

# The importation of the black rhinoceros (*Diceros bicornis*) from Zimbabwe into Australia

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**SUMMARY:** The paper describes a program to import and breed black rhinoceros *ex situ* at Western Plains Zoo in Australia. Nine rhinoceros (7 females and 2 males) captured in 1992 in Chete National Park, Zimbabwe, were transported to Australia via Cocos Island. The veterinary treatment of the animals before and during quarantine in Zimbabwe and on Cocos (Keeling) Islands is described.

Three animals died; an adult male on Cocos Islands and a juvenile male and an adult female at Western Plains Zoo, Dubbo, New South Wales. The juvenile male died as a result of trauma sustained shortly after arrival and the two adults after developing a severe hepatopathy. The group of 6 females and an additional 4 males imported from the USA in 1994 have adapted well to captivity and to the climate and environment of central west New South Wales.

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## Status of the Rhinoceros

There are five extant species of rhinoceros, three in Asia and two in Africa. About 85% of the world's population of rhinoceros have been lost since 1970. In June 1992 the total number of all species of rhinoceros was estimated to be 11 641 (Foose 1992). Of these 928 were held in captivity.

The great one-horned rhinoceros (*Rhinoceros unicornis*) numbers about 1700. Populations in Nepal are reasonably stable being under constant military guard. Populations in the Indian states of Assam and West Bengal trebled between 1964 and 1984, but have failed to expand since because of losses due to periodic poaching. The situation of the Sumatran rhinoceros (*Dicerorhinus sumatrensis*) in the tropical forests of South-east Asia is unclear. The population is estimated to be about 850 animals and is declining throughout its range in the face of serious deforestation and persistent hunting (Foose 1992). The other species in this region, the Javan rhinoceros (*Rhinoceros sondaicus*), numbers fewer than 80 animals, almost all of which are located on an isolated peninsula in western Java, Indonesia.

In Africa, the black rhinoceros (*Diceros bicornis*) has declined faster than any other large terrestrial mammal in recent times. From a minimum continental estimate of 65 000 in 1970 (JD Kelly unpublished), a maximum of 2550 remain today, with most animals found in Zimbabwe, South Africa, Namibia and Kenya. Only the white rhinoceros (*Ceratotherium simum*) population of southern Africa seems secure for the moment with about 5700 animals, while the survival of the northern subspecies rests on a single population of about 30 animals in the Garamba National Park in north-east Zaire (Table 1).

Recent detailed analysis of the remaining population of black rhinoceros on the African continent shows the principal repositories to be Kenya, Namibia, South Africa, Tanzania and Zimbabwe (Figure 1). It is believed that earlier estimates of 3000 to 4000 in Zimbabwe were grossly inaccurate and that the number has declined from about 1550 in 1984 to 250 in 1993 (MD Kock personal communication). This decline is due almost exclusively to poaching for horn. If poaching continues at the present rate then the species will effectively become extinct in Zimbabwe.

The original range for black rhinoceros within Zimbabwe probably exceeded 50 000 km<sup>2</sup>. In 1993 almost all remaining black rhinoceros were confined to four 'secure' national parks or reserves totalling less than 4000 km<sup>2</sup>.

## International Rhinoceros Foundation

As a result of the concern of a number of individuals and organisations world-wide, the International Black Rhinoceros Foundation (IBRF) was formed in 1991. The IBRF was developed from initiatives originating through the Captive Breeding Specialist Group of the Species Survival Commission of the World Conservation Union. The IBRF has three principal objectives:

1. the provision of financial and related support for conservation in situ and breeding, including captive breeding, of black rhinoceros;
2. to provide financial and resource support for anti-poaching activities; and
3. to provide support for the development of captive breeding programs in USA and Australia.

