VETERINARY MANAGEMENT OF THREE SPECIES OF RHINOCEROSES IN ZOOLOGICAL COLLECTIONS

Richard A Kock[1] and Julia Garnier[2]
[1]Zoological Society of London - Whipsnade and International Wildlife Veterinary Services
[2]Zoological Society of London - Whipsnade

INTRODUCTION

The last major reviews of the veterinary management of rhinoceroses were undertaken over ten years ago (Jones 1979, Silberman and Fulton, 1979). General texts cover many aspects of their diseases and veterinary care (Fowler, 1986; Wallach and Boever, 1983). Lindemann (1982) reviewed the African rhinoceroses in captivity and this included information relevant to veterinary care. Reviews of veterinary problems at Berlin zoo (Goltenboth, 1986) and at Dvur Kralove on the black rhinoceros (*Diceros bicornis*) (Vahala, 1990) have been reported. The UK status and veterinary problems of the black rhinoceros were discussed (Kock 1987) at a workshop on the black rhino (du Toit *et al.*, 1987). An international management survey of the *ex situ* black rhino population was completed (Maruska *et al.*, 1986). Ruedi and Tobler (1991) reviewed the situation at Basle for Indian rhinoceros (*Rhinoceros unicornis*). Rookmaaker (1983) completed a bibliography of the rhinoceros .

SUMMARY OF *EX SITU* RHINOCEROS POPULATIONS

A demographic survey for the *ex situ* black rhinoceros population was completed by Lindemann (1984) when the overall picture was one of diminishing stocks. Looking at the situation since that time there is some reason for optimism. From 1978-1988 the black rhinoceros population grew by about 19% not including imports. Comparing the status of captive white rhinos internationally from 1978-88 there was an increase of about 7%. In the period 1984-91, there actually was a decline in the white rhino numbers and this trend is likely to continue. In Europe and North America the black population increased over the same period by 9%. (IZYB, 1984 - 1989; Klos and Frese, 1983, 1987; Frese, 1991). In comparison with the Indian rhinoceroses over a period 1978-88 and 1984-91 there was an increase of about 22% and 7% respectively not including imports (Ruedi and Tobler, 1988; Tobler, 1991).

One possible reason for an improvement in the black rhinoceros situation is the intensive effort that was put into the species management in the mid 80's. Optimism relating to the population trend of the white rhinoceros (Klos and Frese, 1978) was perhaps premature as a detailed look at the European situation shows an aging population with relatively few collections breeding and this will be looked at in more detail.

Trends in the *ex situ* population will be discussed in this paper in relation to veterinary management. The situation globally will be examined where possible and if not, the status in Europe will be a main reference point to illustrate the management needs for the various species.

REVIEW OF REPRODUCTION IN *EX SITU* CENTRES

BLACK RHINOCEROS - EUROPE

At present in Europe 12 collections hold a total of 58 (23.33) black rhinoceros. Breeding has occurred at all these sites. Eight of these collections recorded offspring since 1984 and two, no young for 10 years (Figure 1). Approximately 50% of the females of reproductive age are producing young. There is only one individual female without a male and this will be

resolved soon. This is an improvement from the situation in the 1970's (Lindemann, 1984) when twenty per cent of the captive population and 40% of collections were not breeding due to single sex or incompatible animals in collections. Lindemann (1982) suggested that at least one third of the adult female population might never contribute to the next generation at that time. The movement of proven breeding males to other collections has improved the reproductive rate.

WHITE RHINOCEROS - EUROPE

Approximately 30% of the world's *ex situ* population of white rhino is kept in Europe. In 1983 these animals were kept in 65 collections in 1987. The number of collections holding white rhinos increased to 78 in fifteen countries by 1987. By 1991, there were 89 collections with approximately equal numbers of males and females in the population (Klos and Frese, 1983, 1987; Frese, 1991). A chart of their ages and origin (captive bred or wild caught) is shown in Figure 2. Sixty five per cent of the animals are of wild origin. Further examination of these data shows the following distribution in collections: 46% keep pairs (1.1), 22.5% keep one, two or three of the same sex, 31.5% keep groups of at least three or more individuals of both sexes. Sixty seven per cent of the European collections (handling some 45% of the animals) are essentially in a non-breeding situation (1.1 or single sex). Sixty five per cent of all captive rhino are in a similar position (Klos and Frese, 1991). Of the European animals 66% of them are wild caught and greater than 15 years of age and 34% captive bred of which 11% were bred in the United States. Only 8.10 animals are breeding regularly in 7 collections in Europe.

It is probable that unless the breeding management is sorted out the total population in Europe in ten years might be reduced by 25% with recruitment at the present rate.

Non breeding groups

Taking a closer look at the non-breeding collections in Europe a number of observations can be made. Since Lindemann's (1982) survey which made clear that reproduction in single pairs was unsuccessful, the trend over the last ten years has been to continue to create or maintain pairs. A number of collections reported a lack of cycling behaviour in the female, a fact also recorded in the wild under unfavourable conditions (Owen-Smith, 1973). Not surprisingly there is no significant change in the breeding results when compared to 1980. Approximately 10 animals bred in the United States were sent to Europe into single pair locations since 1982.

There is also evidence that animals which start in a "breeding location" and are subsequently sent elsewhere into a "single pair" system do not breed. For example: two fertile individuals at Whipsnade went to Moscow, were separated and placed with other individuals and have not produced subsequently. A pregnant female went to Sofia and did not produce any further offspring and a female at Antwerp which produced a single calf when it was part of a group of 2.3 did not produce any further calves when the group was reduced to a single pair at that location. Another pair in Paris produced a single calf which did not survive on the initial setting up of the pair. There have been no further offspring.

There are 18 non-breeding collections with three or more individuals, 16 of which have adult males and females accounting for approximately 25% of the European animals. Where management details are known there is a possible explanation for the lack of breeding such as the inability to mix the animals as a group, restriction in the opportunity for mixing to a limited number of hours in the day, or age discrepancy which will not allow for normal reproductive behaviour. It is worth noting that some countries have had rhinoceroses in collections for twenty years without a single breeding success.

