

# “Costs” and Short-Term Survivorship of Hornless Black Rhinos

JOEL BERGER  
CAROL CUNNINGHAM

Program in Ecology, Evolution, and Conservation Biology  
University of Nevada  
Reno, Nevada 89512, U.S.A.

A. ARCHIE GAWUSEB

P.O. Box 220  
Khorixas, Kunene Province, Namibia

MALAN LINDEQUE

Etosha Ecological Institute  
Okaukuejo via Outjo, Namibia

The devastation of Africa's black rhinos (*Diceros bicornis*) by poaching (Western 1987) highlights the challenges found at the interface of biology and economics (Leader-Williams & Albon 1988). One of the most controversial conservation actions to date has been the removal of horns from black and white rhinos (*Ceratotherium simum*), tactics adopted in both Namibia (Lindeque 1990) and Zimbabwe (Kock 1991). While acts such as these have been debated for more than a decade, the efficacy of “dehorning” remains unknown (Western 1982; Leader-Williams 1989), in part due to an absence of data on (1) rates of horn regrowth and the subsequent monetary worth of the horns; and (2) whether the vulnerability of dehorned rhinos or their neonates is altered with respect to poachers and predators. Here we explore economic and biological implications of horn removal using data gathered in Namibia in 1991, 1992, and 1993. Specifically, we make three

points. First, horn regrowth is rapid, averaging nearly 9 cm of total horn per animal per year, a finding that suggests new horns on an average animal are worth \$1775–7750 one year after dehorning. Second, because poachers fail to discriminate between large- and small-horned rhinos, recently-dehorned animals may not be immune from poaching. However, neither horned nor hornless rhinos differed in their vulnerability to poachers more than four years after the initial dehorning. Third, for mothers that varied naturally in horn length, calf age and not horn size affected responsiveness to dangerous predators such as lions (*Panthera leo*) and spotted hyenas (*Crocuta crocuta*).

Horns were removed from a total of 20 black rhinos in 1989 and 1991 by personnel of the Namibian Ministry of Wildlife, Conservation, and Tourism in the Kunene Province. This hyperarid region in the northern Namib Desert has lower densities (about 0.002/km<sup>2</sup>) than those reported for any species of rhinoceros (Hitchins & Anderson 1983; Conway & Goodman 1989; Owen-Smith 1989; Dinerstein & Price 1991). We as-

*Paper submitted September 22, 1992; revised manuscript accepted March 29, 1993.*

sessed possible consequences of dehorning by establishing four study populations: (1) two populations in the Kunene Province, one with horned and one with mostly hornless animals, at the *Namib* and *Escarpment* areas, respectively, which are up to 150 km apart and isolated by a country-length Veterinary cordon fence; and (2) two high-density populations *Pan* and *Vlei*, both with horned animals, about 225 km apart at Etosha National Park. Variation in horn size and growth rates (changes over time, calculated here on a per annum basis) were assessed at night with a Mitutoyo (500 Series) Photogrammetric Digimatic Caliper attached to a 300-mm Nikon lens. This equipment has been used to estimate the size of flukes of killer whales and horns of bison with about 98% accuracy when used within 37 m (Berger & Cunningham, in press). During the day, when rhinos are more dangerous to approach on foot, a Lietz rangefinder with a 500-mm Nikon lens was used at less than 70 m, a distance where the average error of morphological measures is less than 5% (Berger, unpublished).

Horn regrowth is now known for 80% ( $n = 16$ ) of the dehorned black rhinos. Anterior horns grew more rapidly than posterior ones (6.9 cm/yr [SE = 0.7] versus 3.3 (0.4),  $t = 5.96$ ,  $p < 0.0001$ ). The shape is somewhat tubular and, four years after the 1989 dehorning, all of the horns are still blunt rather than pointed. Regrown adult male anterior ( $\bar{X} = 5.3 \pm 0.3$  cm/yr) and posterior ( $2.3 \pm 0.3$  cm/yr) horns did not differ from those for females ( $6.4 \pm 1.0$ ,  $3.0 \pm 0.5$ ;  $t = 0.71$ ,  $0.61$ , respectively), but juvenile horns grew faster ( $8.9 \pm 1.2$ ,  $4.4 \pm 0.5$ ;  $t = 2.14$ ,  $2.88$ ,  $p < 0.05$ ,  $p < 0.01$ , respectively). On average then, adults and juveniles supported about 8.7 and 13.3 cm of total horn per year, which means that adults carried about 26 cm of horn three years after initial pruning.

