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Patterns in rhino poaching activity on private land in South Africa

Laura A. Chapman | Piran C. L. White

Department of Environment and Geography, University of York, York, UK

Correspondence
Laura A. Chapman, Department of Environment and Geography, Wentworth Way, University of York, York YO10 5NG, UK.
Email: laura.chapman@york.ac.uk

Abstract

Poaching on private land may potentially significantly deplete the rhino population yet is poorly studied. We focus on temporal patterns in poaching events, whether there is any evidence of targeting of specific categories of rhino (in relation to species, sex and age) and whether these patterns in poaching show any trends over time. Using rhino owner and (mainstream and social) media reports, we complied a database of private land poaching events between 2003 and 2017. Patterns in poaching activity were broadly consistent over time. Poaching is most likely at night, under the full moon, and close to the property perimeter. Whilst there was no consistent temporal pattern in poaching, there was evidence of increased poaching during the weekend (Friday–Sunday) compared to weekdays (Monday–Thursday) in 2017. Prioritising rhino protection efforts at these times may therefore be the most efficient use of limited resources. Because there is no evidence that poachers selectively target rhinos, efforts undertaken by private owners to protect specific individuals or groups may be ineffective. Our research also highlighted key data that were currently not clearly recorded, including collateral calf deaths and lost pregnancies, which may have a significant impact on the scale of the rhino poaching problem.

KEYWORDS

Ceratotherium simum simum, *Diceros bicornis*, environmental crime, private landowners, social media research

Résumé

Le braconnage sur les terres privées peut potentiellement réduire la population de rhinocéros de manière considérable. Cependant, peu d'études existent à ce sujet. Notre étude se concentre sur les caractéristiques temporelles des événements de braconnage. Elle tente de déterminer s'il existe des éléments permettant d'établir le ciblage de catégories spécifiques de rhinocéros (en relation avec les espèces, le sexe et l'âge) et si des tendances concernant ces modèles de braconnage se manifestent au fil du temps. En utilisant les rapports des propriétaires de rhinocéros et des médias (grand public et sociaux), nous avons constitué une base de données des événements de braconnage sur les terres privées entre 2003 et 2017. Les tendances de l'activité de braconnage étaient globalement cohérentes au fil du temps. Il est plus probable que le braconnage se produise la nuit, lors de la pleine lune et à proximité du périmètre de la propriété. Bien qu'il n'existe pas de caractéristiques temporelles cohérentes

dans le braconnage, des éléments significatifs ont suggéré augmentation du braconnage pendant les weekends (du vendredi au dimanche) par rapport aux jours de la semaine (du lundi au jeudi) en 2017. Mettre en avant les efforts de protection des rhinocéros à ces moments peut donc optimiser l'efficacité de ressources limitées. Du fait qu'aucun élément probant ne suggère que les braconniers ciblent sélectivement les rhinocéros, les efforts entrepris par les propriétaires privés pour protéger des individus ou des groupes spécifiques peuvent s'avérer inefficaces. Notre recherche a également mis en évidence des données clés qui n'avaient pas précisément été enregistrées jusqu'à présent, notamment les décès collatéraux des petits et les fausses couches, qui peuvent avoir un impact significatif sur l'ampleur du problème du braconnage des rhinocéros.

1 | INTRODUCTION

The illegal trade in endangered species and their parts is one of the best known examples of environmental crime (Brack, 2002; Gore, 2011). The illegal poaching of wildlife is particularly lucrative, due to the open-access manner in which such resources may be exploited (Bulte & van Kooten, 1999; Hall et al., 2008), the low costs involved (Douglas & Alie, 2014) and the potentially exceptionally high gains that can be achieved (Bulte & van Kooten, 1999; Douglas & Alie, 2014). When species are rare, as in the case of rhinos, this rarity in itself can further drive the profitability of poaching under such open-access conditions (Hall et al., 2008). Whilst attempts to understand the driving forces of poaching are common (e.g. Duffy, 2014; Lunstrum, 2014), and often focus on economic drivers of such behaviour (Bulte & van Kooten, 1999), research investigating the patterns of poaching activity is only recently developing as a field (Beale et al., 2018; Critchlow et al., 2015; Rashidi et al., 2016).