Breeding Groups

Breeding groups (defined as having produced two or more offspring) exist in ten collections with 58 animals in total (3 of these collections have not bred for 6 years). In Germany only two out of 15 collections are breeding and in the United Kingdom four out of 14 collections

but in fact only three of these are regularly breeding. Two of these breeding collections only keep pairs, Edinburgh and Munster. Edinburgh received a pregnant female and male from Whipsnade where they had been in contact with the breeding group and this model is often quoted as a reason why pairs can breed. Munster's first calf was probably from a conception in the United States. It may well be that pairs that are kept together lose interest in each other, "familiarity breeding contempt" (Lindemann, 1982). With multiple female groups there have been both reproductive and non-reproductive individuals at any one time, the latter primarily due to age with one or two interesting anomalies. For example, the female of the original pair at Whipsnade, after the arrival of a large number of females, never bred. In this collection all the females that have reached reproductive age and survived have bred except for the single female mentioned. Of 14 females at Whipsnade, 10 reproduced (total 38 calves), three adults dying early on. Of seven males that went through the group, four are proven breeders. If one looks at males in breeding situations it is interesting to note that the presence of more than one male was beneficial to breeding (Lindemann, 1982). For example, a male who bred at Copenhagen came from Whipsnade where it was exposed to breeding males and females. Soon after arrival at Copenhagen it was observed to be excited and aware of the scent marks left by a 5 year male which had recently left (Lindemann, 1982).

At Hilvarenbeek the original breeding male who was 3 years old on arrival from the wild became reproductive after the arrival of two new females some years later. In Hodenhagen there were three males together. When the breeding male left and a younger male took over, mating was observed. A pair of animals were then removed, including this male, and sent elsewhere where they produced young from the conception at Hodenhagen but after this there was no further breeding. There are three collections where more than one male was kept with a single female, where breeding occurred. At Whipsnade the reduction of the group's size to nine animals with a single male from 17 with two males did not affect reproduction except in a single female who stopped breeding at approximately 21 years of age after the second male left. In both San Diego and Whipsnade the resident male of a pair, after the arrival of a group of animals including another male, became the dominant individual (Rawlins, 1979).

Of all the white rhinos in breeding collections in Europe, 67% are over ten years of age and approximately 55% of wild caught origin greater than 20 years of age. Second generation breeding is now occurring in a number of collections.

INDIAN RHINO - WORLDWIDE AND EUROPE

Reviewing the status of captive Indian rhino (Ruedi and Tobler, 1988; Tobler, 1991; Ruedi and Tobler, 1989) (Figure 3) the following observations are relevant: in 1991 the population comprised 35% wild caught and 65% captive born living in 43 collections for a total population of 114 (67.47). The captive population increased during the period 1972 - 1991 by 90%. Captive born stock is becoming predominant in Europe with a higher recruitment and lower death rate in this population. The situation in India is not so promising (Figure 4a,4b,4c). Improvement in reproductive rate is due to the increased number of collections with regular propagation and proportionately better performance of cows as they gain experience. Unlike the white rhinoceros, the management of pairs of Indian rhino has proven to be more satisfactory and management conditions adequate to ensure this reasonable growth. There are 18.14 in Europe, three out of the 14 European collections (21%) are breeding regularly from a single pair or with a male and two females. Four out of 14 (29%) retain only males due to the lack of females born recently. Seven out of 14 are not breeding regularly (50%). One young pair which bred twice stopped and there has been no reproduction for five years. Two collections have young animals who might not have been expected to breed yet. One pair together for 16 years produced only a single calf. Another pair which had been together for 20 years produced a calf recently when the animal was about 23 and one stillborn 6 years prior. One other pair aged 24 years has been together for 6 years without results. There appears to be reduced fertility in about 20% of the European breeding females.

REVIEW OF MORTALITY WORLDWIDE

General areas of pathology in the rhino species are presented in Figures 5,6,7.

BLACK RHINO

In 142 post mortem examinations of black rhinoceroses reported (Frese, 1991) the most significant finding in approximately 18% of the deaths was a variety of blood disorders characterised in a majority of cases by haemolytic anaemia (Miller, 1987). This problem is not seen in other rhinoceroses and therefore presumably related to some species-specific factor. Various theories have been put forward including malnutrition and specifically hypovitaminosis E (Kock, 1987; Ghebremeskel *et al.*, 1988; Dierenfeld *et al.*, 1988); and infectious diseases such as leptospirosis (Douglas and Plue, 1980; Mikulica, 1986; Miller and Boever, 1982; Miller and Boever, 1983; Miller and Bolin, 1988). There is no evidence that the syndrome is of autoimmune origin (Chaplin *et al.*, 1986), that a red blood cell metabolic defect was responsible (Paglia *et al.*, 1986), nor that an unstable haemaglobin is the cause (Fairbanks and Miller, 1990). There appears to have been a drop off in cases of the blood disorder since 1986 when various management options were discussed (du Toit, 1987). The next most common cause of death is pneumonia or other respiratory complications. Aetiological factors included aspergillosis (Goltenboth, 1986; Ott *et al.*, 1982; Gemeinhardt and Ippen, 1982) and at one time tuberculosis (Mann *et al.*, 1981, Godfrey *et al.*, 1990). *Pasteurella* has also been recorded as well as neoplasia of the lung (Frese, 1991). Respiratory disease accounts for approximately 14% of the cases recorded in the survey. The next most important cause of death is from accidental causes. This includes anaesthetic deaths, two during transportation, three associated with trauma, only two associated with intraspecific aggression, two associated with intoxication and two due to exposure to adverse weather conditions. These problems are also seen with wild animal translocations (Kock, N., 1989). Digestive problems are reported in about ten per cent of mortality with hepatitis (Schmidt *et al.*, 1982), colic, two impaction cases, volvulus and torsion, prolapse of the rectum and diarrhoea. Metabolic disorders account for about 8% mortality and some of these cases are associated with haemolytic anaemia and myodegeneration. Pathology associated with the urogenital system is relatively uncommon, just over 3%, with one case of pyelonephritis, a uterine prolapse and another with kidney stones following a chronic urinary infection. Cardiovascular disorders have been reported in 12 animals one of which had a pericarditis and six of which showed cardiac pathology including myodegeneration. Calcinosis of the endocardium in a black rhino has been reported (Bambir *et al.*, 1985). Perinatal mortality only counts for about 6% of the survey and it is made up of primarily abortions with some stillbirths and one calf attacked by its primiparous mother. Most of these cases have occurred since 1981 and this should be watched. One abortion was associated with a bout of haemolytic anaemia. There were five cases (3.5%) of neoplasia. Only 5 deaths associated with senility were recorded and this reflects the relatively high mortality of the black rhinoceros in the first 30 years. Infectious diseases have been significant in the past (Mann *et al.*, 1981, Godfrey *et al.*, 1990) and recent cases of encephalomyocarditis virus infection are notable (Miller, 1990). Nine per cent have causes of death recorded as unknown.