Our measures of horn growth represent minimum values because rubbing may obscure maximum horn growth, but the rates we report exceed those from elsewhere (Table 1). Although the extent to which factors such as habitat or population density affect growth rates remains unknown, it is possible that the intrinsic growth of Kunene Province animals is compensatory; that is, dermal proliferation may be stimulated by horn removal.

To estimate the possible monetary worth of regrown horns, we first assessed relationships between horn size and horn mass based on measures of 104 confiscated horns. More than 83% of the variance in mass ( $Y$ ) was explained by the product ( $X$ ) of horn length (m along outside curve) and basal circumference (m) with either power ( $14.32X^{1.05}$ ) or linear ( $15.49X \cdot 21$ ) regressions ( $p < 0.0001$ ). Independently, horn height and basal circumference explained 73% and 65% of the variance. Adults had greater basal circumferences than juveniles ( $t = 5.81$ ;  $p < 0.001$ ,  $n = 27$ ). The above relationships allow prediction of the regrown horn mass per animal  $\text{yr}^{-1}$  (anterior and posterior summed) which, on average is 0.54 and 0.33 kg per adult and juvenile black rhino. Since rates of intrinsic horn growth are similar for horned black and white rhinos (Table 1), we must assume that regrowth is also approximately similar for both species.

To convert mass measures to monetary worth, we relied on the 1990 market value of African rhino horns (per kg), which in Asia varies considerably: \$3737 in Taiwan (Martin & Martin 1991), \$15,205 in Thailand (Vigne & Martin 1991), and \$16,240 in Hong Kong (Milliken et al. 1991; for South Korea in 1988 it was \$4410). Using the minimum and maximum values, average regrown horn mass per black rhino is worth \$1780–7750 by the end of the first year. If unpruned for four years, the value of regrown horn in a small population of 20 adults, assuming no change in market price, would be \$142,000–\$620,000. Given the minimum existing dollar value per kg, regrown horns are worth more than the cost of removing them in less than 10 months. The inevitable conclusion is that rhinos can be completely devalued only by annual pruning. Nevertheless, other factors are involved, including the costs absorbed by the host countries and nongovernmental organizations.

The estimated total expenses (government and non-government combined) of the two Namibian dehorning operations were \$49,000, or \$2450 per rhino. When the costs of relocating younger animals are subtracted, however, the price of dehorning the 20 animals drops to \$1400 per animal. By contrast, the cost of removing the horns of 59 Zimbabwean white rhinos living at high

Table 1. Comparison of mean horn growth rates per  $\text{yr}^{-1}$  (cm) in intact and dehorned rhinos.

Location	Adults			Juveniles			Comment
<i>Black Rhinos</i>							
Kaokoveld, Namibia	6.0,	2.7	(11)	8.9,	4.4	(5)	dehorned
Etosha Park, Namibia	0.7,	0.3	(5,3)	—	—	—	horned; 3 animals estimated at 20+ yrs
Kruger Park, South Africa	5.3	—	(4)	—	—	—	horned; radio-implant inhorn
<i>White Rhinos</i>							
Kruger Park, South Africa	4.9	—	(6)	—	—	—	horned; radio-implant in horn

Juveniles as used here are 3–5 years old (values refer to anterior and posterior horns, respectively; sample sizes are in parentheses). Namibian data are from this study (horn growth in Etosha animals was determined by calculating the change in distance in the location of a groove in the horn); Kruger data are from Pienaar et al. (1991).

densities was estimated at \$425 per animal (Kock 1991). By including the estimated salaries of participating personnel (which were included in the Namibian but not the Zimbabwean sample), the mean cost becomes \$704 per white rhino. Using the Namibian value and assuming a future (and conservative) annual inflation rate of 15%, a scenario can be developed representing extreme horn pruning schedules (one time only and annual) in relation to existing market prices (Fig. 1).

