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EFFECTS OF TRANSLOCATION ON HEMATOLOGIC PARAMETERS OF FREE-RANGING BLACK RHINOCEROS (*DICEROS BICORNIS MICHAELI*) IN KENYA

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Abstract: Management of the endangered black rhinoceros (*Diceros bicornis michaeli*) in Africa frequently involves translocation. These procedures are not without risk, and protocols must be critically examined. Hematologic analyses can be used to evaluate the effects of translocation on animal health. Hematologic data obtained during routine translocation of free ranging black rhinoceros (n = 74) in Kenya between 1991 and 1995 were examined, and subsets of data from rhinoceros (n = 43) that were translocated to different regions of Kenya were compared. All animals showed an increase in total blood protein. Animals transported for longer periods and to lower altitude zones with higher ambient temperatures and trypanosomiasis developed anemia and showed neutrophilia, lymphopenia (males), and eosinopenia. The changes in packed cell volume (PCV), hemaglobin, and neutrophils were more marked in females, and the PCV drop was more significant in subadults. The red cell changes were most probably pathologic, involving the loss of red cells from circulation through sequestration or hemorrhage. The changes in white cell parameters are consistent with the effect of endogenous corticosteroids as a result of stress. Transport and confinement stress might lead to gastric ulceration with hemorrhage. In many animals, exposure to trypanosomes contributes to anemia.

Key words: Black rhinoceros, hematology, translocation, trypanosomes, stress, anemia.

INTRODUCTION

Translocation of black rhinoceros (*Diceros bicornis michaeli*) is an important part of management and conservation of rhinoceroses in Africa. There are now very few animals living in their original range that have not been moved at one time or another for reasons of security or placement in sanctuaries. Over 60% of Kenya's black rhinoceros are located in populations of mixed origin.[1] In Kenya, efforts have been made to reduce the risks associated with translocation procedures, because the long-term survival of the species depends on good survivorship in the population.

Hematologic data obtained from free-living black rhinoceros in Kenya during translocation procedures are routinely examined to assess individual animal health and effects of translocation on these parameters. Here, we report hematologic findings from 120 immobilizations of black rhinoceros (n = 74) in Kenya between 1991 and 1995 as part of translocation protocols and health management for the species.

Retrospective observations on the data suggested anemia and other hematologic changes were developing consistently in certain groups between capture and release from bomas. Paired samples from 43 rhinoceros were compared to determine if transport time, altitude change, ambient temperature change, or infection with trypanosomes had any effect on hematologic parameters.

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MATERIALS AND METHODS

Animals, capture, examination, sampling, and translocation

Data were obtained from 74 individual black rhinoceros of both sexes (37 male, 37 female) and various estimated ages ($\bar{x} \pm$ SD = 8 ± 6 yr, range = 3–20 + yr) that were immobilized using a dart rifle (Capchur, Model 50 long-range rifle, Palmer Equipment Co., Palmer Village, Douglasville, Georgia 30133, USA) with 3-ml metal darts and 60-mm NCE3 needles. Darts contained etorphine (Grampian Pharmaceuticals, Dundee DD2 3XR, Scotland), xylazine (Rompun crystalline, Agrochemical Division, Bayer UK, Bury St. Edmunds, Suffolk IP32 7AH, England), and 1,500 i.u. hyaluronidase (Hylase, Zimethicals, Mount Pleasant, Harare, Zimbabwe). The dose was 3 mg etorphine and 50 mg xylazine for subadult and 5 mg etorphine and 100 mg xylazine for adult animals.

Animals were darted from the ground (n = 38) or from a helicopter (n = 36). Induction and immobilization times were recorded for 109 and 97 animal interventions, respectively.

Animals were aged according to a horn technique[1] and general body conformation. The general health of the animals was assessed by observation and clinical examination. Blood and tissue samples were taken. Blood was taken from the radial vein

of the foreleg within 10 min of recumbency. Blood was collected into tubes containing either ethylenediaminetetraacetic acid or lithium heparin for complete blood counts and plasma biochemistry, respectively. Plain tubes were used for whole blood collection for serum.