The poaching of southern white (*Ceratotherium simum simum*) and black rhinos (*Diceros bicornis*) is of particular importance due to the significant economic gains that can be made from the supply of rhino horn (Milliken & Shaw, 2012) and the high level of poaching rhino currently face in southern Africa. In 2017, poaching deaths represented 5.5% of South Africa's rhinos (Emslie et al., 2019). With increased poaching pressures reducing the white rhino population growth rate in South Africa to only 2% per annum (Knight et al., 2015), continued poaching will significantly impact upon the future of this species. There is therefore an urgent need to understand factors which contribute to poaching patterns.

The privately owned rhino population of South Africa is substantial, comprising 33% of the national herd of black rhinos (Selier, 2019) and 45% of white rhinos (Emslie et al., 2019). Private properties holding rhinos in South Africa range from single-species breeding facilities through to extensive natural areas, with a mean size of 9,761 ha (range: 54–103,000 ha; Balfour et al., 2015). Limited research has been undertaken on rhino poaching in state-protected areas (Koen et al., 2017), but private reserves tend to be disconnected from such research (Maciejewski et al., 2016). In this paper, we therefore focus on patterns on private reserves, utilising poaching reports from private land across South Africa. Specifically, we characterise temporal patterns of poaching incidents, and investigate whether specific rhinos are more likely to be targeted by poachers than others. Understanding the patterns in poaching, such as when rhinos are poached and whether specific animals are targeted may contribute to better preventative measures, which are much more effective in the long-term preservation of species than reactive action after a poaching event (Koen et al., 2017).

For private rhino owners, measures to protect rhinos from poaching include the use of anti-poaching patrols and dehorning, in addition to standard deterrents such as alarms and guard dogs. The effectiveness of these measures has not been considered previously for private reserves, but there is an existing body of work on the effectiveness of anti-poaching patrols and dehorning for protecting rhinos on state-owned land (Barichievy et al., 2017; Cheteni, 2014; Ferreira & Okita-Ouma, 2012; Ferreira et al., 2014; Martin, 1996a; Wellsmith, 2011). Both Barichievy et al. (2017) and Plumptre et al. (2014) highlight the limited use of field ranger patrols against poachers, with Plumptre et al. (2014) determining that there is no single effective strategy for preventing illegal activity on protected land. One concern raised in these studies on state-owned land was that poaching may be displaced to other areas of the reserve where patrols are not currently being undertaken. Given the relatively small size of most private rhino owning properties (mean size 9,760 ha; Balfour et al., 2015), such displacement may be less likely to occur on private land. There are uncertainties about the effectiveness of different anti-poaching activities, and especially on the extent to which existing knowledge from state-owned land can be translated to smaller privately owned properties. Nevertheless, it is expected that private rhino owners would seek to deploy their poaching prevention resources in the most cost-effective manner.

Rhinos have long been regarded as relatively easy to poach due to their generally solitary lifestyle, predictable behaviour, ease of approach (Western, 1982) and horns which are relatively easy to remove (Kock et al., 2008). In 2016, southern white rhinos made up the majority (90.7%) of the privately owned population, with the black rhino comprising only 9.3% (Emslie et al., 2016; Knight, 2017). With their larger horns (Martin & Vigne, 2003), white rhinos tend to be preferred poaching targets (Knight et al., 2015; Milliken & Shaw, 2012). We hypothesise that this targeting of heavier-horned individuals would translate into targeting of mature adults over sub-adults or calves. Males have heavier horns than females (Pienaar et al., 1991) and we hypothesise that males should therefore also be targeted preferentially. Anecdotal evidence, collated from informal discussions with private rhino owners, suggests a belief that these larger-horned individuals are more attractive to rhino poachers. Identifying whether such selection does occur would provide private rhino owners with the evidence needed to determine whether selective dehorning may be an appropriate preventative action to take to reduce the risk of poaching on their property.

