups in some centres. While it is appreciated that wild Blacks lead a solitary existence pairing only at mating, replication of this behavior in captivity has failed to achieve reasonable levels of fertility. In the Czech Republic at the Dvur Kralove Zoo (Vahala, J. 1997), group housing of Blacks (1 male with 2-3 females for extended periods 3-4 months) achieved an optimum level of fertility compatible or better than in the wild. Experience to date in Australia, in a similar social interaction, has failed to duplicate these fertility results.

A recent study (Benirschke K. *et al* 1995) of the reproductive tracts of Indian, Black, Sumatran and White Rhinos has shown that the placentation is very similar although they differ markedly in size. The rhinoceros placenta was identified as being very similar to the horse, representing a diffuse epinelio-chorial type with large areas of villus-free regions. The anatomical structures of the reproductive tracts of all species are very similar except for differences in size.

The White and Black Rhinos females normally mate a number of times with one male; the Indian, in contrast, usually mates with a number of males at each oestrous. Again, significant behavioural characteristics that cannot be accepted as the norm for the family but differ generally between species.

Also of relevance is the different diet of each of five Rhino species. This in itself raises a large number of variables that could have an effect on fertility.

Our observation of bovines records similar symptoms as those recorded for captive Southern White Rhinos under conditions of nutritional, environmental or management stress. Furthermore, our experience with on-farm embryo collection programs with cattle of the same breed (i.e. same genetic pedigrees), the variation between farms (even those in close proximity) can yield significantly different results in the number and quality of embryos collected. The major variable in these situations is nutrition. When the diet is supplemented and standardized, the results become compatible, i.e. similar number of viable embryos collected in response to superovulation. Again, the comparison between species i.e. *Bos Tuarus*, *Bos Javanicus* and *Bos Indicus* can account for significant variations in fertility even though all species have been maintained under similar conditions.

In consideration of the species within the order *Perissodactyla*, the horse is a classic example when we compare the results of behavioral changes when domesticated or in the wild. In the domestic mare (Rossdale, P.O. *et al* 1974), a number of symptoms were reported which have

particular clinical importance with regard to pathological and physiological conditions responsible for infertility i.e.

individual oestrous lengths vary from 1 to 50 days
individual dioestrous lengths vary from 10 days to several months.

While Hughes *et al* (1972) observed three types of anoestrous in a group of domesticated mares studied over a 2-year period:

(a) ovulation on a regular cycle interval but failed to show any sign of oestrous
(b) persistent CL; and
(c) inactive ovaries, anoestrous

Recent observations of studying a group of horses in the wild (Asa, C. 1998) showed a completely different picture of sexual behaviour during the peri-ovulatory period than that which has been described for the domestic horse. Most wild mares show full estrous behaviour and copulate at variable times during the anovulatory season. Similarly, a smaller percentage (about 20%) may solicit stallions but are less likely to copulate during early pregnancy.

The difference between horse breeds can also account for a varying level of these symptoms when managed together under certain circumstances, i.e. the Arab in comparison to the Thoroughbred.

The five species of Rhinos and those of related species all have symptoms of irregular or abnormal reproductive cycles. In this context, with the current available data, it is difficult to accept that there is any parallel that could be clearly identified and recommended to address the cause of infertility in the captive Southern White Rhino. It is clear that field observation of reproductive behaviour in the wild may not be relevant in captive situations or in domestication.

Clinical Approach To Diagnosis

A clinical approach to diagnosing the basic factor or factors resulting in the symptoms of subfertility or infertility is required. Such an investigation requires a detailed systematic study before any relevant results can be used to formulate and recommend corrective measures. This investigation would need to include the following:

a detailed analysis of the diet in the wild, as compared to that fed in captive centres with a successful breeding program compared to those experiencing infertility
a study of the metabolic and hormonal status of both wild and captive females and males, based on similar studies in horses and cattle, to determine if there are major factors that appear to be deficient or excessive (i.e. thyroid, cortisone, prolactin, selenium, iron, calcium, pheromones, testosterone, *et cetera*)
an investigation of the possibilities of the occurrence of chronic venereal disease being responsible for the cause of absorptions, abortions and conception failures (ie. chlymadia, mycoplasma, leptospriosis, herpes virus, *et cetera*).

These proposed areas of clinical investigations could be implemented as the next phase of the ongoing research program into reproductive failure of the captive bred Southern White Rhino and that of the 4 related species.