Blood smears and blood separation were completed within 8 hr in all animals, and complete blood counts were performed within 48 hr after collection. Red blood cell (RBC), white blood cell (WBC), and hemaglobin (Hb) counts were done on an automated analyzer (Coulter Counter, Model ZM equipped with a Coulter Channelyzer 256) or using the quantitative buffy coat (QBC) technique (Becton Dickson and Co., Franklin Lakes, New Jersey 07417, USA) with manual differential WBC counting of 100 cells on blood smears stained with methylene blue. Mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) were calculated from packed cell volume (PCV) and Hb values. Plasma and serum after separation were frozen immediately in liquid nitrogen for later analyses. Serum total protein (TP) were measured using a hand-held refractometer. PCV was measured at the capture site using a field microhematocrit centrifuge (Compur M1101, Bayer Diagnostics, Munchen, Germany) spinning for 7 min.

After capture, the animals were revived using narcotic antagonists (nalorphine, Megasource, Waterkloof 0145, South Africa) at a dose of approximately 50 mg nalorphine for subadults and 75 mg for adult animals', titrated to provide a partial recovery for loading into wooden transport crates. Full reversal was ensured by administering diprenorphine (Revivon, Grampian Pharmaceuticals) 4.5 mg for subadults and 7.5 mg for adult animals. The crate was then winched up a ramp onto a truck for transport to various locations. Total transport times were recorded. After transport, the animals were placed individually into bomas at the release site, where they remained for 3–4 wk. A second immobilization with etorphine administered by blowpipe (Daninject-Ahlmannshof 50a, 45889 Gelsenkirchen, Germany), using 0.6 mg for subadults or calm animals and up to 3 mg for adults and nervous individuals, was performed prior to final release for placement of radiotracking transmitters in the horn and/or health checks. Blood samples were taken and processed as described previously.

Animals were translocated from two locations in the Laikipia plateau or from Nairobi National Park to three other sites in the Laikipia region or Nairobi or Tsavo National Park, East and West. Nairobi and Laikipia were considered one region (high altitude) and the two Tsavo locations were considered a second region (low altitude). The construction of the release bomas varied little, and the management was similar in all cases. For the purposes of analysis, the variation within a region is considered to be minimal but the differences between the regions were of interest. For statistical analyses, only two locations, high (H) and low (L) are listed. Movement distances within the high-altitude region (H-H) were significantly less than those between high-altitude and low-altitude regions (H-L) where, in addition to the altitude change, the animals were exposed to trypanosomes and to a higher mean ambient temperature.

Data analyses and statistical methods

Summary data for all blood samples were analyzed from paired samples (blood taken from an individual rhinoceros at capture and again prior to release from the holding bomas) representing 43 animals (females: $n = 21$, age range = 3–20 yr, $\bar{x} \pm SD = 5.77 \pm 4.3$ yr; males: $n = 23$, age range = 3–20 yr, $\bar{x} \pm SD = 8.45 \pm 4.7$ yr). The total number of paired samples for each parameter varied: PCV ($n = 43$), RBC ($n = 26$), Hb ($n = 26$), MCV ($n = 23$), WBC ($n = 30$), and TP ($n = 24$). Paired samples and parameters were selected for consistency of methodology and accuracy of results. Platelets were not included.

The data were initially explored for normality, and appropriate tests were selected to determine differences between and variation within the data sets. Independent samples and paired samples *t*-tests (SPSS 6.0, SPSS, Chicago, Illinois 60611, USA) were used to compare means within and between subsets of the data at the $P < 0.05$ level. Levene's test for equality of variation in the population subsets was used. Unequal variation was detected for data on transport time (H-H, H-L) and for neutrophils at capture by sex. For these data, nonparametric statistics were used, either the Mann–Whitney *U*-test or Wilcoxon's rank sign test.