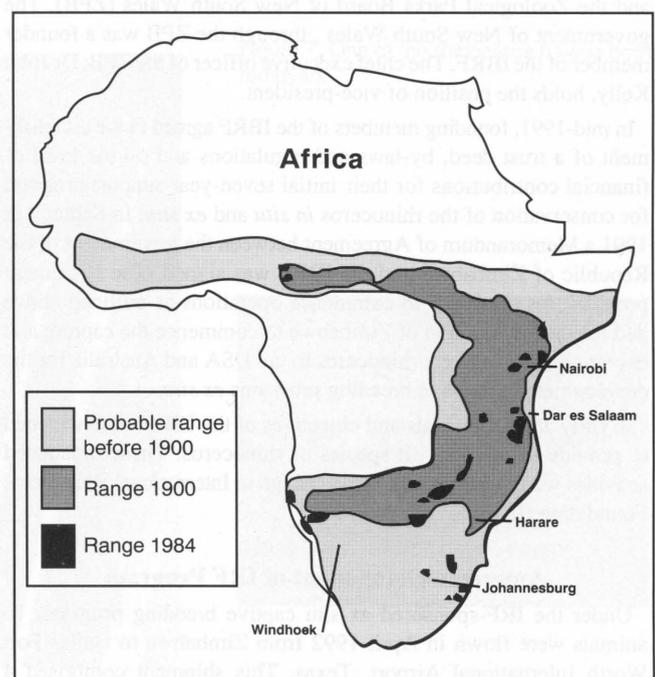


Figure 1. Black Rhino Range

Figure 1. The continent of Africa showing change in distribution of black rhinoceros.

TABLE 1  
Numbers of resident Rhinoceros on the African continent  
in 1992

Country	Rhinoceros	
	Black	White
Angola	0	0
Botswana	5	17
Cameroon	40	0
Central African Republic	0	74
Chad	0	0
Ethiopia	0	0
Kenya	414	74
Malawi	0	0
Mozambique	50	< 10
Namibia	450	90
Rwanda	0	0
Somalia	0	0
South Africa	818	5294
Sudan	1	< 10
Swaziland	< 10	< 30
Tanzania	185	0
Uganda	3	0
Zaire	0	37
Zambia	45	0
Zimbabwe	450	220
Total	< 2471	< 5856

The third objective was designed to ensure survival of the black rhinoceros in the wild by augmenting the gene pool outside Africa through the establishment of captive breeding centres *ex situ* as part of the global program to save the species from extinction.

The founding members of IBRF included The Save African Wildlife Foundation, Game Conservation International, privately sponsored conservation facilities including Fossil Rim and El Coyote in the USA, representatives of the international zoological community and the Zoological Parks Board of New South Wales (ZPB). The government of New South Wales, through the ZPB was a founder member of the IBRF. The chief executive officer of the ZPB, Dr John Kelly, holds the position of vice-president.

In mid-1991, founding members of the IBRF agreed to the establishment of a trust deed, by-laws and regulations and on the level of financial contributions for their initial seven-year support program for conservation of the rhinoceros *in situ* and *ex situ*. In September 1991 a Memorandum of Agreement between the government of the Republic of Zimbabwe and the IBRF was signed. The agreement provided for the IBRF to commence operations as outlined above and for the government of Zimbabwe to commence the capture and export of suitable black rhinoceros to the USA and Australia for the development of captive breeding programs *ex situ*.

In early 1993, the goals and objectives of the IBRF were widened to provide support for all species of rhinoceros. These broadened activities were reflected in a name change to International Rhinoceros Foundation (IRF).

#### American Component of IRF Program

Under the IRF-sponsored *ex-situ* captive breeding program, 10 animals were flown in April 1992 from Zimbabwe to Dallas Fort Worth International Airport, Texas. This shipment comprised 4 males and 6 females. After clearance by US quarantine authorities, animals were then shipped to Fossil Rim, Texas, El Coyote Ranch, Texas, and White Oak Conservation Centre, Florida, to be included in breeding programs for black rhinoceros.

Within two months of their arrival in the USA, two males and a pregnant female had died. All three showed signs of depression, inappetence, jaundice, lethargy and skin ulceration. Clinical signs were attributed to liver malfunction and anaemia. Mucous membranes were icteric and mouth ulcers were common. Haematological abnormalities included anaemia (PCV < 0.33 L/L), while biochemical abnormalities included increased bilirubin (mostly unconjugated, > 200 µmol/L) and hypophosphataemia (all animals < 0.5 mmol/L) (E Blumer personal communication). The normal range of PCV is 0.29 to 0.50 L/L, of bilirubin is 2 to 26 mol/L and of inorganic phosphorus is 0.5 to 2.0 mmol/L (Kock *et al* 1990).

