

Letters

Dissimilar home range estimates for black rhinoceros *Diceros bicornis* cannot be used to infer habitat change

The strategically important black rhinoceros *Diceros bicornis* population in Hluhluwe-iMfolozi Park, South Africa, appears to have declined. Some suggested the population exceeded carrying capacity (Emslie, 2001a) and required increased harvest (Emslie, 2001b). Others were concerned about over-harvesting (Balfour, 2001). Reid et al. (2007) used apparently larger home range sizes in the Park than previous estimates to infer habitat deterioration, a conclusion that appears to be influencing the opinion of local managers (Morris, 2009) and may be used to support changes in the management of the Park's black rhinoceros population (Authors, pers. obs. at 36th Biannual Meeting of the KwaZulu-Natal Rhino Management Group, 5 November 2008, and Hluhluwe-iMfolozi Park Research Forum, 4 June 2009).

Home range estimates are sensitive to the method of data collection and analysis (e.g. convex polygon, kernel or grid cell), and number and period of observations (Laver & Kelly, 2008). Researchers, therefore, are rightly hesitant to compare estimates that differ in one of these ways. It is of concern, given the importance of their conclusion for the management of a Critically Endangered species, that Reid et al. (2007) compared estimates differing in all these respects.

Reid et al. (2007) compared their estimates using locations gathered over 11 years with an historical value from Adcock (1996), reported in Emslie (1999). Adcock's (1996) original calculations were from 1 km² grid-occupancy data incorporating a 4-year subset (1991–1994) of the Reid et al. (2007) data (1991–2002; Table 1). Lack of independence between datasets and the longer sampling period in Reid et al. (2007) will increase range estimates because individual home ranges shift inter-annually (Lent & Fike, 2003).

Home ranges may also be 40–300% larger with few locations and disjointed observations, such as those in Fig. 5 of Reid et al. (2007), when kernel techniques are applied (Downs & Horner, 2008; Huck et al., 2008; Boyle et al., 2009). Simulations suggest that ≥ 50 locations are required for accuracy (Seaman et al., 1999), and location data for some animals may require considerably more (e.g. 200–500 locations; Hemson et al., 2005). Reid et al. (2007) did not report numbers of locations but used as few as 10 per individual and thus probably overestimated range size.

Moreover, rhino locations in Reid et al. (2007) were not from standardized sampling but fortuitous sightings. Detection bias among sites and individuals may inflate range sizes because patrolled Park boundaries (i.e. fence-lines) and settlement areas (i.e. tourist camps and ranger stations) receive disproportionate observer effort. Animals in the Park's

centre may be more likely detected on the periphery of their range and those living near settlements may be frequently displaced, thus inflating range size estimates. All examples in Fig. 5 of Reid et al. (2007) are along Park boundaries (A), surround a human settlement (C & D; i.e. Mbuzane Section Ranger Camp), or are adjacent to public roads (A, B and D).

Even if home range estimates were comparable, increases in ranging cannot be used as evidence of deteriorating habitat (particularly as no data on changes in habitat were provided) without accounting for inter-specific (e.g. competition and predation) and intra-specific interactions and anthropogenic effects (Schwartz et al., 2003; Morrison et al., 2006). Reduced animal density, for example, may drive larger range sizes, especially in an asocial species such as black rhinoceros where range overlap is limited by intra-sexual competition (particularly amongst males). If population size in Hluhluwe-iMfolozi Park has declined (Fig. 1 in Reid et al., 2007) home range size might have increased because of lower density and be unrelated to habitat quality.

Lastly, Reid et al. (2007) claim larger home ranges as evidence of deteriorated habitat but report smaller ranges during the dry and cold winter than during summer when resource conditions are better. They explain this as the result of more food allowing energy for greater movement and expanded home ranges in summer. This contradicts their contention that poor habitat causes increased range size. They cite more widely distributed water in summer to explain the contradiction but their results show no change in proximity to permanent (winter) water between seasons.

Home range size is not a reliable proxy for habitat quality. Understanding the dynamics of Hluhluwe-iMfolozi Park's black rhinoceros population requires systematic monitoring of the vital rates of an unbiased sample of individuals and their habitat through time. The severity of the management challenge at hand and the danger of misleading conservation policy requires that we resist the temptation to over-interpret poor quality data.

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TABLE 1 Historical sequence of estimates of black rhinoceros *Diceros bicornis* var. *minor* home ranges in Hluluwe-iMfolozi Park, South Africa.