Data for animals of different sexes (male and female) and ages (adult or subadult) at capture and in the boma were compared to determine any variation from normal within the rhinoceros population that required further analysis. Where variation existed, further subsets of data were formed and analyzed. For RBC, TP, MCV, and eosinophils, the population was not subdivided by sex or age; there was no significant variation, and only two translocation groups of animals were then compared. For PCV, lymphocytes, and neutrophils, sex and or age variation required further subdivision before the an-

imals were compared according to translocation group.

One translocation group (H-H) comprised those animals transported on average 3.5 hr with no significant altitude or daily mean temperature change and no exposure to trypanosomes (n = 17: 12 males, age = 9.7 ± 5.3 yr; five females, age = 5.8 ± 5.1 yr). These animals were from protected areas in the Laikipia district (11 males, five females) or Nairobi National Park (one male), and the destination was either within the district of Laikipia (10 males, four females) or Nairobi (two males, one female). The other group (H-L) was transported for on average 9 hr, with reduction in altitude, elevation in ambient temperature, and exposure to trypanosomes (H-L, n = 26: 10 males, age = 7 ± 3.8 yr; 16 females, age = 5.8 ± 4.2 yr). These animals were from protected areas in the Laikipia district (five males, six females) or Nairobi Park (five males, 10 females), and the destination was Tsavo (10 males, 16 females).

RESULTS

Immobilization and translocation

Chase times in the helicopter were <5 min for all animals. The anaesthetic induction and immobilization times ($\bar{x}$ ± SD) for H-H and H-L translocation groups were not significantly different (induction: H-H, n = 16, 7.0 ± 3.5 min; H-L, n = 24, 7.4 ± 3.5 min; immobilization: H-H, n = 14, 42.5 ± 15.0 min; H-L, n = 22, 59.9 ± 87.5 min). Comparison of induction and immobilization times between capture and boma samples showed no significant differences (induction: n = 26, 7.77 ± 3.8 min and 7.35 ± 3.6 min; immobilization: n = 32, 55.7 ± 72.5 min and 31.1 ± 13.6 min).

Transport times were longer for H-L (n = 23, 547 ± 201 min) than for H-H (n = 13, 213.5 ± 102.5 min).

Hematology

Blood parameters: Table 1 gives a comparison of changes in PCV, RBC, Hb, MCV, TP, and WBC for 43 rhinoceros between time of capture and release. Comparison was made within and between rhinoceros groups at capture and in the boma (all rhinoceros, male vs. female, adult vs. subadult, H-L vs. H-H). At capture, there was no significant variation or differences within groups for RBC, TP, eosinophils, and MCV in all animals. Significant variation was detected for PCV, neutrophils, and lymphocytes, within all rhinoceros divided by sex. The males had a higher PCV and higher lymphocyte and neutrophil counts at capture than did females. In the boma, there was significant variation in PCV according to age and sex of rhinoceros, with male and adult animals having higher values. Hemaglobin values were variable between males and females.

The paired data showed, for animals in the H-L translocation group, a significant decrease in PCV, RBC, and eosinophils between capture and boma sampling. This was true in all animals, male or female, or adult or subadult. In the H-L group, lymphocytes decreased significantly in males and neutrophils significantly increased and hemaglobin significantly decreased in females between capture and boma sampling. No such changes were seen in the H-H group, but MCV was significantly elevated in the boma samples. TP was significantly elevated in all animals after 3 weeks in the boma.

Summary data (Table 2) for black rhinoceros sampled in this study (n = 74 rhinoceros, n = 120 immobilizations) were compared with data from other published studies. Results indicated values similar to those for other wild and captive animals except for Hb. This variation was due to the anemia recorded in rhinoceros transported to Tsavo, and a high proportion of the total sample set for Hb was from these animals.

Blood parasites: In animals transported to trypanosome-infected areas, the presence of parasites was confirmed by methods previously reported[14,15,17] prior to release from the boma. Trypanosomes were confirmed by blood smear examination in six animals (22%) and by xenodiagnosis in eight animals, three of which also had positive blood smears, for a prevalence of 11 trypanosome-infected rhinoceros of 27 examined (40%) after 3–4 wk in bomas in trypanosome-endemic areas (*Trypanosome congolense, T. vivax, T. simiae*). This prevalence may be lower than the actual infection rate because not every animal was examined by xenodiagnosis, which is more reliable than microscopic examination. Theileria were noted in blood samples from 21/44 rhinoceros from all regions, and stephanofilaria were noted in 4/44 rhinoceros.