Treatment included anabolic steroids, corticosteroids and antibiotics, and was not effective.

Necropsies were inconclusive although all animals exhibited generalised signs attributed to a severe hepatopathy and non-regenerative anaemia.

Prevention strategies for unaffected rhinoceros included increasing available vitamin E levels in the diet, vaccination with polyvalent leptospiral vaccine and avoiding contact with possible predisposing compounds such as creosote. (E Blumer personal communication).

#### Role of Western Plains Zoo

The Zoological Parks Board of New South Wales operates two zoos: Taronga Zoo in Sydney and Western Plains Zoo at Dubbo.

It was determined at an early stage that the appropriate site for the major captive breeding program in Australia should be at the Western Plains Zoo where sufficient land of the quality and with a climate comparable to that of Zimbabwe was available. The principal strategy of this program was to develop the largest single breeding complex for black rhinoceros outside Africa in a politically stable, relatively disease-free environment, which could ensure survival of the species.

Accordingly, construction of the breeding complex with a connecting public exhibit complex commenced in February 1991. The major component including breeding yards, crush and veterinary facilities, sufficient to hold up to 32 rhinoceros, was completed in October 1991. The whole complex including public viewing facilities was completed in August 1992 (Figure 2).

The area of the breeding complex is 7.2 ha. The yards, which are constructed of 75 mm x 75 mm x 4 mm steel rails, are holding or night yards (18 m x 24 m) and larger day yards (39 m x 51 m). A raceway separates two rows of yards. An irrigation system allows the watering of yards to settle dust, to cool animals and to water the trees and grass. Safety of handlers was a prime consideration in the design. The complex has been arranged to allow animals to be moved from yard to yard or to be moved to the rubber-sided veterinary yards, which feature a chute and scales. The concept for the facility allows for its expansion to house the projected increase as the breeding program succeeds. In addition, an extensive agistment area comprising about 20 ha is available to complement the intensive breeding complex.

About 7500 trees have been planted to provide shade and browse. There are five species of eucalypt (*Eucalyptus camaldulensis*, *E nicholii*, *E robusta*, *E viminalis*, and *E saligna*), two acacias (*Acacia howittii* and *A cardiophylla*) and one melaleuca (*Melaleuca gibbosa*). Shadecloth shelters have been provided to complement natural shade. Wallows have been provided to allow for the animals' natural behaviour. The breeding complex has access by a raceway to the black rhinoceros exhibit, which currently houses one adult female and a young male.

#### Capture of Black Rhinoceros for Australia

In June 1992 15 black rhinoceros were captured for transport to the Boulton quarantine area near Harare and subsequent shipment to Australia. The area in which animals were captured was the Chete National Park comprising some 1000 km<sup>2</sup> in the west of Zimbabwe, adjacent to the border with Zambia on Lake Kariba. Two years previously, this remote area was surveyed and about 150 black



Figure 2. Breeding complex for black rhinoceroses at Western Plains Zoo showing sandy night yards, grassed day yards, shelter sheds, tree plantings and working raceway and crush.



Figure 5. Examination of immobilised rhinoceroses in the bush in Zimbabwe.



Figure 8. The rhinoceros were lifted in crates onto trucks for transport to Harare airport, Zimbabwe.



Figure 3. Poaching of rhinoceros for horn was evident on the expedition to capture rhinoceroses in Zimbabwe.



Figure 6. An immobilised rhinoceros being loaded onto a vehicle for transfer to holding facilities.



Figure 9. Loading of the crates onto the aircraft was difficult because of the confined space.



Figure 4. Dr MD Kock, Zimbabwe National Parks and Wildlife Management, and helicopter used for capture of rhinoceroses.

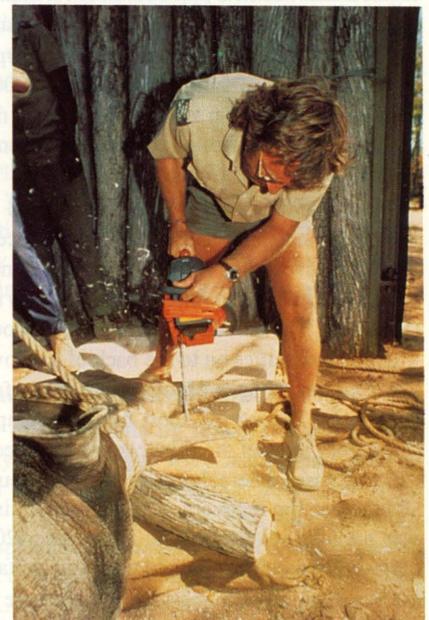


Figure 7. One of the rhinoceros having horn removed.