Research on the poaching of rhinos on state land has indicated that poachers show a preference for poaching during the full moon (Mulero-Pázmány et al., 2014) and during twilight hours (Koen et al., 2017), whilst the level of rhino poaching increases through the calendar year towards December (Koen et al., 2017; Mulero-Pázmány et al., 2014). Understanding whether the same or different patterns hold for private land could greatly benefit rhino owners in directing their poaching prevention activities more effectively (Ratcliffe, 2004). As private rhino owners receive no financial support from the South African government (Lee & Du Preez, 2016), they must fund any poaching prevention activities themselves. Increasing costs may reduce the effectiveness of rhino conservation on private land, having been linked to preventing reserve expansion in Zimbabwe (Langholz, 1996) and to increasing disinvestment in rhinos by private owners in South Africa (Jones, 2013). Identifying when poaching preventive actions are likely to be most effective against poaching may reduce expenditure and serve to mitigate some of these concerns.

Here, we use collated records of rhino poaching incidents on private land between 2003 and 2017, to identify any patterns in the selection of black and white rhinos, and in the selection of age or sex categories of rhinos for poaching. In particular, we test our hypotheses that poachers would target the more heavily horned white rhinos and show a preference for the heavier horns of males over females and adults over the other age classes. We also investigate whether there are times when poaching is more likely on private land. To assess temporal changes in poacher behaviour, we investigate these trends between years. This is the first formal study to investigate poaching patterns on private land in South Africa. Moreover, whereas previous work on state-owned land has been place-specific, this study considers poaching across the whole country.

2 | METHODS

2.1 | Database

Data on poaching incidents were obtained directly from 23 private rhino owners and from mainstream and social media reports of poaching incidents on private property. Private owners were asked to provide details of all previous poaching events on their properties, which provided the earliest event in the final dataset (2003) and comprised a total of 48 rhinos poached. For security reasons, the mainstream and social media (Facebook) sources utilised have not been disclosed. To ensure the sample was as representative as possible, social media groups and pages covering rhino poaching at both national (nine sources) and provincial (10 sources covering all provinces except Free State, Northern Cape and Western Cape) levels were utilised, alongside national newspaper websites. Social media sources represented a range of interest groups, from private rhino owners and anti-poaching groups to citizen engagement groups and veterinary organisations involved in the care of rhino orphans. Incidents reported by group members, but not corroborated by further (social) media reports, or by the group/page administrators, were discarded, as were reports where it was unclear if the incident happened on private land. Where multiple reports were suspected to be of the same incident, efforts were made to match details to avoid replication of data. After matching details against media reports to eliminate any repeats, the owner reports were combined with the media reports to produce a dataset of poaching events between 2003 and 2017, totalling 473, covering 127 properties, across all provinces. All events reported as poaching events were recorded, regardless of whether the animal survived and whether the horns were removed. To assess the potential future impacts of current poaching on rhino populations, data on collateral deaths of calves who died after their mothers were poached and pregnancies which were terminated due to the death of the mother were also recorded. The method of poaching was also noted, as was whether the animals had previously been dehorned by their owners or not. As many of the reports did not contain all the required information, the sample size, n, is given for each test.

2.2 | Provincial differences

We collated the locations of poaching events only to test for any differences in the incident or individual data between provinces, which would preclude combining the data for further analysis. We conducted two-way chi-squared analyses to test whether patterns of poaching across months, days and moon phase were consistent across provinces. Further two-way chi-squared analyses identified relationships in the selection of individuals for poaching based on species, sex and age category across provinces.

2.3 | Incident data

To assess temporal patterns in poaching events, for each incident, where possible, the date, time of day and moon phase were recorded. Moon phase was determined by using a moon phase calendar based on the date of the incident. If more than one animal was poached, the incident was only recorded once to avoid pseudo-replication of results. This resulted in 248 separate incidents for which at least some of the data were available. We used chi-squared analysis to determine whether there were any patterns in the timing of poaching incidents. For these analyses, we grouped years together where sample sizes were too small to allow for comparisons across time based on individual years. Limited reports also included the method of poaching and where on a property a rhino was poached, which permitted some descriptive analysis of this data.