WHITE RHINO

This review covers a total of 106 deaths (Frese, 1991).

In white rhinos the largest single cause of death (24.5%) is due to accidents and the majority are associated with trauma. Incidents varied from drowning, intraspecific aggression, anaesthetic accidents and one death occurring during transportation. 73% of the incidents involved males. There is a high mortality of males in the wild from fighting (Owen-Smith, 1973) and it was noticed (Lindemann, 1982) that juvenile males were frequently involved in these accidental deaths. Seven out of eight accidental juvenile deaths in our survey involved males under two years of age. The next highest area of pathology is associated with the digestive system (23%). Approximately one-third of these cases involved hepatitis. Three cases of impaction including two of the colon were notable.

The next most significant class of deaths (10%) were perinatal, of which two-thirds were stillbirths. Of an equal importance were conditions affecting the cardiovascular, respiratory and urogenital systems. The majority of cardiovascular disturbances were associated with the heart; myocarditis, myopathy and pericarditis (Schneider and Wisser, 1987). Respiratory conditions were primarily pneumonia with one case associated with shipping stress. Infectious diseases are uncommon and only 5% associated with metabolic disturbances which may be related to nutrition and other factors. Thirteen percent of the deaths had no significant pathology recorded.

INDIAN RHINO

This review covers the period 1959 - 1991 (Ruedi and Tobler, 1988; Tobler 1991) with a total of 59 deaths.

Perinatal causes account for 29%; three abortions, seven stillbirths and seven neonatal. Eight of the dams involved were primiparous. Two pairs contributed significantly to this total count with six perinatal deaths. One of these pairs has not yet produced a live calf. Mortality associated with problems of the digestive system (24%) includes: impactions (Beehler and Bush, 1981); two cases associated with severe worm infestation, one in a 4-month old animal; one colic associated with sand ingestion, two cases with ulcerative gastritis in mature adults, one of these perforating with a peritonitis and a case of enterocolitis in a 24 year old and enteritis in a youngster, one rectal prolapse in a 16 year old and a case of indigestion with respiratory complications in another individual. No specific liver disorder has been noticed, in contrast to the white and black rhinos. Chakrabarty *et al.* (1989) describe the liver anatomy. Neoplasia caused caused 8% of deaths; 2 deaths with the incidental finding of leiomyoma were recorded at ages of 24-36 years (Montali *et al.*, 1982); and two cases with squamous cell carcinoma (Naik *et al.*, 1986; Nandi and Kumar Deb, 1972). Eight per cent of the mortality was associated with severe respiratory pathology, four cases with emphysema including marked fibrosis in one case and one which died from trauma, these conditions were chronic and in one case leiomyoma was also observed. A 35 year old animal died from *Klebsiella* pneumonia. Cardiac conditions were uncommon. One cardiac dilatation with lung pathology including fibrosis and one case of undifferentiated cardiac disease were noted. Five per cent involved the urogenital system, one case involving kidney and liver failure (Strauss and Seidel, 1985). One case of pyometra in a 35 year old female and one nephritic case were reported. Leiomyomas were recorded in the uteri of two individuals. Accidental deaths accounted for about 8%, one associated with intraspecific aggression, two accidental trauma, one drowning and one associated with transportation. Two died of senile changes, one being 50 years old. Twelve causes of death were not found accounting for 20% of mortality.

CLINICAL MANAGEMENT OF RHINOS

General

Veterinary care and medical problems associated with rhinoceroses were reviewed in 1979 (Jones, 1979; Silberman and Fulton, 1979). This paper will concentrate on developments since then with reference to earlier works when necessary.

With the increase in the percentage of captive born animals and fewer importations, the incidence of protozoan infections and parasitic helminthiasis related to pathology has declined. Filarial skin lesions are still common in wild populations in certain areas (Kock and Kock, 1990). Ectoparasites can still be a problem in certain locations, for example flies causing direct irritation or contamination of wounds. There are no new reports in literature relating to this aspect.

Three reports in the literature of *Salmonella* infection (Page and Schmidt, 1987; Schaller, 1981; Char *et al.*, 1984) re-emphasizes the importance of this opportunistic pathogen in perissodactyls. Young animals seem to be particularly susceptible and stress is a complicating factor. Infections and infectious diseases still occur (for example, poxvirus

infection has been diagnosed in black and white rhino (Pilaski *et al.*, 1982)). However, due to the relatively isolated nature of zoological parks and good hygiene practices it is not a major problem now in rhinos. Accidents in all rhinos remain a concern and most are preventable. Superficial skin wounds will resolve without treatment, but deep wounds need vigorous attention (Clausen and Ashford, 1980). Successful treatment of traumatic injuries to the horn in one individual and the horn and facial bones in another were reported (Franz *et al.*, 1988; Altmann, 1987). In general the integument, the digestive and cardio-respiratory systems remain the main areas of clinical concern. Close attention to nutrition, access to wallows, attention to temperature in winter and the healing of minor wounds (topical antibiotics and fly spray) will reduce skin complications. For the digestive system the main problem period is in the first two years of life with dietary upsets and bacterial enteritis. Problems in adult life will be largely prevented by a high quality diet with appropriate nutrient levels although the latter has not been adequately defined as yet. *(But, see Spala, this volume - ed.).* There needs to be more diagnostic work on liver disease as etiological factors are unclear. Cardio-respiratory conditions continue to occur and close attention should be given to ventilation in housing, exposure to allergens such as hay dust and general exercise and fitness.

Restraint procedures in the rhinoceros have not changed markedly. Etorphine (Immobilon - C-Vet Limited) is still the main agent for immobilisation in all rhinos. There are certain adverse physiological effects including an elevated heart rate and hypertension, respiratory depression, a degree of hypoxaemia and acidosis probably due to a combination of respiratory effects and muscle activity as there is considerable tremor (Personal Observation, Leblanc *et al.*, 1987; Kock *et al.*, 1990b). Mortality associated with anaesthesia is a risk and protocols should include close monitoring of physiology. As the white rhino, in particular, appears to show post recovery renarcotisation and sometimes inadequate reversal, care must be taken to ensure sufficient antagonist is given, more usually diprenorphine (Revivon -C-Vet Ltd) although naloxone (Narcan - Du Pont) can produce a better result. The longer acting antagonists such as naltrexone are not evaluated in rhinos. During stressful situations such as transportation and reintroductions to groups, long acting tranquilisers such as haloperidol (Haldol - Janssen Pharmaceuticals Ltd) piportil (Pipothiazine - May & Baker Ltd) trilafon (Perphenazine - Schering Plough Ltd) and clopixol (Thioxanthene zuclopenthixol -Lundbeck Ltd) are worth considering in light of some of the positive findings with wild translocated rhinos (Kock, 1991). When stressed, free ranging white rhino showed a significant cortisol response (Van Heerden *et al.*, 1985), and black rhino a cortisol and glucose response (Kock *et al.*, 1990).