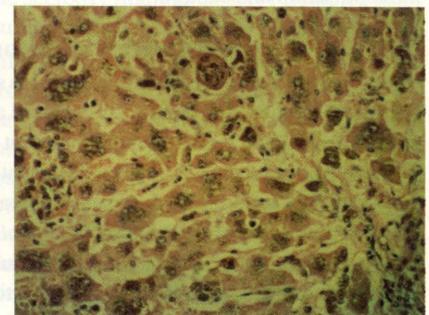


Figure 10. Section of liver from the female black rhinoceros that died at Western Plains Zoo showing grossly swollen hepatocytes. (Haematoxylin and eosin x 100).

rhinoceros were identified. By June 1992, despite the most extensive aerial and land-based survey, only 15 animals were located. The drastic decline was due to poaching (Figure 3).

The site was selected for the capture and removal of animals for breeding *ex situ* in Australia for two reasons. Firstly, evidence of poaching was such that it was believed that unless animals were removed from Chete, they would not survive after 1992. Secondly, the area, because of its remoteness and isolation from traditional agricultural enterprises including cattle production, was less likely to harbour diseases exotic to Australia.

The process of capture involved three phases of locating and identifying suitable animals, immobilising the animals, and recovering and transporting the animals to holding facilities. Intensive surveys of the Chete area were conducted using fixed-wing aircraft, a helicopter and ground support scout teams (Figure 4). Animals were located either by observation from a fixed-wing aircraft or by tracking by the scout teams. As soon as a black rhinoceros was sighted and was in a place suitable for immobilisation, the support helicopter was called in and the subject animal was injected by a projectile syringe with a mixture of etorphine ( $3.9 \pm 0.18$  mg), xylazine (100 mg) and hyaluronidase (2000 IU) (Kock 1992). This usually occurred from a height of about 50 m. Animals were usually fully immobilised within 1 to 2 min, after sometimes having travelled up to 500 m from the site of injection.

Ground crews located the immobilised animal by tracking of footprints and spoor and with the assistance of the helicopter crew. The animal was then restrained by ropes and slings. Blood samples were collected and a preliminary veterinary examination undertaken (Figure 5). The animal was placed on a wooden sledge, which was lifted by hydraulics on to the back of a recovery vehicle for immediate transport for up to 20 km to the holding facilities at the base camp (Figure 6). During transport by road, temperature, heart beat and respiratory rates of the rhinoceros were checked frequently.

In rare cases where, because of the difficult terrain, it was impossible to use the recovery vehicle, immobilisation of the rhinoceros was partially reversed using nalorphine (20 to 40 mg IV) and the animal was carefully walked to a more suitable collection point.

After a journey of up to 10 h to the base camp, the immobilised animals were dehorned to minimise traumatic injuries (Figure 7), ear marked and ear tagged for identification and injected with antibiotics to prevent infection of skin wounds and, in some cases, anabolic steroids to counteract catabolic effects of anorexia due to confinement in small pens. All of the animals captured for the Australian shipment were, in addition, implanted with a microchip transponder\*. Immobilisation of the animals was then fully reversed with 50 mg naloxone (IV) and the ropes and slings were removed. Within 1 to 2 min, they were mobile and moving freely.

No undue side-effects were observed as a result of the process of immobilisation and capture.

### Care and Quarantine before Export

Captured animals were then transported to small holding yards near Harare where they, and previously captured animals, were in the care of staff from the Zimbabwean Department Of National Parks and Wildlife Management. During confinement their health was monitored and they were tested for diseases as part of the agreed Australian quarantine import protocol. Doyle *et al* (1995) have described the development and application of the quarantine requirements.

At the end of the period of health monitoring and quarantine, 9 animals (7 females and 2 males) were judged suitable for transport to Australia. Funding for the animals' care during the quarantine period was provided by IRF.