Although the frequency of dehorning exercises will undoubtedly be affected by monetary costs, to evaluate dehorning as a conservation tactic it is also critical to know whether poachers prefer rhinos with larger horns. If poachers discriminate, then rhinos with smaller or regrowing horns would be less at risk, an assumption that alters the economics of how to render rhinos valueless. Although one of us was convicted of felony rhino poaching and feels that preferences for horn size trophies do not exist, it seems prudent to evaluate the issue of poachers' choices statistically. Hence, we used data from our four study populations, in which more than 95% of the horn sizes of adults and subadults were known; the frequency distribution was then compared to that for horns matched by animal and confiscated by enforcement agencies (Fig. 2). Since rhinos carry two unequal-sized horns, a poacher might select for cumulative value rather than for the length of only one horn.

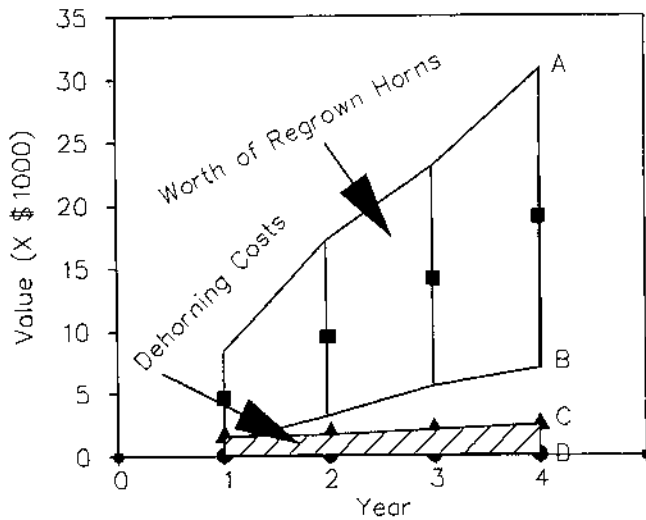


Figure 1. Comparison of 1990 Asian market value (mean \$ per kg per rhino)—dark squares—and range—vertical lines through squares (A—maximum, B—minimum) with two horn-pruning schedules—cross-hatching ((C) annual and (D) one-time only) based on mean regrowth rate of anterior and posterior black rhino horns. Dehorning costs assume annual inflation rate of 15%. Year 0 is the initial year of dehorning at \$1400 per rhino.

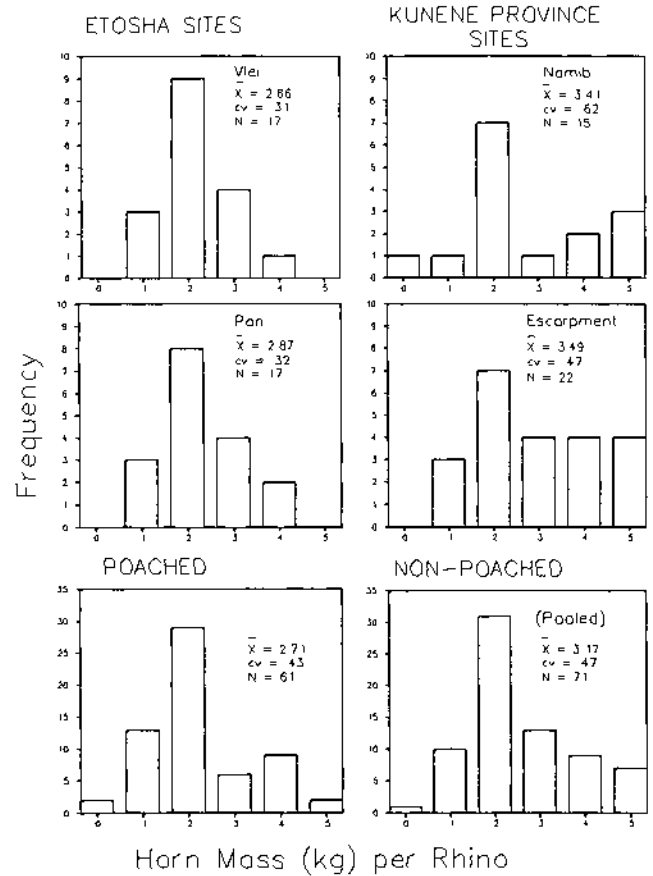


Figure 2. Frequency distribution of horn mass (kg per adult and subadult) in four living Namibian black rhino populations, and that (nonpoached) sample pooled for comparison with a confiscated (poached) sample. Horn mass estimated by method described in the text.