2.4 | Categories of poached rhinos

To investigate any evidence for selection of specific individuals, the species, age and sex of the poached animals were also recorded. All individuals targeted by poachers were included in this data set, including those where multiple individuals were poached in one incident, giving a total of 300. Whilst some reports identified poached animals as adult, calf etc., others gave the age of the individual. Thompson et al. (2016) provided a detailed breakdown of the age classes of white rhinos, whilst Walpole et al. (2001), defined black rhino calves as those under 3 years old, sub-adults as those aged four to seven, and adults as all those over 7 years of age. Due to the crossover in age categories for both black and white rhinos, the exact age of individuals often not being reported, and the fact that individuals may reach sexual maturity earlier or later than others, we utilised the broader definitions used by Walpole et al. (2001) in this study. When a pregnant female or one with a calf was poached, that female was assumed to be an adult. The ratios for sex (1.52 F:M) and age (18.63% calves, 29.65% sub-adults and 51.72% adults) from Balfour et al. (2015) were used for both species. We used a population ratio of 90.68% white rhino and 9.32% black rhino based on Emslie et al. (2016) and Knight (2017). Using these factors, we categorised rhinos as male/female, black/white and adult/sub-adult/calf.

As the rhino population is biased towards white rhinos, females and adults, for those reports which were complete ($n = 81$), the proportion of expected rhinos was calculated by dividing the total counts by what would be expected from the composition of the population (using the proportions above) if poached rhinos were selected at random. These proportional values were used in a linear regression model to identify any effect of species, age or sex in the number of rhinos poached. To confirm the findings of this linear regression for the full dataset, we utilised the above population ratios in chi-squared analyses to identify whether specific categories were more likely to be targeted by poachers than would be expected due to chance (Li et al., 2003).

3 | RESULTS

3.1 | Provincial differences

Due to small expected values, all incident analyses between provinces required the combining of KwaZulu-Natal, Mpumalanga, Free State and Gauteng, and also the three Cape Provinces (Northern, Eastern and Western). Poaching across the country was not related to the day of the week (Two-way $\chi^2_{(27,n\,=\,187)} = 29.94$, $p = 0.32$), weekday against weekend (Two-way $\chi^2_{(7,n\,=\,187)} = 0.73$, $p = 1$) or the four major phases of the moon (Two-way $\chi^2_{(15,n\,=\,187)} = 13.76$, $p = 0.54$). There was no significant difference in poaching levels between different months of the year (Two-way $\chi^2_{(23,n\,=\,218)} = 30.10$, $p = 0.15$; months combined into pairs—January/February, March/April etc. due to low sample sizes).

For individual rhino analyses, Mpumalanga was not analysed, as none of the reports from that province contained information on the individuals poached. To test our hypothesis relating to the selection of males over females across provinces, data from Free State, Gauteng, Northern Cape and Western Cape had to be combined due to small sample sizes. This analysis indicated no relationship between selection for sex and province ($\chi^2_{(9,n\,=\,209)} = 3.74$, $p = 0.93$). Black rhino numbers were too small ($n = 16$) for analysis between provinces, but white rhino figures (with Western Cape and Free State combined due to small sample sizes) showed no relationship with province ($\chi^2_{(6,n\,=\,186)} = 0.60$, $p = 1$). To assess any differences between provinces in terms of selection of different age categories, only data from Limpopo, KwaZulu-Natal and Eastern Cape were sufficient for analysis, and gave no indication of differences ($\chi^2_{(8,n\,=\,97)} = 2.61$, $p = 0.96$).

As these analyses indicated no differences in patterns of poaching between the provinces analysed, all data were combined for further analysis.