### Transport from Zimbabwe to Cocos (Keeling) Islands

Early on the morning of 30 November 1992, the 9 rhinoceros were cleared for export and were crated ready to leave Zimbabwe. Each animal was coaxed into a loading yard and injected with 0.5 mg etorphine using a projectile syringe. Once lightly sedated they were encouraged into crates and the gates were closed behind them. The animals were then treated for ectoparasites using deltamethrin and given zuclopenthixol acetate (200 - 250mg), a sedative neuroleptic used in human medicine with a duration of activity of 72 h.

The crates containing the rhinoceros were lifted onto a semi-trailer for the short journey to the airport (Figure 8) where they were strapped onto pallets and loaded onto an Affretair DC8 for the journey of 9 hours direct to the Cocos (Keeling) Islands.

Difficulties in loading were encountered because of the tight fit of the boxes in the aircraft (Figure 9) leading to a delayed departure time. During a delay of 8 h the animals remained tranquil under the influence of the medication.

On arrival at Cocos, the rhinoceros were unloaded and transported to the quarantine station where they were placed in individual pens. All animals settled down quickly. The animals spent 60 days quarantine in Australia's high security animal quarantine station on the Cocos (Keeling) Islands.

### Care and Maintenance on Cocos

Cattle pens in the sheds had been modified to accommodate the rhinoceros. The pens were lined with plywood and rubber matting. Concrete containers for feed and water were transported from Australia. All locking mechanisms were reinforced. The rhinoceros were housed in individual pens and were moved from pen to pen across a central raceway to allow thorough cleaning of the yards. The pens were hosed out daily using high pressure hoses. Generally this was done with the rhinoceros present in the enclosure as most animals became quite docile during the quarantine period. The animals were fed a diet comprising lucerne hay, carrots, horse cubes, apples and browse.

All animals, except the adult male, had good appetites and quickly adapted to the daily routine. The male did not adapt well and had a poor appetite. By the fourth day of quarantine the animal's mucous membranes were icteric and he was inappetent and depressed. These signs were consistent with those of the hepatopathy syndrome described in the animals that died after the shipment to the USA or translocation to conservancies in Zimbabwe (Kock *et al* 1994). These signs were also similar to those described for haemolytic anaemia in black rhinoceros (Miller and Boever 1992). Kock *et al* (1994) implicate creosote toxicity as the most likely aetiology with clinical, haematological and pathological findings in affected black rhinoceros similar to those described in creosote toxicosis in other species. All affected rhinoceros had access to the chemical in the treated timber of their holding yards in Zimbabwe. The aetiology of the haemolytic anaemia syndrome described by Miller and Boever (1992) is unknown with vitamin E deficiency, leptospirosis and immune-mediated disease all suggested by those authors.

No treatment was given until day 15 of the quarantine period when all animals were immobilised for collection of samples. On that day the adult male was treated with vitamins A, D and E, vitamin B complex (all IM), 5625 mg benzathine penicillin (IM) and 7500 mg procaine penicillin (IM), 250 mg 1-dehydroxytestosterone undecylenate (IM), 25 g sodium phosphate (IM) and 200 mg ivermectin (IM), and 1500 mg flumethrin topically. A zeranol implant was placed subcutaneously to stimulate appetite even though this is contraindicated for potential breeding animals. Samples for haematology, biochemistry and bacteriology tests were not collected because the tests could not be carried out on Cocos. The animal was treated daily with oral electrolytes<sup>†</sup>. The diet was varied to encourage

\* Euro ID, Gross Buellshheimer Strasse 56, 530 Euskirchen 16, Germany

† Lectade (R) SmithKline Beecham, Frenchs Forest, NSW

TABLE 2  
Results of tests of samples of blood from a female black rhinoceros at Western Plains Zoo

Date	PCV (L/L)	Bilirubin ( $\mu\text{mol/L}$ )	Phosphate (mmol/L)	Vitamin E ( $\mu\text{mol/L}$ )
Normal range*	0.29 to 0.50	2 to 26	0.5 to 2.0	6.9 to 12.6
19/3/93	0.45	217	0.48	5
22/3/93	0.48	188	0.19	5
25/3/93	0.42	162	0.97	2
1/4/93	0.42	189	0.78	6
7/4/93	0.42	213	1.27	6
15/4/93	0.36	170	0.51	nt
21/4/93	0.26	127	1.15	6
30/4/93	0.16	113	1.86	nt

\* Kock *et al* (1990)

nt = not tested

appetite but the appetite continued to decline. Specialist veterinary treatment was unavailable because of the island's isolation.