Hence, the mass of each horn (derived previously; see above) was added so that a frequency distribution of mass per animal could be contrasted between the live and confiscated samples. It was necessary to check first whether differences in the frequency distribution of horn mass varied among live populations; if it did, we could not safely assume that the confiscated horns came from the same population. However, because interpopulation differences were not evident (Heterogeneity Chi Square Analysis using four horn mass categories;  $\chi^2 = 13.47$ ,  $df = 9$ , NS), the data were pooled and contrasted with those from the poached sample (Fig. 2). The lack of differences in mean horn mass ( $t = 1.41$ ,  $df = 130$ , NS) or frequency distributions (Kolmogorov-Smirnoff Test;  $D = 0.0444$ , NS) supported our suspicion that poachers did not discriminate among rhino horn sizes. This information suggests that even animals with small regrown horns are as likely to be killed as animals who have not been dehorned.

Economic points aside, the critical biological issue is

whether demographic viability is enhanced by horn pruning? Assessment is necessary at two levels. First, we have not seen interactions between dehorned mothers and dangerous predators. If hornless animals were more vulnerable to predators than were intact rhinos, however, then dehorned animals in the process of regrowing their horns should also be at a greater risk, since their horns would be smaller than those of intact animals. Therefore, we inferred whether hornless rhinos might react differentially to predators by contrasting the behavior of mothers that varied naturally in horn size during 27 witnessed interactions with lions and spotted hyenas in Etosha. Those ( $n = 15$ ) with anterior horns below the mean (31.5 cm) were no more likely to run from predators than were larger-horned mothers (18% versus 19%, respectively;  $p = 0.68$ , Fisher's Exact Test). What affected maternal responsiveness was calf size; those with neonates younger than about 18 months fled more than those with older calves (50 versus 10%) ( $p = 0.056$ ), though the sample is still too small to remove the possibility that horn size and calf size do not exert independent effects.

Second, the claim that demographic viability improves with dehorning is untenable for at least three reasons: (1) although no dehorned black rhinos have been poached, neither have any horned ones elsewhere in the Kunene Province, even though they outnumber hornless conspecifics by about 4–5:1; (2) all ( $n = 3$ ) calves of hornless mothers that were sympatric with hyenas have died whereas no calves of hornless mothers in predator-free areas or of horned mothers who were sympatric with hyenas and transient lions have perished (Berger & Cunningham 1993); and (3) a country-length veterinary cordon fence isolates the dehorned animals so that a high degree of uncertainty about their long-term population viability exists.

With respect to dehorning as a conservation tactic, it is worthwhile to recall that such radical actions were *not* intended as a long-term biological solution. Therefore, they cannot be judged solely on biological criteria; economic and political environments will always mediate the success of any long-term conservation plan. While poaching of Kunene Province animals has not occurred since 1989, both black and white rhinos are still killed in other regions of northern Namibia, areas where poaching had not previously occurred. Perhaps the overly sensational, massive, and often inaccurate publicity about dehorning, both local and international, may have caused poachers to shift actions away from the Kunene Province to areas where only horned rhinos occur. Ostensibly, this may even have been the purpose of the media campaign. Nevertheless, without adherence to a time frame in which the demographic response of target species can be evaluated and without attention to monies allocated for resource protection (Leader-Williams & Albon 1988; Milner & Leader-

Williams 1992), it is imprudent to attempt persuasive arguments about the soundness of dehorning, particularly given the lack of precision in predicting the timing and intensity of poaching epidemics. Finally, political events in 1990 unrelated to the media but associated with Namibian independence may have prompted an overall decline in poaching. Although these may relate in some combination to the cessation of hostilities involving South Africa, Angola, Namibia, and the removal of South African Defense Forces, it is also likely that the development of auxiliary game guard systems (Owen-Smith 1986; Owen-Smith & Jacobsohn 1989) has facilitated rhino conservation. Whatever the cause or causes, it is clear that biological solutions to regional conservation problems will be effective only as far as geography, socio-economics, and cultural influences on behavior are considered.