Young and quiet individual white rhinos can be sedated effectively with modern alpha 2 agonists; Detomidine (Domosedan -Norden). Suggested dose is 0.1 mg/kg by intramuscular injection but it will not be effective in all cases particularly with excitation and cases should be carefully selected. It is useful for general examination, bleeding and minor treatments. The drug can also be reversed using alpha 2 agonist antagonists (Kock et al 1989) and this is beneficial.

Artificial breeding technologies are much improved and the reproductive status of the rhinoceros can be evaluated through urine sampling (see the Proceedings). The latter has distinct advantages for management (Hodges and Green, 1989) but the use of artificial insemination should not be seen as a means of resolving problems as there are clearly management techniques which can do this more effectively at much lower cost and stress to the animal. Whenever opportunities arise reproductive organs should be carefully examined as the understanding of their structure is essential (Schaffer and Beehler, 1990). Reproductive failure is more likely to lead to a decline in the white rhinoceros as, in general, mortality is not constraining population growth. It is surprising that changes have not been implemented to date. Information was available over 10 years ago which indicated the general direction that the captive breeding community should be going (Lindeman, 1982; Klos and Frese, 1978; and Rawlins, 1979).

Recent work (Kirkwood *et al.*, 1989) on hand rearing techniques show this to be a viable procedure, but clearly the behavioural implications are significant and every attempt should be made to retain the animal with its mother to reduce potential problems. Male hand reared white rhinos can be dangerous to man and other rhinos. An attempt to introduce a 13 year old hand reared male to the Whipsnade herd recently proved to be too dangerous and was abandoned.

Prophylaxis and Management

Medical prophylaxis in the rhinoceros is probably unnecessary in the majority of collections with the exception of leptospirosis (Miller, 1990). A recent case of rabies (Mukherjee *et al.*, 1984) may justify vaccination in high risk localities. Husbandry practice, exhibit design and general management are keys to success in all areas of veterinary management. The general principles are discussed and recommendations made for each species.

A clinical pathology update in the three rhinoceroses discussed is given in Table 1 - 4 (Results from Department of Vet Science Zoological Society London - C. Hawkey and B Gascoine).

BLACK RHINO

Since fertility is not so much of a problem when compared to the white rhinoceros the success of the population will depend on improved health care and subsequent survival. In the wild individuals have been known to breed into very old age (Goddard, 1970). The fact that a number of captive animals stop reproducing at an earlier age is of concern. The main problem is associated with the blood disorders, cardiac and metabolic problems which together account for approximately 30% of all mortality. Successful recovery from haemolytic episodes evidenced by haemaglobinurea is possible with treatment with antibiotics and vitamins A, D, and E (Personal observation, Jarofke and Klos, 1988). It is tempting to speculate on a single cause but there is probably a complex pathogenesis. Nutrition and specifically hypovitaminosis E may be important, infection by bacterial and viral agents (e.g. leptospirosis) might be involved. The role of stress with confinement in this species has not been examined in detail. Since more attention has been given to the management and feeding since 1986 it is interesting to observe what appears to be fewer incidences of disorders of this kind.

There is room for improvement in housing and exhibit design in most collections. Whether the captive management of the black rhinoceros is in general stressful is open to debate. Respiratory conditions such as aspergillosis may occur with immunosuppression, a possible sequel to chronic stress but most cases reported were associated with steroid treatment (Goltenboth, 1986; Ott *et al.*, 1982). Confinement stress is real and exhibit design must take this into account. Good design and management will also have the advantage of reducing the number of accidents, transport and anaesthetic deaths, intraspecific aggression, and traumatic injuries.

Encephalomalacia in three black rhino under the age of 3 was recorded, but the cause is not clear (Miller *et al.*, 1990).

Ulcerative dermatitis during pregnancy in an 18 year old female where hypophosphataemia and anaemia with subsequent uterine torsion were noted. Another 20 year old rhino with similar dermatitis was treated with phosphorus and the condition improved (Gillespie *et al.*, 1990). An ulcerative dermatitis was recorded in 1982 (Ott *et al.*, 1982) and over a period responded to dietary changes and steroid treatment, but it was also noted that the conditions the animals were in were stressful and one individual died of aspergillosis. Goltenboth (1990) showed the presence of an epitheliotrophic herpesvirus in cases of ulcerative dermatitis at Berlin. Recent work in the United States on a series of dermatitis cases has not shown a clear aetiology (Miller, 1990). Personal observations were made of three cases in the United Kingdom of chronic ulcerative dermatitis, in a male

which was behaviourially stressed and in a pair in poor housing conditions which might be considered stressful.

The black rhinoceros is not as tractable or sociable as the white and this has implications for management. Clearly good isolation facilities are necessary so that pairs can be separated.

Nutrition is an area requiring further research but some general advice can be given. The black rhinoceros has morphophysiological adaptations related to their feeding almost exclusively on browse (Clemens and Maloiy, 1982, 1983). Research is needed to clearly define these adaptations and compare them to the white rhino, a grazer. There is good information about ruminants in this regard (Hofmann,1989, 1991a, 1991b) and evidence of pathological changes when inappropriate diets are fed (Marholdt, 1991). A specific adaptation of interest relates to the larger liver size compared to the white rhino with an apparent greater tolerance to toxic plants in their natural environment (Goddard, 1968). Feeding of "browser" type diets (SDS Browser Diet) in a number of species has been successful (Personal observation) and is to be recommended in the species. There has been attention given to Vitamin E supplementation in rhinos (Dierenfeld and Citino, 1989; Lewis and Kirkwood, 1990) and the development of new products (TPGS vitamin E) have resulted in elevated plasma levels (Papas *et al.*, 1990; Kirkwood *et al.*, 1991). The metabolic significance of this is unclear.

Compatibility and tractability are important aspects of black rhino management. Solitary by nature and a species evolved to inhabit thick bush vegetation, the black rhino might be stressed by many aspects of zoo management (e.g. open paddocks and close association with other rhinos and humans). Comparing black to white, black rhinos appear to be more nervous and stressed in confinement. The more nervous animals often become clinical cases!