3.2 | Incident data

The day of the week had no significant effect on poaching overall ($\chi^2_{(6,n\,=\,195)} = 2.02$, $p = 0.92$), or when data were broken down into year groups (2008–2011, 2012–2013, 2014–2015, 2015–2016 and 2017). There was also no significant difference between levels of poaching at weekends (Friday–Sunday) and on weekdays (Monday–Thursday) ($\chi^2_{(1,n\,=\,195)} = 1.84$, $p = 0.12$) across the whole dataset. When we compared poaching activity between week days and weekends across the year groups, we also found no significant differences for any year (2008–2010 were combined due to limited data) except for 2017, when there was a higher level of poaching at the weekend ($\chi^2_{(1,n\,=\,45)} = 5.06$, $p = 0.02$).

An analysis of the impact of moonlight on poaching was conducted by dividing the data into quarter phases (0%–25% full, 26%–50%, 51%–75% and 76%+). There was a significant difference in poaching between moon phases ($\chi^2_{(3,n\,=\,195)} = 36.24$, $p < 0.001$). Partial chi-squared values indicated that poaching was significantly higher than expected when the moon is over three quarters full and significantly lower than expected at 26%–50% full. A higher frequency of poaching when the moon is 76%–100% full was found across most time periods (2008–2011, 2012–2014 and 2017; Table 1), although no differences in poaching due to moon phase were found in 2015 or 2016.

TABLE 1 Chi-squared analyses of rhino poaching events due to moon phases

	All moon phases ($df = 3$)			76%–100% removed ($df = 2$)		
Year	χ^2	*n*	*p*-value	χ^2	*n*	*p*-value
2008–2011	15.59	35	0.014*	4.45	17	0.11
2012–2014	8.36	53	0.039*	4.55	33	0.10
2017	10.69	45	0.013*	2.18	25	0.34

*Significant values are indicated.

There were significant differences in poaching events across the months of the year ($\chi^2_{(11,n\,=\,228)} = 19.75$, $p = 0.05$), but this showed no seasonal pattern. There were also no significant differences in poaching across the months of the different year groups: 2006–2012 ($\chi^2_{(11,n\,=\,69)} = 16.74$, $p = 0.12$), 2013–2015 ($\chi^2_{(11,n\,=\,71)} = 13$, $p = 0.29$) and 2016–2017 ($\chi^2_{(11,n\,=\,88)} = 16.01$, $p = 0.14$). Overall, higher levels of poaching occurred in January, March, August and October, with lower poaching levels in May, June, July, September and December (Figure 1).

Whilst the exact time of some poaching incidents was reported, many reports simply stated 'early morning' or 'day'. Far more poaching events ($n = 51$) occurred at night (52.9%), rather than at dawn or dusk (33.3%) or during the day (13.7%). The small data set precluded temporal analysis of this data.

