SHORT COMMUNICATION

Rhino birth recovery and resilience to drought impact

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1 | INTRODUCTION

Climatic variation can have a dramatic impact on wildlife populations (Ameca y Juárez et al., 2012; Young, 1994). Drought is an extreme element of climate variation, frequently experienced in semi-arid and arid ecosystems (Easterling et al., 2000). Drought conditions have greater impact on certain species because of life history traits such as surface water dependency and feeding strategy; grazers and mixed feeders are more susceptible than browsers due to dependence on drought-intolerant forage, and herbivore species that are strongly dependent on surface water are similarly more affected (Duncan et al., 2012). Population resistance results from low susceptibility to climatic variation such as drought, while a resilient population has the ability to withstand and recover from these environmental perturbations (Oliver et al., 2013).

Drought conditions most often contribute to increased population extinction risk through population size reductions (Dunham, 1994; Knight, 1995) and the consequent negative effects of genetic bottlenecks (Young, 1994). Population size reductions typically occur as a direct result of reduced resource availability and decreased survival, but indirect impacts such as increased vulnerability to predation and disease may also occur (Loveridge et al., 2006). In addition to reduced adult survival, drought conditions may affect birth rate and early survival (Foley et al., 2008; Loveridge et al., 2006). In numerous large herbivore species, juvenile survival is more sensitive to climatic variation than adult survival (Gaillard et al., 1998). As recruitment of young animals into the population is a key component of large-mammal population growth (Eberhardt, 2002), birth rate and early survival play a significant role in population recovery and resilience.

During 2015/2016, decreased rainfall and vegetation biomass resulted in severe drought conditions and increased herbivore mortalities (Staver et al., 2019) in the Kruger National Park (Kruger), South Africa. In accordance with expectations based on feeding strategy, the grazing white rhinoceros (*Ceratotherium simum;* white rhino) in Kruger exhibited increased natural mortalities during the drought period and decreased annual recruitment rates in the year following the drought (Ferreira et al., 2019). The browsing black rhinoceros (*Diceros bicornis;* black rhino) did not exhibit changes in either natural mortality or annual recruitment rate during the drought. Kruger is one of the world's largest rhino strongholds and maintains large, free-ranging populations of both white and black rhino; these populations are therefore vital for species persistence at the global scale. Understanding the ability of these megaherbivores to resist or recover from population-level impacts is therefore key to predicting long-term population viability.

The contrasting drought impacts seen in black and white rhino predict similar species-specific postdrought responses. The long gestation time of rhinos (white rhino: 16 months, black rhino: 15 months; Skinner & Chimimba, 2005) means that the annual birth rate of both species is relatively low. Even so, if conception rates decrease (e.g. as a result of reduced body condition) for a substantial time period, birth rates should increase once conditions improve as a result of an increased number of cows coming into oestrus simultaneously. Birth synchronisation after an environmental perturbation increases recruitment (Wittemyer et al., 2007) and forms part of population recovery, contributing to long-term resilience. Recruitment rates of impacted populations should therefore be higher postdrought than during the drought and predrought periods. We expect no significant change in populations resistant to drought impacts, that is populations that did not exhibit reduced conception rates during that period. In this study, we investigate whether white rhino demonstrate evidence of population resilience to environmental impacts by exhibiting increased recruitment following a drought period. We compare these findings with those of the seemingly unaffected black rhino and discuss the comparison in the context of species-specific behaviour and local conservation challenges.

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2 | METHODS

Kruger covers 19,485 km^2 of low-lying semi-arid savannah in South Africa. Annual rainfall ranges from 450 to 750 mm, with increasing rainfall from north to south (Gertenbach, 1980). Granite and gneiss deposits separated by Karoo sediment combine with wooded savannah (comprising *Sclerocarya caffra* and *Senegalia nigrescens*) and mixed *Combretum* spp. and *Senegalia* spp. to create 35 different landscape types across Kruger (Gertenbach, 1983).

For this study, we used population-level estimates of recruitment (the number of calves that were born and survived between consecutive years) from 2014 to 2019 to investigate recruitment changes in black and white rhino in response to climatic variation in the semi-arid savannah. As the gestation period of both rhino species is greater than a year, we classified our predrought, drought and postdrought impact periods using 2 years of data for each period in order to fully encompass changes in recruitment. Furthermore, our study periods are 'rhino impact' periods rather than the calendar year/s in which the ecological phenomenon was recorded, that is the ecological drought occurred in 2015/2016, but the impact on rhino births would only reflect more than 16 months later, in 2016 and 2017. Similarly, rhinos conceived in the year following the drought (2017) would only be born in 2018 and 2019. We therefore combined 2 years of data to represent each impact period: predrought impact (2014 and 2015 recruitment), drought impact (2016 and 2017 recruitment) and postdrought impact (2018 and 2019 recruitment) periods (Figure 1). Recruitment was defined as the number of rhinos that were born and survived between survey year ($x − 1$) and survey year (x); these are represented by the A- and B-class calves (less than 1 year of age) recorded during survey year (x). Recruitment rate was then calculated as a fraction of the number of rhinos estimated during the survey year ($x − 1$).