WHITE RHINO

Regarding housing and exhibit design; large barn-like housing is ideal for a minimum of three animals with the ability to separate individuals when necessary, but with a policy of mixing 24 hours a day. Well ventilated, spacious accommodation will reduce respiratory complications, enable a stable social organisation of the group and reduce intra-specific aggression. Isolation facilities are necessary to deal with sick individuals, to obtain samples for monitoring reproductive status, for parturition and as part of reintroduction protocols for new animals. Heating is advisable in severely cold conditions. In most temperate areas deep litter systems are adequate in providing the necessary warmth.

External paddock systems should be as large as possible. The advantages of this are to improve fitness through exercise and reduce crowding. There are key advantages relating to reproduction such as the ability for the male to express territorial marking behaviour (dung piles) to obtain exclusive rights to the female and stimulate appropriate behaviour (Owen Smith, 1971; O'Connor, 1982). If grass pasture (mixed hay) is available this is optimal for the species' nutrition. It will reduce digestive complications associated with dry forage and concentrate feeding. Mortality associated with moats particularly where they are water filled, indicate that this is an unwise barrier choice as solid perimeters using cabling, electrical fencing and boarding are adequate.

There is evidence that the keeping of more than a single male particularly at the setting up of a group is beneficial. This should be done and sufficient space provided so that multiple males can be present in the area at the same time without restriction. At the present time relatively few males in the population carry out the breeding and this has long term genetic implications. With a relatively balanced sex ratio in the captive population it should be possible to replace males more frequently, but the likely effect of doing this on the reproductive rate is not known.

White rhinos are generally tolerant of other species and can be managed in mixed exhibits.

Due to their complex social bonding in captive breeding groups, care must be taken in deciding on introductions and alterations in the group structure. An excellent study of the group behaviour of white rhinos in group circumstances is given by O'Connor (1982). It appears that pairs of females bond and spend a great deal of time together. It is general practice to isolate females for parturition and for a period afterwards, but where circumstances allow reproductive rate can be increased by allowing the male access to the female as soon as practicable. The high mortality in juvenile males means that during periods of increased agonistic behaviour (e.g. oestrus) removal or isolation of these individuals at this time may be beneficial. Care must be taken with feeding as there is usually aggressive interaction at this time. Any stress factors whether social or associated with confinement are likely to lead to veterinary problems at some point and by providing space it allows expression of normal behaviour. It is worth mentioning at this point that Owen-Smith (1973) commented on the fact that the black rhino were not dissimilar to the whites except in that there was a greater social grouping in whites in their natural state. Grouping in *ex situ* breeding clearly is an essential practice, but as there are disadvantages primarily associated with density and social stresses, these should be considered.

INDIAN RHINO

This species does not appear to have as many health problems as the black rhinoceros and, in general, the situation looks promising.

Perinatal mortality (29% of total mortality) is clearly highly significant, but as pointed out by Ruedi (Reudi and Tobler, 1991) much of this was linked to primiparous animals and as they mature there is an improving success. Also the fact that 6 out of 17 of these fatalities were related to two pairs means that the majority are now performing well. Nevertheless the periparturient period requires close observation and management. The leimyomas in the uterus and a pyometra are of interest as there is some possibility of them being related to abnormal oestrus cycles (Montali *et al.*, 1982). This may be associated with behaviour and management, the proximity of the male perhaps adversely affecting the female and this should be researched. There is some information published on the normal pre-parturient behaviour which provides a reference point. Gairola (1987) for example, describes a change in behaviour 9 days prior to parturition in wild pregnant rhino with rejection of previous offspring .

In general Indian rhinos are very tractable and close management seems to suit them, but as much space as possible should be provided for the purposes of exercise. Heated housing is beneficial and a pool as opposed to a wallow is ideal.

Another important area of pathology was the digestive system with (22%) of cases including ulcerative gastritis. The effect of stress in this species needs to be evaluated in light of these findings. Nutrition seems to be adequate with a basic ration of mixed forage, protein concentrate, vitamin and mineral supplement but with a relatively high level of mortality associated with the digestive system this needs further evaluation.

Clinical conditions of the feet are reported (Char *et al.*, 1984 and Strauss and Seidel, 1982). As with most rhinos they are susceptible to trauma of the foot from stones (flints), and surface materials need to be carefully selected. A case of ulcerative keratitis was also reported (Khan, 1981).

SUMMARY AND RECOMMENDATIONS

For all three species of rhinoceroses discussed in this paper the main thrust for veterinary management should be towards prophylaxis through good and appropriate management. As reproduction and health are key factors in the long term viability of the rhinoceros in

ex situ breeding situations the veterinarian has a key role in resolving problems. When there are so many demands on zoological societies to breed endangered species for conservation the resources directed towards rhino breeding are often not adequate. Appropriate management techniques are available for the white, black and Indian rhinos to ensure success. For the white rhino these techniques are not being practised in a large percentage of collections. The main recommendation relating to improving the growth of the white rhinoceros population in captivity is to develop a greater number of group breeding facilities. This has been implemented in the SSP over the last few years and the benefits are clear.

The future of the black rhinoceros in captivity is not so certain although there are early indications that the major health concerns over the last decade or two are now being tackled with some success. The Indian rhino to date has a satisfactory status in captivity and the population is growing. There are pressing demands to establish captive populations of the Sumatran and Javan rhinoceros. These are hardly justified until the future of other species in captivity is guaranteed. The removal of valuable individuals from natural populations into an uncertain future should not occur. Collaboration between veterinarians in the field and in *ex situ* breeding situations should be encouraged to ensure that a free flow of information reduces the repetition of errors. Veterinarians reporting on cases would help managers if more information was given on the location, studbook number and other areas of husbandry. Publications otherwise are only of academic significance. Comparative information also will help to improve management in both areas. Refinement of diagnosis in the rhinoceroses is needed and international co-operation with pathological diagnosis will help in this regard. There has been limited success in attempts to do this to date with material from relatively few institutions being made available. Bureaucratic difficulties (e.g. CITES) are one reason for delays in sending material across international borders to central laboratories.

There will need to be a more disciplined approach to co-operation in all areas of *ex situ* rhino management whether it be through studbook control or some other mechanism to ensure that recommendations are implemented. In this way the contribution of the *ex situ* breeding community will be positive to the conservation of these species and the conservation community at large will become more supportive of their efforts.