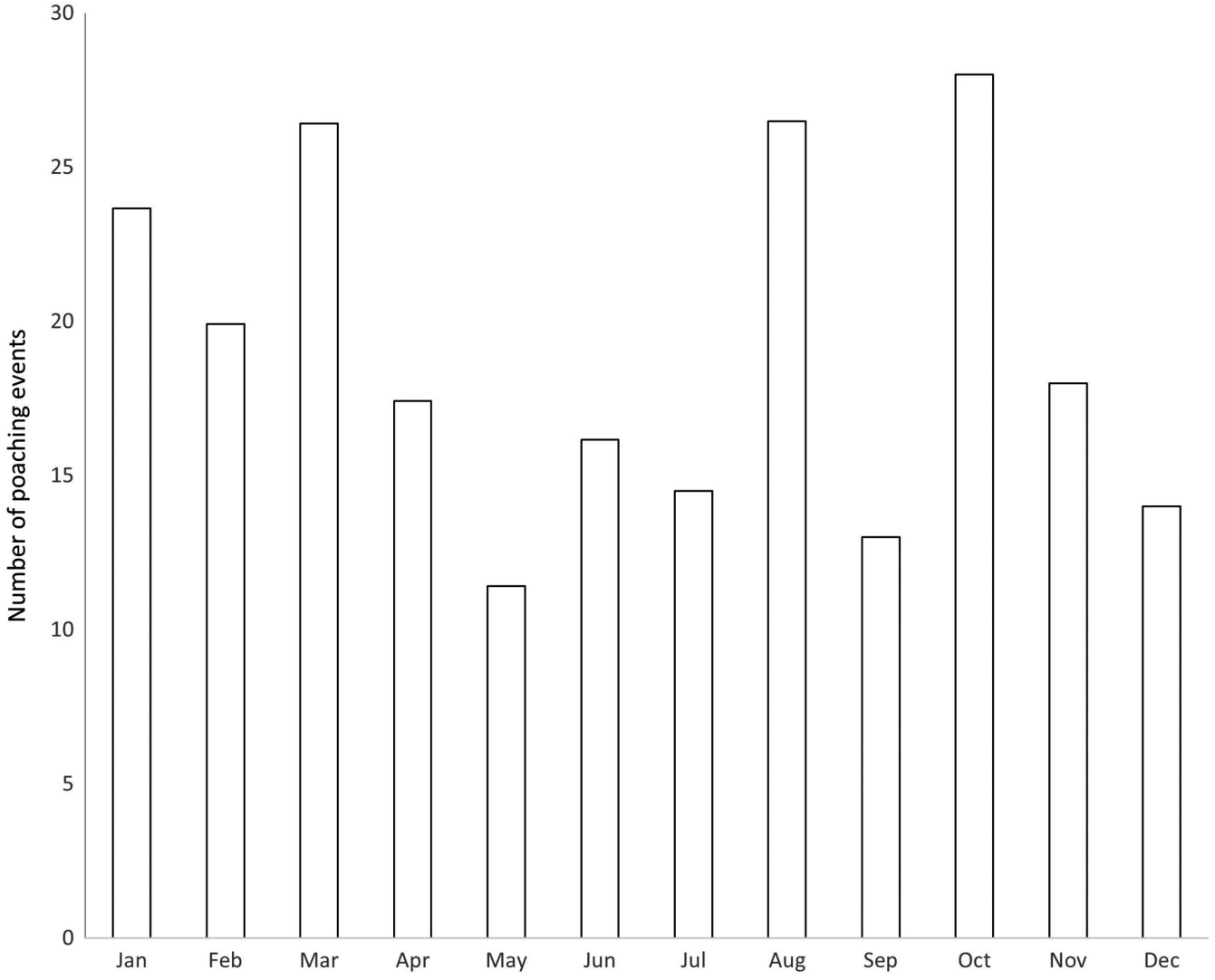

FIGURE 1 Total rhino poaching events by month (2006–2017)

For poaching events where detailed location data were available (n = 57), 29.8% occurred on the perimeter, 35.1% within 3 km of perimeter, 22.8% in the core, 8.8% in breeding kamps and 3.5% in bomas. Animals poached near the perimeter were mostly poached alongside roads (70.8%), 8.3% alongside roads and settlements and 20.8% alongside other wildlife habitats (n = 24). Where the poaching method was provided (n = 258), most of the animals were shot (89.2%), 16.7% were darted, four were poisoned and one was caught in a snare. Whilst the poisoning and snaring incidents were one-off occasions (the poisoning was in 2012 in the Eastern Cape and the snaring was in 2011 in Limpopo) and guns were used consistently through time and across all provinces, darting of rhinos was predominantly based in the Eastern Cape. Darting events did occur in other provinces, but never in more than 1 year.

3.3 | Categories of poached rhinos

We found no linear relationship between the number of animals poached and their proportion in the population in terms of sex, age or species (F = 1.31, df = 1,10, p = 0.34). There was no evidence to suggest that the heavier-horned males were targeted by poachers over females ($\chi^2_{(1,n\ =\ 217)} = 0.50$, $p = 0.48$), or that larger-horned white rhinos were selected over black rhinos ($\chi^2_{(1,n\ =\ 210)} = 0.018$, $p = 0.89$). These findings were consistent across all years. We also found no indication of selection by poachers in relation to the age of rhino (calf, sub-adult or adult) ($\chi^2_{(2,n\ =\ 158)} = 5.86$, $p = 0.053$), although this was approaching significance. There was no selection due to age in any year.