DISCUSSION

Hematologic data from black rhinoceros in Kenya during translocation procedures are consistent with published data for healthy animals, both free ranging and captive, which suggests that the animals were in general from a normal population. The variation in Hb levels can be explained by the development of anemia in a large number of animals transported to Tsavo.

The comparisons between animals at capture and after 3–4 wk in the boma revealed significant dif-

Table 1. Hematologic data from black rhinoceros at capture and after 3–4 wk in a boma.

Variable	At capture		In boma	
	n	$\bar{x} \pm$ SD	*n*	$\bar{x} \pm$ SD
Translocation groups				
High to low elevation (H-L)				
Packed cell volume (%)	26	46.1 ± 4.0	26	38.9 ± 4.4[a]
Red blood cells ($\times 10^6$ µl)	21	5.5 ± 0.9	21	4.6 ± 0.68[a]
Hemaglobin (g/dl)	21	12.9 ± 1.6	21	11.8 ± 1.7[a]
Neutrophils (cells/µl)	21	4,173 ± 1,593	20	6,063 ± 2,443[a]
Lymphocytes (cells/µl)	20	3,426 ± 1,004	20	2,359 ± 729[a]
Eosinophils (cells/µl)	20	612 ± 462	20	257 ± 213[a]
Total protein (g/dl)	18	7.8 ± 1.0	18	8.7 ± 1.0[a]
Mean cell volume (fl)	18	81.9 ± 11.8	18	86.7 ± 11.8
High to high elevation (H-H)				
Packed cell volume (%)	17	46.5 ± 4.4	17	46.5 ± 4.4
Red blood cells ($\times 10^6$ µl)	5	5.8 ± 0.5	5	5.8 ± 0.8
Hemaglobin (g/dl)	5	14.6 ± 1.4	5	13.5 ± 1.6
Neutrophils (cells/µl)	12	4,875 ± 1,188	10	4,108 ± 1,707
Lymphocytes (cells/µl)	10	2,540 ± 1,333	10	3,206 ± 483
Eosinophils (cells/µl)	10	354 ± 342	10	379 ± 161
Total protein (g/dl)	6	8.1 ± 1.4	6	9.4 ± 1.1[a]
Mean cell volume (fl)	5	80.0 ± 10.1	5	86.9 ± 8.9[a]
Sex subgroups				
All rhinoceros				
Packed cell volume (%)				
Male	22	48.0 ± 4.2[b]	22	45.2 ± 5.1[b]
Female	21	44.4 ± 3.1	21	38.5 ± 4.3
Hemaglobin (g/dl)				
Male	13	13.5 ± 2.0	12	12.9 ± 1.4[b]
Female	18	13.3 ± 1.4	17	11.3 ± 1.8
Neutrophils (cells/µl)				
Male	7	5,271 ± 450[b]		6,043 ± 2,544
Female	8	3,334 ± 1,419		5,675 ± 1,146
Lymphocytes (cells/µl)				
Male	7	3,886 ± 899[b]	7	2,229 ± 632
Female	8	2,836 ± 861	8	2,125 ± 732
Male H-L				
Packed cell volume (%)	22	48.6 ± 4.0	22	41.7 ± 4.1[a]
Hemaglobin (g/dl)	9	13.0 ± 1.9	9	12.5 ± 1.3
Neutrophils (cells/µl)	8	4,950 ± 1,397	8	5,663 ± 2,628
Lymphocytes (cells/µl)	8	4,125 ± 944	8	2,413 ± 742[a]
Female H-L				
Packed cell volume (%)	21	44.5 ± 3.1	21	37.1 ± 3.7[a]
Hemaglobin (g/dl)	12	12.89 ± 1.4	12	11.2 ± 1.8[a]
Neutrophils (cells/µl)	8	3,545 ± 1,531	8	6,331 ± 2,392[a]
Lymphocytes (cells/µl)	12	2,959 ± 762	12	2,323 ± 751
Age subgroups, packed cell volume (%)				
All rhinoceros				
Subadult	26	45.3 ± 4.3	26	40.5 ± 5.4[b]
Adult	17	47.7 ± 3.4	17	44.1 ± 5.8
H-L				
Adult	8	48.1 ± 2.9	8	40.5 ± 5.4[a]
Subadult	18	45.2 ± 4.1	18	38.2 ± 3.7[a]