Questions Raised

What is the optimum breeding weight or condition for captive Southern White Rhino?
Does the amount of exercise affect the reproductive performance of females or males?
Difference in the amount or duality of the pheromones produced by wild bred/captive bred females and males?
Is the cause of infertility or subfertility a result of female fertility or is there a major male factor involved?
Hodges, K. 1998, considers that it's important to concentrate on clear understanding the biology of natural reproduction in the Whites, and raises the following questions.
What are the effects of behavior, social structure and the role of the male?
What is controlling the luteal function and are the recorded extended cycles (60 days or so) associated with early embryonic loss due to social disturbances or what?
Does the captive fed diet correspond in nutrient values and minerals to that normally found in the wild? i.e. Owen Smith (1974) reported that, in Natal, four species of grasses constituted 74% of the food intake, these being: rouges, *Thumbed trainer;* Buffalo grass, *Panic maximum;* small buffalo grass, *P. coloratum,* and Gonyya grass, *Urochloa mosambicensis,* the first named being by far the most heavily utilized. Some thirty species are eaten to a lesser extent. The dry matter protein content of this ration varies from 5% to 20% in parallel to seasonal conditions (Jones, D. 1979) in relation to seasonal conditions.

A number of relevant questions raised by Jiri Vahala (1998) are worth considering:
The importance of space, temperature and light?
Why do males and females exhibit sexual preferences?
Why young females fail to conceive even though they are mated to a proven breeder?
Why do young females have only one or two oestrous cycles/season? (and usually at the end of summer in Middle Europe).

Summary

The captive Southern White Rhino exhibits classic symptoms of infertility or subfertility as observed in a wide selection of wildlife when held in captive management. Reported results of the reproductive performance of the wild bred Black Rhino and the Southern White Rhino in Australia are equally as dismal as those reported in other countries for the captive bred Southern Whites.

Research techniques have been successfully established and developed to confirm the observed signs of irregular or abnormal oestrous cycles.

Varying management programs have been trailed with little positive response other than by running mixed groups in large range areas. Group management in restricted areas has been largely unsuccessful.

Social interaction, group behavior or adaptation are major factors in captivity, the fertility results achieved do not resemble those observed in the wild or correspond to those found successful for other related species i.e. the Black Rhino (even these are extremely variable between centers).

While there are numerous similarities in the reproductive characteristics of the five Rhino species and others in the *Perisssodactyca* order, along with other herbivorous species, it would be inappropriate to assume significant parallels to the Southern White Rhino and adopt management strategies based on the current available data.

Further detailed investigations are warranted in an attempt to diagnose, treat or prevent the ongoing incidence of reproductive failure in captive bred Southern White Rhinos. Investigations should concentrate on determining if the species is affected by nutritional, social or management stresses in captivity and identify the specific factors involved.'

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Figure 1 - Basic Hormonal Status