On days 17 and 31, the rhinoceros was given cimetidine (600 mg). On day 38, the animal was anaesthetised using 1.5 mg etorphine (IM), examined clinically and treated with intravenous compound sodium lactate and corticosteroids. At this stage he exhibited bleeding about the gingival margin, obvious but unspecified weight loss, generalised subcutaneous oedema and jaundice. Blood and urine samples were collected although only limited testing was able to be carried out. The PCV was 0.25 L/L (normal range 0.29 to 0.50 L/L, Kock *et al* 1990). Total protein was 62 g/L (normal range 70 to 100 g/L, Kock *et al* 1990). Urinalysis revealed marked bilirubinuria.

Despite these limited attempts at diagnosis and treatment the animal died on day 41 of quarantine. Significant necropsy findings were haematomas in the musculature and subcutaneous tissues, jaundice and a green liver. These findings were consistent with the clinical diagnosis made on day 4. An unidentified parasite was found in the small intestine. The green colour of the liver was due to a remarkable amount of yellow-green-brown pigment, both in macrophages and hepatocytes (Figure 10).

Throughout the 60-day quarantine period, no health problems were encountered with the other 8 rhinoceros. All ate well and quietened down markedly so that the keepers were able to pat most of them by the end of the quarantine period. The animals spent most of the days resting and were most active during feeding times in the early morning and late afternoon. The younger animals were often heard vocalising in the early morning. The keepers spent time in the pen area to familiarise the rhinoceros to people. Each animal was moved to a different pen every three days to prepare it for transfer to the transport crates.

On day 15 of the quarantine period, each animal was immobilised with 1 mg etorphine (IM) and blood was collected for quarantine testing. Routine treatments, including both ectoparasite (flumethrin) and endoparasite (ivermectin) treatment, were administered. Immobilisation of the animals was reversed with 37.5 mg naloxone (IV) and 3 mg diprenorphine (IM).

### Transport from Cocos to Western Plains Zoo

One young male and 7 female rhinoceros were permitted to leave Cocos at the end of the quarantine period. A Russian-built IL76, an aircraft with suitable loading and unloading systems for rapid handling of the crates, was used for the transfer. The animals were sedated with 0.5 mg etorphine (IM) and 200 to 250 mg zuclopenthixol acetate

(IM) and individually crated, beginning 3 h before departure. Daily during the previous week, the animals had been moved through the quarantine facility to familiarise them with the procedure. The loading of the 8 animals proceeded very smoothly. The aircraft refuelled at Perth and then flew to Canberra, arriving late in the evening of 3 February 1993. Two semi-trailers transported the 8 crated animals to Dubbo, arriving at Western Plains Zoo early on the morning of 4 February.

Two cranes were used in the unloading procedure – one to transfer each crate from the semi-trailer to a smaller truck, the other to transfer the crate from the truck to the yard. The gates of the crates were then opened to allow the animals to walk out into their yard. The rhinoceros had been allocated yards so that each animal was placed near another with which it would not fight.

The animals reacted to their release from the crates into their enclosure by charging the fences. This behaviour probably resulted from the release into the bright outdoor facility at Western Plains Zoo compared with the darkened indoor facility on Cocos and on the plane. Unfortunately, the juvenile male did this repeatedly, succumbed to injury and died overnight. Necropsy revealed severe damage to the turbinate bones and sub-dural haemorrhages with no other gross abnormality.

The time from the loading on Cocos Island to completing the unloading at Western Plains Zoo was about 25 h. This was considerably shorter than the 36 h taken for the transfer from the pens at Boulton near Harare until the arrival on Cocos. The 7 female animals all settled in their new enclosures within a few minutes and by evening most were eating and drinking well and had explored the full range of their yard.