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TABLE 1

DEPARTMENT OF VETERINARY SCIENCE

ZOOLOGICAL SOCIETY OF LONDON

HAEMATOLOGY REPORT USING LYNX REFERENCE DATA

Latin name: CERATOTHERIUM SIMUM
Common name: WHITE RHINOCEROS
Age: ALL
Sex: ALL

REFERENCE RANGES FOR WHITE RHINOCEROS

Variable	Units	Range			N
Total haemoglobin (Hb)	(g/dl)	14.15	-	20.56	34
Red blood cell count (RBC)	(10^12/1)	5.65	-	8.64	31
Packed cell volume (PCV)	(1/1)	0.39	-	0.55	31
Mean cell volume (MCV)	(fl)	56.07	-	76.27	31
Mean cell haemoglobin (MCH)	(pg)	20.02	-	28.72	31
Mean cell haemoglobin conc(MCHC)	(g/dl)	33.63	-	40.01	31
Reticulocytes	(% RBC)	0.00	-	0.00	34
Total white cell count (WBC)	(10^9/1)	4.77	-	13.73	34
Neutrophil count	(10^9/1)	2.38	-	9.35	33
Lymphocyte count	(10^9/1)	0.83	-	4.22	33
Monocyte count	(10^9/1)	0.00	-	0.87	33
Eosinophil count	(10^9/1)	0.00	-	1.17	33
Basophil count	(10^9/1)	0.00	-	0.11	33
Platelet count	(10^9/1)	81.63	-	807.34	29
Erythrocyte sedimentation rate	(mm in 1 hr)	0.00	-	30.87	27
Fibrinogen	(g/l)	2.32	-	5.88	6 *

* - indicates observed range

TABLE 2

DEPARTMENT OF VETERINARY SCIENCE

ZOOLOGICAL SOCIETY OF LONDON

HAEMATOLOGY REPORT USING LYNX REFERENCE DATA

Latin name: DICEROS BICORNIS
Common name: BLACK RHINOCEROS
Age: ALL
Sex: ALL

REFERENCE RANGES FOR BLACK RHINOCEROS

Variable	Units	Range			N
Total haemoglobin (Hb)	(g/dl)	10.34	-	15.82	69
Red blood cell count (RBC)	(10^12/1)	3.28	-	5.26	69
Packed cell volume (PCV)	(1/1)	0.29	-	0.43	69
Mean cell volume (MCV)	(fl)	72.12	-	97.12	69
Mean cell haemoglobin (MCH)	(pg)	26.10	-	35.39	69
Mean cell haemoglobin conc(MCHC)	(g/dl)	33.20	-	39.51	69
Reticulocytes	(% RBC)	0.00	-	0.51	69
Total white cell count (WBC)	(10^9/1)	4.69	-	12.38	69
Neutrophil count	(10^9/1)	2.79	-	8.94	69
Lymphocyte count	(10^9/1)	0.49	-	3.40	69
Monocyte count	(10^9/1)	0.00	-	1.05	69
Eosinophil count	(10^9/1)	0.00	-	0.58	69
Basophil count	(10^9/1)	0.00	-	0.27	69
Platelet count	(10^9/1)	96.30	-	161.84	57
Erythrocyte sedimentation rate	(mm in 1 hr)	6.83	-	74.02	21
Fibrinogen	(g/l)	2.49	-	5.83	59

TABLE 3

DEPARTMENT OF VETERINARY SCIENCE

ZOOLOGICAL SOCIETY OF LONDON

HAEMATOLOGY REPORT USING LYNX REFERENCE DATA

Latin name: RHINOCEROS UNICORNIS
Common name: GREAT INDIAN RHINOCEROS
Age: ALL
Sex: ALL

REFERENCE RANGES FOR GREAT INDIAN RHINOCEROS

Variable	Units	Range			N
Total haemoglobin (Hb)	(g/dl)	13.60	-	18.70	6 *
Red blood cell count (RBC)	(10^12/1)	6.10	-	8.46	6 *
Packed cell volume (PCV)	(1/1)	0.40	-	0.49	6 *
Mean cell volume (MCV)	(fl)	52.53	-	65.57	6 *
Mean cell haemoglobin (MCH)	(pg)	18.79	-	23.84	6 *
Mean cell haemoglobin conc(MCHC)	(g/dl)	34.00	-	38.14	6 *
Reticulocytes	(% RBC)	0.00	-	0.00	6 *
Total white cell count (WBC)	(10^9/1)	5.40	-	9.90	6 *
Neutrophil count	(10^9/1)	3.19	-	6.43	6 *
Lymphocyte count	(10^9/1)	1.12	-	2.67	6 *
Monocyte count	(10^9/1)	0.00	-	0.30	6 *
Eosinophil count	(10^9/1)	0.00	-	0.72	6 *
Basophil count	(10^9/1)	0.00	-	0.09	6 *
Platelet count	(10^9/1)	124.00	-	302.00	5 *
Erythrocyte sedimentation rate	(mm in 1 hr)	16.00	-	32.00	4 *
Fibrinogen	(g/l)	2.87	-	3.66	2 *

* - indicates observed range

TABLE 4

DEPARTMENT OF VETERINARY SCIENCE

ZOOLOGICAL SOCIETY OF LONDON

BIOCHEMISTRY REPORT USING LYNX REFERENCE DATA

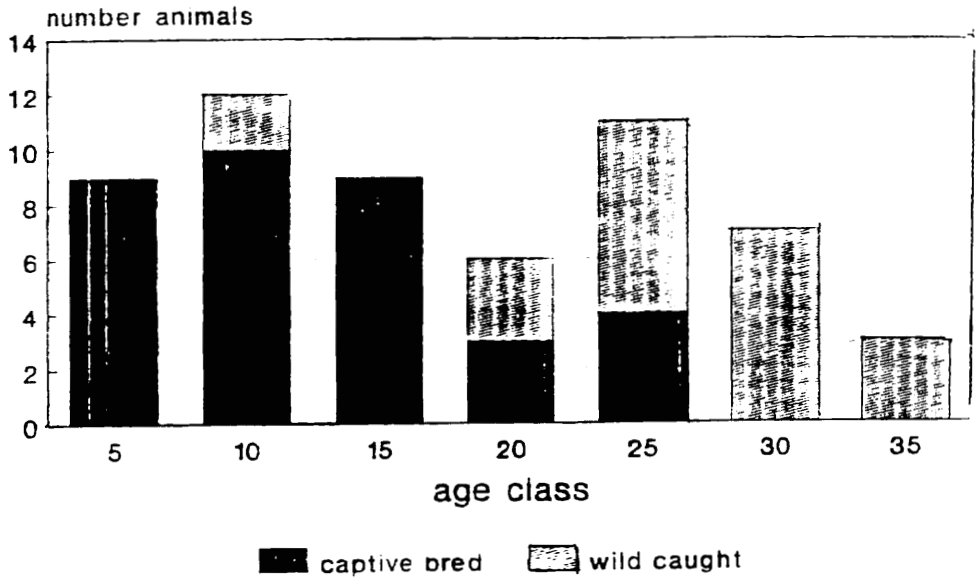
Latin name: DICEROS BICORNIS
Common name: BLACK RHINOCEROS
Age: ALL
Sex: ALL