[a] Values that are significantly different between paired samples in H-H and H-L groups and subgroups, $P < 0.05$.

[b] Values that are significantly different within capture and boma groups, $P < 0.05$.

Table 2. Comparison of hematologic values for wild and captive black rhinoceros.

Variable	n ($\bar{x}$ = 74)[a]	Wild Kenyan rhinoceros $\bar{x} \pm$ SD	n ($\bar{x}$ = 86)[a]	Wild Zimbabwean rhinoceros[b] $\bar{x}$	n[a]	Captive rhinoceros[c] $\bar{x}$	Captive rhinoceros[d] (no n given)
Red blood cells ($\times 10^6$ µl)	76	5.4 ± 0.98	84	5.2	7	4.8	5
Hemaglobin (g/dl)	72	13.4 ± 3.4	84	16.1	7	14.7	15.2
Mean cell volume (fl)	64	82.4 ± 10.9	81	82.5	7	89.5	84
Mean cell hemaglobin (pg)	63	24.4 ± 3.7	82	30.9	7	31.6	29.8
Mean cell hemaglobin concentration (g/dl)	64	28.8 ± 4.6	83	37.7	7	35.4	38.2
Packed cell volume (%)	120	43.7 ± 5.8	87	43	7	42	42
White blood cells (cells 10^{-3}/µl)	117	9.02 ± 3.1	85	1.2	7	8.5	9.3
Neutrophils (cells 10^{-3}/µl)	101	5.1 ± 1.2	81	6	7	5.1	5.6
Lymphocytes (cells 10^{-3}/µl)	101	3.1 ± 1.1	86	4	7	2.9	2.8
Eosinophils (cells 10^{-3}/µl)	101	0.4 ± 0.3	83	0.6	7	0.3	0.1
Basophils (cells 10^{-3}/µl)	101	0	11	0	7	0	0.2
Monocytes (cells 10^{-3}/µl)	101	0.4 ± 0.4	82	0.7	7	0.3	0.6

[a] Each sample is from a separate immobilization.
[b] See Literature Cited.[7]
[c] See Literature Cited.[22]
[d] See Literature Cited.[13]

ferences between sexes and between age groups for certain parameters.

The paired data showed significant differences between the two translocation groups (H-H, H-L) for all rhinoceros and for the different sexes and age groups for certain parameters. The drugs used, immobilization protocols, and boma management were consistent in both H-H and H-L, and no significant differences between or within groups could be determined. These factors should not influence the differences in hematologic parameters.

A reduction in PCV and RBC was confirmed in all sexes and ages of rhinoceros of the H-L group. A significant Hb drop was noted in female rhinoceros, with a similar trend in males. Males in this study had higher PCVs and Hb levels in general than did females. Younger animals had significantly lower PCVs in the boma than did adults, which may indicate a greater susceptibility to anemia. Most animals showed an increase in MCV; the increase was significant in the H-H group. This increase would mask a relatively greater drop in RBC than was indicated by the use of PCV as a measure of anemia.

These data suggest a loss of erythrocytes from circulation or possible sequestration, which could be due to pathologic anemia or fluid retention in the H-L group. Some causes of anemia are hemorrhage, intravascular hemolysis, inappropriate phagocytosis of RBCs (e.g., trypanosomiasis), aplastic effects of toxins or irradiation, and depression of erythrocyte production.