We extracted and averaged annual recruitment rates for predrought and drought impact years from Ferreira et al. (2019). We made use of a simulation technique to average annual rates that comprised an impact period by extracting a value from the statistical distribution for each year and getting the average for that period. We repeated this procedure 100,000 times and obtained the average as well as 2.5% and 97.5% percentiles that reflect a 95% confidence interval for a specific period.
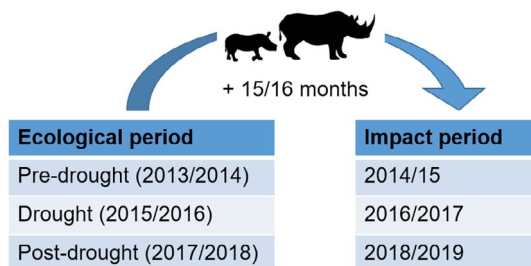

+ 15/16 months

Ecological period	Impact period
Pre-drought (2013/2014)	2014/15
Drought (2015/2016)	2016/2017
Post-drought (2017/2018)	2018/2019

FIGURE 1 Schematic representation of the classification of ecological periods into their impact years on recruitment for black and white rhino [Colour figure can be viewed at wileyonlinelibrary. com]

We calculated recruitment rates for the postdrought impact period from SANParks observation data collected in 2018 and 2019 during the annual rhino surveys, following the same method as used for previous surveys. Data were utilised from randomly selected 3 × 3 km blocks covering 44.2% and 48.2% of southern Kruger (south of the Olifants River) in 2018 and 2019, respectively. Surveyors systematically completed transects comprising a 200 m observation strip on each side of the helicopter within each block, with flights 45 m above ground at 65 knots. The survey team was comprised of a pilot, a data recorder and two observers. Age classes (A:F) were assigned to all observed rhino using relative body sizes, following the criteria set by the Rhino Management Group (Emslie et al., 1995).

Population size estimates were generated from the rhino observations using Jolly's estimator (Jolly, 1969), accounting for availability bias (using the relationship between rhino visibility, cover and Enhanced Vegetation Index) and observer bias (calculated in a prior survey; Ferreira et al., 2011), as was done in previous surveys (Ferreira et al., 2015, 2018). Chi-square tests for significant differences in proportions using the point estimates were performed in R v3.6.2 (R Development Core Team, 2019). To incorporate the uncertainty of the population and birth estimates, significance was assigned to differing vital rates when the 95% confidence intervals between impact periods did not overlap.

3 | RESULTS AND DISCUSSION

3.1 | White rhinos

In 2018, the white rhino population estimate for Kruger was 4,116 (95% CI: 2,994–5,726), with 10.9% of observed animals less than 1 year of age (Ferreira & Pienaar, 2020). This translated to 449 (95% CI: 326–624) calves born and surviving between the 2017 and 2018 surveys. In 2019, the white rhino population in Kruger was estimated as 3,549 (95% CI: 3,152–3,949), with 11.8% of observed animals less than 1 year of age. This translated to 419 (95% CI: 372–466) calves born and surviving between the 2018 and 2019 surveys.