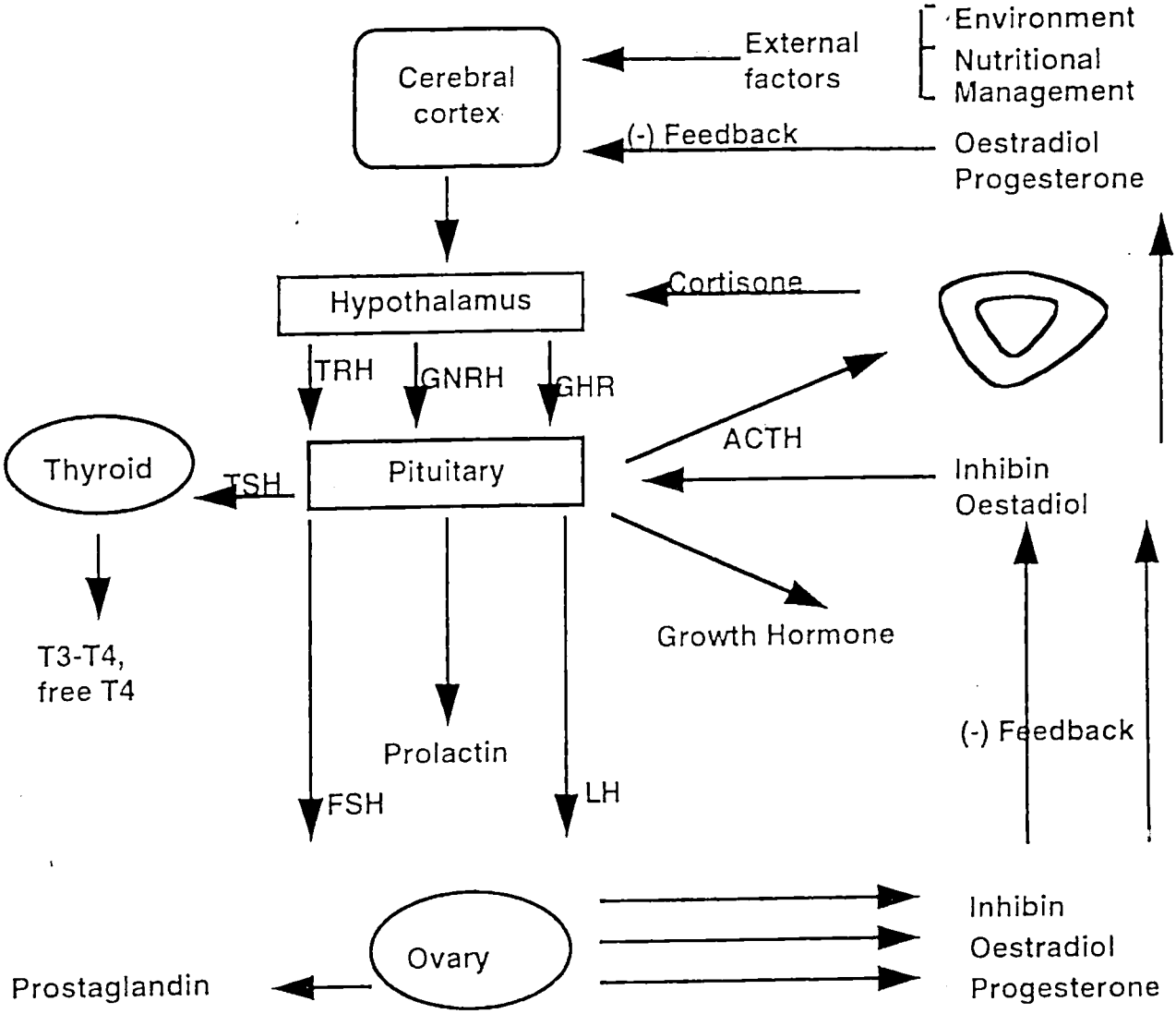

Table 2.

WHITE RHINO REPRODUCTIVE PARAMETERS, AUSTRALIA*

Name	Location	Age	Reproductive history	Offspring
LIKWEZI (I)	ZBV Werribee Park	14	Oestrus cycle lengths between 4-10 weeks, no apparent cycle regularity, but luteal activity. No matings.	-
NICOLE (II)	WPZ 1980 (Wild Born)	α 30	No observed signs oestrus. No matings.	-
ALEXANDRA (II)	WPZ 1989 (Captive Born)	18	Anestrus, no signs of mating.	Stillborn Calf 1991

* Full details Appendix 1.

(I) ref. Lynch ,M.1998
(II) ref. Thorne, A. 1998

Table 2.

BLACK RHINO REPRODUCTIVE PARAMETERS, AUSTRALIA*
(Thorne A. 1998)

Name	Location	Age	Reproductive history	Offspring
MUSINA PONGO	WPZ 1993	α 18	Anestrus	Calf 1990 (wild)
CHITUNDA MUSERE MUSERE	WPZ 1993	α 14	Oestrus cycles 22 days with periods of anestrus. 10 matings 96-97	Calf 1990 (wild)
KALUNGWIZI	WPZ 1993	α 12	Oestrus cycles 30 days. 3 matings 95-98	Calf 1996 Preg. 1998
PEPE KALLA	WPZ 1993	α 9	Sporadic incidences of oestrus behaviour, no breeding	-
UTAHWEDANDE	WPZ 1993	α 9	Oestrus cycle lengths 23 day 10 matings 95-98. Periods of anestrus	-
DONGAJUMU	WPZ 1993	α 9	Oestrus cycle lengths 21 days. Irregular and variable in length, anestrus. 28 matings 95-98.	-

* Full details Appendix 1.

The oestrus cycles of this group of female's range from 21 to 30 days in length.
Possible reasons for apparent irregularities in cycling and low conception rates include early embryonic death, retained corpora lutea, reproductive tract infection, behavioural anestrus (silent heat) and even seasonal anestrus despite this species being accepted as non-seasonal, as well as factors affecting the fertility of males. The seasonal distribution of matings at WPZ has been:

Summer - 34% Autumn - 26% Winter 17% Spring 23%

(Thorne, A. 1998.)