In these rhinoceros, fluid retention as a cause of relative anemia was not supported by the data. The significant increase in TP levels (Table 1) in all translocated rhino indicates fluid loss or dehydration, suggesting that the anemia was greater than it appeared. Higher temperatures did not appear to have a significant effect on thirst/water intake observed in these animals. Effects of depressed erythrocyte production are unlikely to be seen within 3 wk,[4] but this is a component of anemia in chronic trypanosomosis in cattle. Aplastic anemia is unlikely as an explanation in the short period between sampling.

Pathologic anemia was the most likely cause for the drop in PCV, possibly due to hemorrhage or hemolysis. The serum and plasma did not show evidence of hemolysis at the time of sampling. There was no obvious frank hemorrhage associated with trauma, melena, or frank blood in feces of any animal. One possible cause of the anemia is gastric ulceration. Studies in rats[4] and voles[16] have shown that considerable blood loss from gastric ulceration can occur in a short period after stress. The low

mortality in these translocation studies prevented exploration of this hypothesis.

Hemolytic anemia has been reported in captive black rhinoceros.[18] Considerable research in recent years has suggested a tendency for the black rhinoceros RBC to hemolyze under conditions of metabolic stress, possibly because of an inherently low catalase level in the RBC.[19] Leptospirosis has been implicated in the syndrome in captive animals[15] but is an unlikely factor in these animals because they did not show any signs of illness. Reports of hemosiderosis[10] in stressed captive and translocated animals when compared with animals dying of natural causes or very recently translocated animals that died <1 wk postrelease is suggestive that hemolysis may in part be involved and could explain the drop in PCV observed in the rhinoceros of this report.

Causes for hemolysis include blood parasites, bacterial or viral infection, drugs, toxic plants or venoms, intraerythrocytic defects, immune system-mediated reactions, metabolic disease or disorder, and water intoxication. Most of these possible causes can be excluded as very unlikely. There was no evidence of blood pathogens other than typanosomes (*T. vivax, T. congolense, T. simiae*). The significance of theileria in rhinoceros is unknown, and it has been reported previously but its presence in healthy animals suggests a certain tolerance.[11] Drugs used were consistent in the two subsets of animals (although slightly different protocols were used between capture and boma management; lower doses with no adrenolytic agent were used in the boma rhinoceros). There was no access to toxic plants or venomous reptiles during boma confinement. A metabolic disorder cannot be ruled out, but it must be precipitated by stress in a similar fashion in all cases. There was no evidence of water intoxication.

Some of the hematologic changes can be attributed to stress effects, either physiologic or disease related. In domestic animals, the changes noted in blood following stress are reproducible with the administration of exogenous corticosteroids.[5] Cortisol data[18] from translocated Zimbabwe rhinoceros show evidence for a stress response and similar trends were recorded in the present study. In this study, female and younger animals showed significant changes in PCV and Hb when compared with adult males.

The changes in WBC in the H-L group could be described as a stress hemogram, with significant neutrophilia and eosinopenia in both sexes in the bomas and to a greater degree in females. Lymphopenia in the boma was significant in males. Also, all males at capture had relatively higher levels of neutrophils and lymphocytes than did females.

Some of the differences noted would be consistent with the behavior observed between males and females and between younger and older animals in a natural rhinoceros population. Males are more solitary than females and aggressive encounters are more frequent, perhaps indicating a greater tolerance in males to stressful circumstances. Younger animals in the 3–5-yr age group tend to be under a social stress that begins when they are rejected by the mother and remains until they became reproductively active. Thus, as a group these younger animals may be more susceptible to stress.

Similar trends in PCV, RBC, Hb, relative neutrophilia, lymphopenia, and eosinpenia were noted in Zimbabwe[6,7] after boma confinement (1–80 days), but the protocols for translocation were different and the data are not directly comparable. No sex difference was noted in that study, although younger animals tended to have lower Hb and higher WBC parameters.

In this study, three factors may have been significant in the development of anemia in the H-L group: exposure to trypanosomes or another blood parasite, change in altitude, and degree of transport stress. These factors, theoretically, could have contributed to lysis or sequestration of red cells from circulation and depression of RBC production. Transport and confinement stress and/or infection with blood parasites could explain the WBC changes.