Overall recruitment rate during the postdrought period for white rhinos was 9.4% (95% CI 7.3–11.6). Point estimate comparisons showed significantly higher recruitment in the postdrought period than the drought ($\chi^2 = 41.171$, $p < 0.01$) period. Postdrought and predrought recruitment rates were not significantly different ($\chi^2 = 0.141$, $p > 0.05$). When incorporating the uncertainty surrounding point estimates, the increase in recruitment rate in the postdrought period relative to the drought (6.3%, 95% CI: 5.1–7.4) was bordering significant. No significant difference between the postdrought and predrought (9.6%, 95% CI: 8.7–10.5) periods could be detected (Figure 2). This suggests that some degree of birth synchronisation may have occurred in the postdrought period, but it was insufficient to surpass predrought recruitment rates. This may reflect only a moderate vital rate response to disturbance in white rhino, or their long gestation time may result in reduced
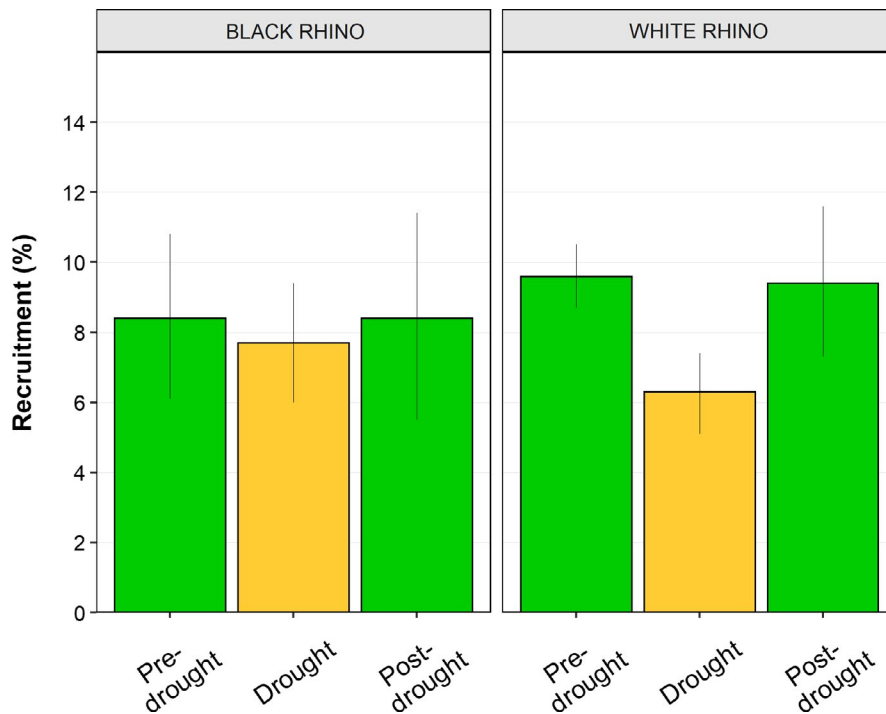
FIGURE 2 Recruitment rates for black and white rhino across the three impact periods. Vertical lines depict 95% confidence intervals [Colour figure can be viewed at wileyonlinelibrary.com]

synchronisation. Alternatively, the poaching of cows with dependent calves that die and go unrecorded may mask the magnitude of the postdrought response. Fewer white rhinos were poached in the postdrought compared with the predrought period (SANParks protected unpubl. data), however, and therefore, this is more likely a minor contributing factor.

3.2 | Black rhinos

In 2018, the estimated Kruger black rhino population size was 291 (95% CI: 151–441), with 8.4% of observed animals less than 1 year old (Ferreira & Pienaar, 2020). This translated to 24 (95% CI: 12–37) calves born and surviving between the 2017 and 2018 surveys. In 2019, the population size was estimated as 268 (95% CI: 191–342), with 13.3% of observed animals less than 1 year of age. This translated to 36 (95% CI: 25–46) calves born and surviving between the 2018 and 2019 surveys.

Combined recruitment rate during the postdrought period for black rhinos was 8.4% (95% CI 5.5–11.4). Point estimate comparisons also showed no significant changes in recruitment rate between the postdrought and the predrought ($\chi^2 = 0.016$, $p > 0.05$) or drought ($\chi^2 = 0.230$, $p > 0.05$) periods. Similarly, when incorporating the uncertainty surrounding point estimates, no significant differences in recruitment rate between the postdrought and the drought (7.7%, 95% CI: 6.0–9.4) or predrought (8.4%, 95% CI: 6.1–10.8) periods could be detected (Figure 2). While evidence suggests that black rhino fecundity/recruitment has been slowly declining for some years in Kruger (le Roex & Ferreira, 2020), this long-term decline appears unrelated to the drought experienced in Kruger over 2015/2016. Reduced mating opportunities when populations are

small can influence birth rate (Courchamp et al., 2008), and black rhino are likely to be particularly susceptible to localised impacts as a result of their low density in Kruger and poor dispersal (Linklater & Hutcheson, 2010). Similarly, delayed mating as a result of social disturbance may reduce fecundity and recruitment over long periods (le Roex & Ferreira, 2020).

Ferreira et al. (2019) showed drought impacts on annual white rhino vital rates during the drought and 1-year lag periods, but no detectable effects in black rhino. These results suggested that white rhino populations were impacted by drought conditions, but black rhino populations were resistant. Our analysis of the postdrought responses of both species supported those results by demonstrating population resilience in white rhino, with a greater magnitude of response potentially undetected as a result of the loss of dependant calves through poaching. We clearly showed no changes in black rhino recruitment in response to the climatic impact periods identified.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
All data are presented within the manuscript.

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