### Management at Western Plains Zoo

In March 1993, one of the remaining females developed the hepatopathy/anaemia syndrome. Signs were inappetence, loss of weight, lethargy, skin eruptions and jaundice. Repeated blood analyses demonstrated progressive red cell loss, bilirubinaemia, initially decreased phosphate concentrations, an increased white cell count and low vitamin E concentration (Table 2). The PCV decreased from an initial 0.45 L/L to 0.16 L/L over the 42-day course of the disease. Total serum bilirubin was initially 217  $\mu\text{mol/L}$  and decreased to 113  $\mu\text{mol/L}$  the day before she died (normal range 2 to 26  $\mu\text{mol/L}$ , Kock *et al* 1990). These findings led to treatment with 750 mg dexamethasone (IM), 5625 mg benzathine penicillin (IM) and 7500 mg procaine penicillin (IM), 4 g vitamin E (IM), 50 g sodium phosphate (IM), 250 mg vitamin K (IM), 250 mg 1-dehydroxy-testosterone undecylenate (IM) and 800 mg iron (III) hydroxide-carbohydrate complex (IM). Daily oral treatment was 1200 mg prednisolone, 5 g vitamin E and 25 g sulphadimidine/5 g trimethoprim. The day before her death she was given 5 L whole blood intravenously. The necropsy findings closely resembled those for the male that died during quarantine on Cocos Island.

Black rhinoceros, unlike white rhinoceros, progressively lose vitamin E when taken from the wild into captivity (Papas *et al* 1991) presumably due to dietary deficiency not seen in animals in the wild where they browse legume pods and leaves high in the vitamin. The black rhinoceros at Western Plains Zoo were found to be severely deficient in vitamin E with blood concentrations from 0 to 5  $\mu\text{mol/L}$ . The normal range in the wild is 6.9 to 12.6  $\mu\text{mol/L}$  (Papas *et al* 1990). Vitamin E deficiency in black rhinoceros may be associated with haemolytic anaemia (Dierenfeld *et al* 1988). The animals at WPZ are now receiving a diet high in vitamin E by supplementation with wheat germ and soybean oil. All appear to be in good health.

Progress with the remaining six female animals has been excellent. They have all adapted to the husbandry routines, and have gained weight. Their horns are growing (Figure 11) at the normal rate of 4 to 7 cm *per annum* (Fowler 1993). The oestrous cycles of the three adults are being characterised by observing their behaviour and



Photo © : Steve Thomas

Figure 11. Healthy black rhinoceros at Western Plains Zoo 12 months after arrival.

measuring urinary oestrogens using the method described by Ramsay *et al* (1987). Additional males were imported from the USA in November 1994 to complete establishment of the breeding group. Artificial breeding facilities at both Taronga and Western Plains Zoos have been established to support the breeding program. A team of research scientists from the University of Sydney and Monash University together with veterinary and medical practitioners experienced in artificial breeding has been formed to enable techniques available for humans and for domestic animals to be used in the breeding program. The whole exercise is the subject of a documentary titled *Flight of the Rhino* filmed for the National Geographic Society.

### Conclusion

Future movements of black rhinoceros should avoid exposure to creosote, ensure adequate dietary concentrations of vitamin E and also ensure release into non-transparent yards.

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### References

- Dierenfeld ES, du Toit R and Miller RE (1988) *J Wildl Dis* **24**: 547
  - Doyle KA, Robinson BA and Wilson D (1995) *Aust Vet J* **72**: 364
  - Foose TJ (1992) In *Rhino Global Captive Action Plan (GCAP)*, a report to the Captive Breeding Specialist Group of the World Conservation Union, Apple Valley, MN, USA
  - Fowler ME (1993) *Zoo and Wild Animal Medicine Current Therapy* **3**: 473
  - Kock MD (1992) *J Zoo Wildl Med* **23**: 181
  - Kock MD, Du Toit R, Morton D, Kock ND and Paul B (1990) *J Zoo Wildl Med* **21**: 283
  - Kock ND, Kock MD and Young KB (1994) *J Zoo Wildl Med* **25**: 270
  - Miller RE and Boever WJ (1982) *J Am Vet Med Assoc* **181**: 1228
  - Papas AM, Cambre RC, Citino SB and Sokol RJ (1991) *J Zoo Wildl Med* **22**: 309
  - Ramsay EC, Kasman LH and Lasley BL (1987) *Zoo Biol* **6**: 275
- (Accepted for publication 3 March 1995)