Previous studies[14,15,17] have suggested that trypanosome infection is detectable (direct microscopic inspection or xenodiagnosis) 3–4 wk after translocation from a trypanosome-free area to an trypanosome-endemic area. The parasite probably is cryptic in the early period and may cause some damage to the RBC, which may in part explain the change in PCV observed without overt parasitemia in every case. A drop in PCV at 4 wk postcapture was found in another study in one rhinoceros positive for trypanosmes under a moderate tsetse fly challenge (this animal recovered spontaneously without treatment).[14] *Trypanosome brucei* infection was implicated in the death of another animal.[14] In recent translocations, at no time did animals appear ill or show visible symptoms of trypanosomiasis, although the PCV, WBC, and platelet anomalies observed could be referable to trypanosomiasis. At no time were prophylactics administered, and after release the animals thrived. The boma locations were different from the earlier locations[14] where animals became clinically ill, and the fly challenge in the present study was much lower. Translocations were timed to coincide with periods when the vegetation

was optimal and, when possible, with times of low fly activity. The change in boma location and protocols may in part explain the lack of clinical disease in recent translocations.

Although evidence for anemia and mortality has been recently attributed to *Babesia* infection in South Africa (Morkel, pers. comm.), this parasite was not observed or implicated in the drop in PCV in the present study.

The animals in the H-L group went from areas at approximately 2,100 m to areas 350 m above sea level. In one study,[5] movement of cattle from 1,800 m to 3,100 m elevation led to a 6% increase in RBC. This small increase in RBC was considered an underestimate because there was a seasonal effect occurring at the time of the relocation masking a higher potential rise. A change of similar magnitude from a lower to a higher altitude might lead to a drop in PCV. Reduced production of erythropoeitin and hence, erythropoiesis, could impact the PCV.

Stress is difficult to quantify, but clearly the procedure of darting a free-living animal and placing it in a relatively small box, transporting it long distances on poor road surfaces for periods up to 14 hr, and then putting it in a confined area with contact with conspecifics and humans at close quarters for 3–4 wk is stressful. Elevated corticosteroids are a likely sequel, and indicated in previous studies.[19]

Cell metabolism is affected by a change in feed intake (volume and type), increased oxygen demand,[12] and oxidative stress (lactic acidosis), which is especially relevant at the time of immobilization with respiratory depressants such as narcotics and during transportation when there is considerable strain on the muscles. The only significant difference in the translocation protocols between the two groups of animals examined is in transport time because other procedures and presumed stress factors were similar. One translocated rhinoceros was remarkable in that there was no change in hematologic parameters between capture and boma confinement. This rhinoceros was a tame animal that had been handreared, and although it was immobilized for crating it showed no stress and appeared relaxed throughout the journey and in its new boma. For this reason, data from this animal were not included in the data set. This rhinoceros was subjected to all the other stressors, including probable trypanosome infection, which suggests that stress may be a factor in the changes observed in wild rhinoceros in this study.

CONCLUSION

Techniques for capture and translocation have improved in recent years,[8] and some effort has been made to ascertain effects of these procedures on biologic parameters.[6,7,9,10,19] Considerable effort has been put into understanding the RBC in this species because anemia has been a concern in captive animals.[2,3,18,20,21]

The evidence suggests that in addition to the stress of boma confinement, the degree of transport stress might be important in the hematologic changes recorded in the wild translocated rhinoceros. Trypanosomiasis is likely to be involved in the RBC pathology and possibly some of the WBC changes. Tolerance to trypanosomes may be poor in stressed animals. Particular attention should be given to female and subadult animals during these procedures, in whom hematologic changes are likely to be more significant than those in males.

Under field conditions in Africa with free-ranging rhinoceros, it is difficult to create an experimental condition to further test the hypotheses presented. The conclusions are based on retrospective analyses of data collected as systematically as practicable in the field and are important to the management of translocations of the black rhinoceros.

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