REFERENCE RANGES FOR BLACK RHINOCEROS

Variable	Units	Range		
Urea	(mmol/l)	1.83	-	5.07
Creatinine	(µmol/l)	33.17	-	117.51
Bicarbonate	(mmol/l)	13.12	-	23.85
Chloride	(mmol/l)	85.20	-	104.30
Sodium	(mmol/l)	121.99	-	134.58
Potassium	(mmol/l)	3.77	-	5.29
Total protein	(g/l)	76.31	-	99.46
Albumin	(g/l)	18.56	-	29.84
Globulin	(g/l)	41.85	-	76.59
Calcium	(mmol/l)	1.86	-	3.50
Inorganic phosphate	(mmol/l)	0.50	-	1.76
Total bilirubin	(µmol/l)	1.00	-	10.00
Conjugated bilirubin	(µmol/l)	0.00	-	6.00
Alkaline phosphatase	(iu/l)	33.00	-	187.00
Alanine transaminase	(iu/l)	1.00	-	18.00
Gamma-glutamyl transferase	(iu/l)	12.00	-	71.00
Aspartate transaminase	(iu/l)	72.00	-	204.00
Creatine kinase	(iu/l)	218.00	-	497.00
Iron	(µmol/l)	20.57	-	68.90
Cholesterol	(mmol/l)	2.80	-	2.80

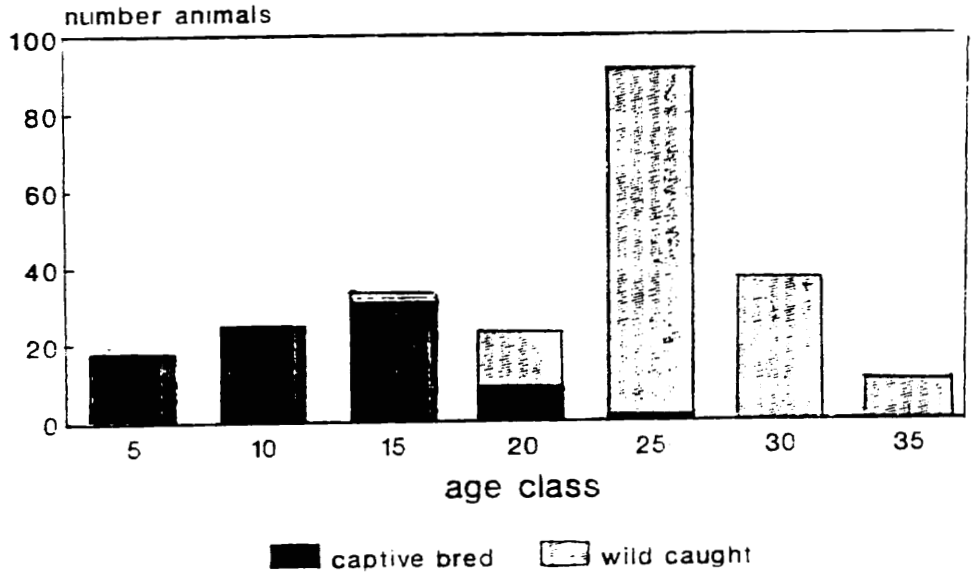
BLACK RHINOCEROS -- EUROPE

Age & Origin chart (fig.1)

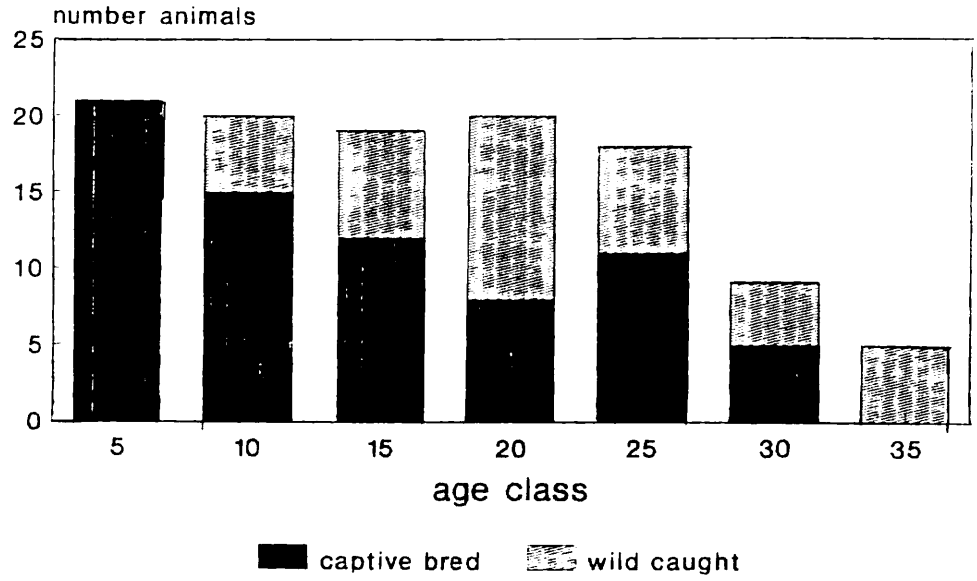


WHITE RHINOCEROS - EUROPE

Age & Origin chart (fig.2)