Method	Focal population	Locations per rhino	Observation period	Home range size (ha)	Reference
Ground search & fortuitous observations: visual approximation using all points	2m, 4f	Not reported	1962–1963	Males: 199.9–223.0 Females: 212.5–494.9	Hitchins (1969) ¹
Radio telemetry & ground search: visual approximation using all points	10m, 4f	47–503 (twice daily)	86–396 days (Nov. 1969–Dec. 1971) ²	Males: 170–619 Females: 460–950	Hitchins (1971); P.M. Hitchins (unpubl. data)
Fortuitous observations: 1 km ² grid occupancy	Not reported	~6–20	c. 1991–1994	Males: 1,200–1,900 ³ Females: 1,300–2,300 ³	Adcock (1996); K. Adcock (pers. comm.)
Fortuitous observations: 95% kernel	125	≥10	1991–Feb. 2002	Range: 500–5,500 Average: 2,302 ± SE 295	Reid et al. (2007)

¹Reid et al. (2007) did not mention the earlier estimates of home range size in Hluluwe-iMfolozi Park from Hitchins's (1969, 1971) intensive observations, including radio telemetry, although the same problems would arise in comparison.

²Sometimes included a broken sequence of two or three different transmitters in the same individual

³Represents the range of average values from five different regions of the Park. The value of 1,500 ha quoted by Emslie (1999) and cited by Reid et al. (2007) was only for the northernmost region of the Park.

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Use of black rhino range estimates for conservation decisions: a response to Linklater et al.

We note the concerns of Linklater et al. (2010) regarding our conclusions for management of black rhinoceros *Diceros bicornis* in Hluhluwe-Umfolozi Park (Reid et al., 2007). Regarding their methodological issues, we pointed out potential biases in data collection and highlighted that the quality and quantity of information used reduced the quality of our analysis. The reader was therefore forewarned to be cautious in any interpretation.

We used opportunistic data collection throughout. Lack of independence would make any contrast conservative in terms of bias, and the effect of sample size on range size was the opposite to the concern of Linklater et al. (2010) as the 95% kernel range increased significantly with sample size (regression: $F_{1,124} = 60.2$, $P < 0.001$). Using only subsets with larger sample sizes, for ≥ 30 sightings ($n = 43$ rhino) mean home range was $29.8 \pm \text{SE } 1.7 \text{ km}^2$ and for ≥ 50 sightings ($n = 19$) $34.3 \pm \text{SE } 2.5 \text{ km}^2$. While accepting potential data issues (and noting that we used kernel rather than minimum convex polygons), these ranges are substantially larger than those of P.M. Hitchins or K. Adcock/R.H. Emslie (Table 1 in Linklater et al., 2010). We believe it reasonable to conclude that range sizes in general have increased.

Linklater et al. (2010) state ‘increases in ranging cannot be used as evidence of deteriorating habitat . . . without accounting for inter-specific interactions . . . and anthropogenic effects’. We were not the first to propose that rhino range size increased with degrading habitat (Emslie, 1999). Furthermore, we highlighted that changes in range size could be related to disruption of social networks, and that this and effects of elephants *Loxodonta africana* require further investigation (Reid et al., 2007).

Differential range use by rhino (Reid et al., 2007) and other mega-herbivores between dry and wet seasons is well

documented, even in small fenced reserves (Shannon et al., 2006). It is thus not appropriate to use seasonal responses to resource variation as an argument when contrasting ranging across years, as is done by Linklater et al. (2010). They conclude that ‘home range size is not a reliable proxy for habitat quality’. While there may be problems with our data this does not negate the potential for home range size to be an indicator for habitat quality, and Linklater et al. (2010) do not present any data to counter this possibility. Our conclusion that ‘declining habitat quality . . . may have resulted in larger home ranges’ was deliberately cautious, and we went on to emphasize the importance of more detailed work examining the potential mechanisms affecting habitat quality for black rhino.

Linklater et al. (2010) are correct that all potential explanations for changes in population productivity of a Critically Endangered species such as black rhino should be investigated. However, our purpose was not to exclude any particular explanation (such as social factors or management interventions) but rather to point out that there may be ecological aspects affecting productivity that need to be investigated. As stated in our original abstract: ‘Ongoing review of stocking rates, population performance . . . and intervention strategies are necessary to manage black rhino in dynamic savannah ecosystems’ (Reid et al., 2007). Simple ecological indices may not necessarily be appropriate as a framework for management planning (e.g. carrying capacity estimates should not be used for black rhino population management; Morgan et al., 2009), and incorporating individual variation in biology is critical (Morgan et al., 2009). Furthermore, interventions should acknowledge the importance of the social clusters that rhino develop (Morgan et al., 2009) and avoid any indiscriminate removal from these groups (Reid et al., 2007; S.R. Morgan, pers. comm.).

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