Alongside those incidents recorded as poaching events, a further seven calves were recorded as subsequently dying following the loss of their mother and 29 pregnancies were lost.

4 | DISCUSSION

We were unable to find an official definition of 'poaching' from the Department of Environmental Affairs, yet Austin (2019) notes that animals which are wounded and subsequently die are not included in the official poaching statistics. Previous informal discussions with private rhino owners and social media statements issued by some NGOs (Saving the Survivors, 2015) highlight a further belief that animals which are not dehorned by poachers are also not recorded in the official figures. One report included that the cause of death was septicaemia and was therefore not officially a poaching death. As it was not possible to determine which events were recorded as official poaching events, all were included in the data set. For 2017, the dataset represents 41.07% of all the rhino poaching events on private land (Rhino Alive, 2018). We do not suggest that this dataset fully represents all poaching on private land in South Africa, but rather it broadly represents a general picture of poaching events. The absence of data from poaching events in Mpumalanga prevents a categorical conclusion that there were no differences in private land poaching trends across the whole country, but as we found no evidence of differences in patterns of poaching activity between the provinces investigated, we suggest the following general findings can be applied across those provinces.

4.1 | Incident data

We found some evidence of a greater level of poaching towards the end of the week and at the weekend, as had been suggested during informal discussions with private rhino owners, but this difference was only statistically significant for 2017. Further analysis of data from 2018 and beyond may indicate if this pattern is continuing.

As was expected, we found a link between moon phase and rhino poaching on private land, due to the increased visibility afforded by a fuller moon improving the poachers' chances of success. Whilst Gwin (2012) suggested that a half moon is preferred by poachers, other authors' findings concurred with ours (Martin, 1996b; Milliken & Shaw, 2012; Mulero-Pázmány et al., 2014). However, this pattern was not consistent across all years. We found no evidence of poachers focussing their efforts during full moon periods in 2015 or 2016, indicating that there may have been a change in poacher behaviour during this time. Our finding that poaching was not lower than expected when the moon was 0%–25% full runs contrary to the general pattern, but it may be that some poachers opt to operate under the cover of almost complete darkness.

There were differences in the number of poaching events in different months of the year, but no consistent patterns. Studies on poaching of other species (Haines et al., 2012) have found seasonal differences in poaching events, as has other research focused on rhino poaching, both in Africa (Koen et al., 2017; Mulero-Pázmány et al., 2014) and in Asia (Martin, 1992). The general reported trend is an increase in rhino poaching towards the end of the year (DEA, 2016; Milliken & Shaw, 2012). However, the Rhino Alive (2018) data indicate that, in 2017, total poaching peaks (state and private land combined) occurred in January, March, May, June, July and September and poaching on private land peaked in January and October. The poaching peaks in January, March and October apparent in the Rhino Alive data were reflected in the dataset analysed here. The Rhino Alive data also suggest poaching on private land was lowest in July, November and December, which was reflected in our findings of poaching lows in July and December. It is clear that poaching on private land is inconsistent across the year, and there is no strong evidence from this study to suggest it is any more likely to occur during specific months than others.

The finding that most rhinos were poached at night was also expected. Whilst Koen et al. (2017) suggest that twilight is thought to be preferred by poachers and Martin (1996b) found Asian rhino poachers were more likely to poach in the early morning or late afternoon, anecdotal evidence suggested that night would be preferred by rhino poachers. Around a third of poaching events in this

study did occur at dawn or dusk, supporting the suggestion that these times would also be important for poaching.

Finally, it was anticipated that more rhinos would be poached with guns than by other methods, with prior research on rhino poaching in South Africa (Milliken & Shaw, 2012; Mulero-Pázmány et al., 2014) identifying that poaching by means other than shooting the animal is uncommon. Our findings indicate that darting of rhinos on private land is primarily confined to the Eastern Cape and is rare elsewhere, suggesting that there may be differences in the method of poaching utilised by poachers in different provinces. Further information would be required to confirm this.