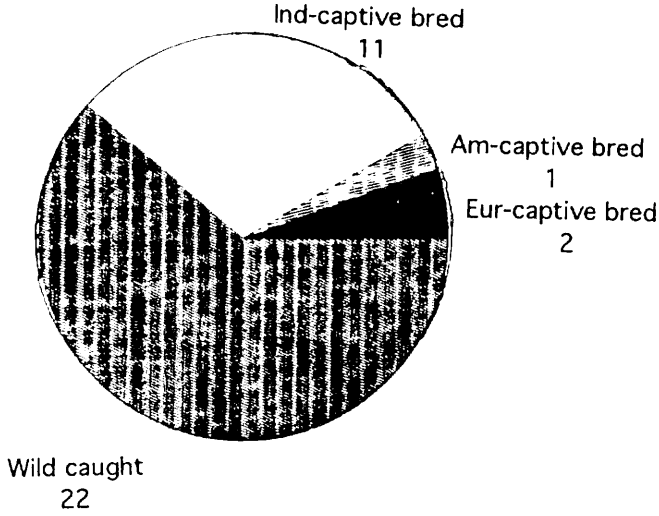


INDIAN RHINOCEROS
Age & Origin chart (fig.3)

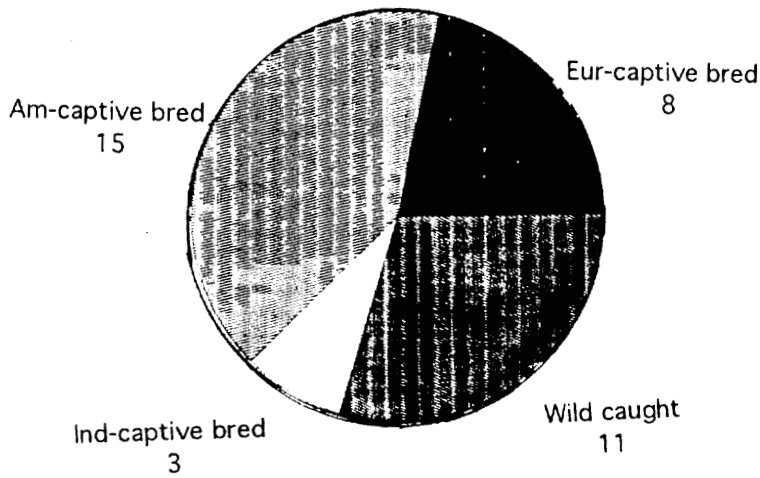


World ex situ population

INDIAN RHINO /INDIA
Origin (fig.4a)

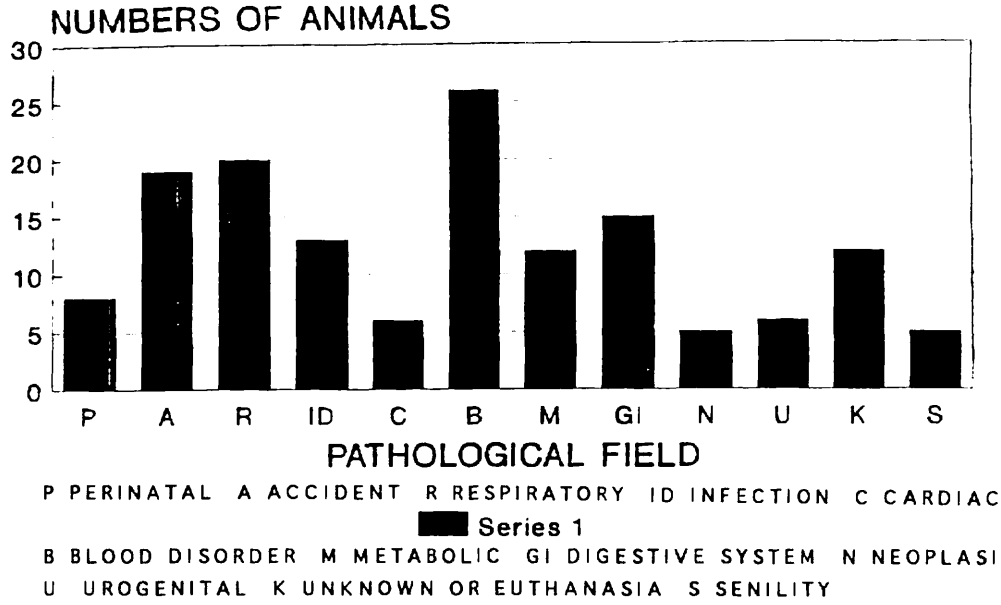


INDIAN RHINO / AMERICA
Origin (fig.4b)

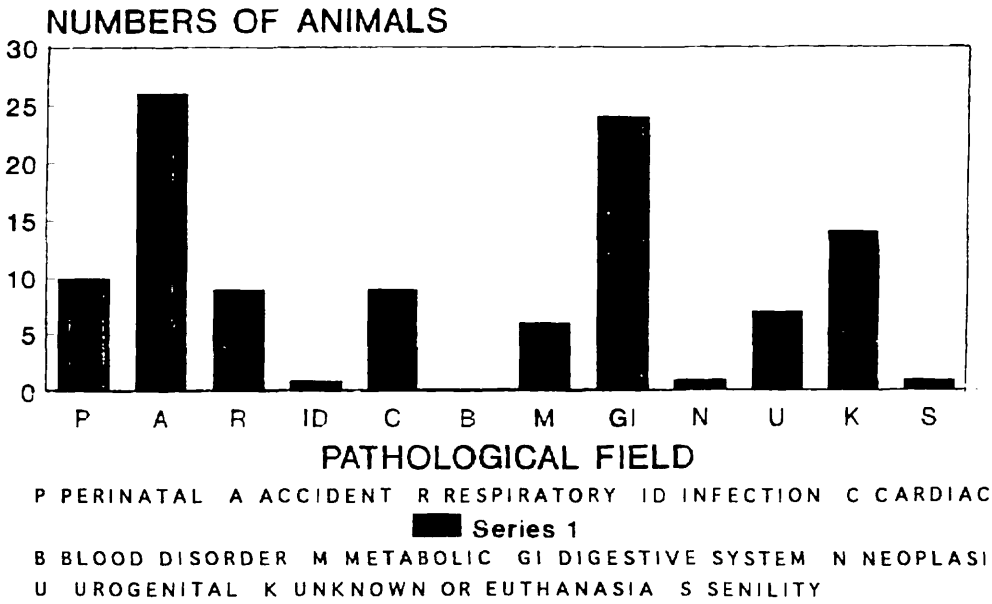


INDIAN RHINO / EUROPE
Origin (fig.4c)

MORTALITY IN CAPTIVE BLACK RHINOS
Review of 141 studbook cases/1967-1990
(FIG 5)



MORTALITY IN CAPTIVE WHITE RHINOS
Review of 106 studbook cases/1967-1990
(FIG 6)



MORTALITY IN CAPTIVE INDIAN RHINOS
Review of 59 studbook cases/1973-1990
(FIG 7)