### Acknowledgments

Our research has been graciously sponsored by the American Philosophical Society, the Frankfurt Zoological Society, the Hasselblad Foundation, the National Geographic Society, the Conservation and Research Center of the Smithsonian Institution, Rhino Rescue Ltd., Save the Rhino Trust, the University of Nevada, Wildlife Conservation International (New York Zoological Society), the National Science Foundation, the Office of Forestry, Environment, and Natural Resources of the Bureau of Science and Technology of the U.S. Agency for International Development (under NSF Grant BSR-9025018), and the World Wildlife Fund-USA. We thank Namibia's Ministry of Wildlife, Conservation, and Tourism, W. Gasaway, E. Joubert, M. Jacobsohn, M. Kock, R. and B. Loutit, G. Owen-Smith, J. Rachlow, and an anonymous reviewer for discussions or comments on a prior draft.

### Literature Cited

- Berger, J., and C. Cunningham. Mating, conservation, and bison. Columbia University Press, New York. In press.
- Conway, A. J., and P. S. Goodman. 1989. Population characteristics and management of black rhinoceros *Diceros bicornis minor* and white rhinoceros *Ceratotherium simum simum* in Ndumu Game Reserve, South Africa. *Biological Conservation* 47:109–122.
- Dinerstein, E., and L. Price. 1991. Demography and habitat use by greater one-horned rhinoceros in Nepal. *Journal of Wildlife Management* 55:401–411.
- Hitchins, P. M., and J. L. Anderson. 1983. Reproduction, population characteristics and management of the black rhinoceros *Diceros bicornis minor* in the Hluhluwe/Corridor/Umfolozzi Game Reserve Complex. *South African Journal of Wildlife Research* 13:78–85.

- Kock, M. D. 1991. Report on experimental dehorning operation on white rhinoceros (*Ceratotherium simum*) in Hwange National Park, Zimbabwe. Final report. Department of National Parks and Wildlife Management, Harare, Zimbabwe.
- Leader-Williams, N. 1989. Desert rhinos dehorned. *Nature* 340:599–600.
- Leader-Williams, N., and S. D. Albon. 1988. Allocation of scarce resources for conservation. *Nature* 336:533–536.
- Lindeque, M. 1990. The case for dehorning the black rhinoceros in Namibia. *South African Journal of Science* 86:226–227.
- Martin, C. B., and E. B. Martin. 1991. Profligate spending exploits wildlife trade in Taiwan. *Oryx* 25:18–20.
- Milliken, T., E. B. Martin, and K. Nowell. 1991. Rhino horn trade controls in East Asia. *Traffic Bulletin* 12:17–21.
- Milner-Gulland, E. J., and N. Leader-Williams. 1992. Illegal exploitation of wildlife. Pages 195–213 in T. M. Swanson and E. B. Barbier, editors. *Economics for the wild*. Earthscan Publications, London, England.
- Owen-Smith, G. 1986. The Kaokoveld. *African Wildlife* 40:104–115.
- Owen-Smith, G., and M. Jacobsohn. 1989. Involving a local community in wildlife conservation. A pilot project at Purros, South-western Kaokoland, SWA/Namibia. *Quagga* 27:21–28.
- Owen-Smith, N. 1989. *Megaherbivores*. Cambridge University Press, Cambridge, England.
- Pienaar, D. J., A. J. Hall-Martin, and P. A. Hitchins. 1991. Horn growth rates of free-ranging white and black rhinoceros. *Koedoe* 34:97–105.
- Vigne, L., and E. B. Martin. 1991. *Pachyderm* 14:39–41.
- Western, D. 1982. Dehorn or not dehorn? *Swara* 5:22–23.
- Western, D. 1987. Africa's elephants and rhinos: Flagships in crisis. *Trends in Ecology and Evolution* 2:343–346.