The higher frequency of poaching events recorded at the perimeters of properties is also consistent with results from other studies, although this sample size was limited. Wato et al. (2006), Metzger et al. (2007) and Watson et al. (2013) all found links with poaching and proximity to the perimeter of protected areas, with Wato et al. (2006) recommending a 10 km buffer zone along boundaries to reduce poaching risk. However, this would not be feasible for most of the private properties in our study due to their relatively small size (mean area of properties for which owner reports were provided was 13,637 ha). Conducting poaching close to the perimeter would reduce the length of time a poacher needs to remain on a property and the presence of a nearby road would aid access (Martin & Vigne, 2003; Mulero-Pázmány et al., 2014). However, the low level of poaching in our study when perimeters of reserves were alongside roads with settlements suggests that poachers attach greater importance to the risk of being seen entering or leaving a property.

4.2 | Categories of poached rhinos

We found no indication that specific categories of rhinos are targeted preferentially by poachers on private land. Whilst Knight et al. (2015) suggest that white rhinos make up 95% of poached rhinos (greater than their population contribution), and Milliken and Shaw (2012) suggest they are over-represented in the poaching statistics, we found no evidence to support that. Contrary to our initial hypothesis, the heavier horn of white rhino (Martin & Vigne, 2003) appeared to be irrelevant to poachers when selecting a target. There also appeared to be no indication of selection of heavier-horned (Pienaar et al., 1991) males over females, also contrary to our initial hypothesis. This apparent lack of selection towards larger-horned targets is in accordance with the assertion by Lee and Roberts (2016) that rational poachers do not poach selectively. Poachers are opportunistic, poaching animals they encounter, rather than directly targeting individuals (Milner-Gulland & Leader-Williams, 1992).

Our finding that calves were poached in proportion to their abundance in the population was unexpected. The South African Department of Environmental Affairs (DEA) (2015) states that poachers target adults and leave the calves, but the data analysed here suggest that calves are targeted as any other rhino. Many of the poaching reports noted that dependent calves were rescued, indicating that not all poachers will target them. The large number of pregnancies lost, combined with orphaned calves which subsequently died and the lost reproductive potential from poached females suggest that the future impacts of current rhino poaching levels on private land may not be fully represented by considering only poaching deaths. Given that birth and death rates of white rhinos are associated with both density and rainfall (Ferreira et al., 2015) management of rhino populations in light of poaching must also consider wider demographic factors, especially this potential loss of future reproduction.

4.3 | Dehorning

At least five of the poached rhinos in our study had been recently dehorned. As discussed above, the presence of a large-horned individual may encourage poachers onto a property and so dehorning may seem prudent. However, the results presented here indicate that individuals are not directly targeted, and so selective dehorning of individuals may not be effective as a preventative measure against poaching. Several others were poached after permit applications to dehorn them had been made (as noted in some media reports). Damania and Hatch (2005) suggest that salaried staff members, where income is not dependent upon performance, have no incentives not to accept bribes from poachers and it may be the case that this relates not only to reserve workers, but also potentially to those involved in production of dehorning permits. Poachers are known to take dehorned animals (Berger et al., 1993), but the suggestion that there may be an aspect of corruption in the process of securing permits to dehorn, leading to properties due to dehorn being specifically targeted, has, as far as we are aware, not been thoroughly researched. This potential is, however, beyond the scope of this study.

5 | CONCLUSIONS AND RECOMMENDATIONS

Rhino poachers do not appear to show strong weekly or monthly patterns in their poaching activities on private land but are more likely to poach at night and particularly during a full moon. There is a suggestion that these poachers may be more likely to poach during the weekend (Friday-Sunday), but since this temporal pattern was only found for 2017, we recommend further research to identify whether this pattern has continued in recent years. Animals are potentially more vulnerable to poaching when they are in close proximity to the perimeter of a property, particularly if a road adjoins the property at that point. Although the effectiveness of poaching prevention actions is debatable, their effectiveness is likely to be maximised when they are targeted during the hours between dusk and dawn, especially on nights when the moon is full and between Friday and Sunday.

Our results suggest that poachers do not appear to target specific categories of rhinos. Whilst we acknowledge that the presence of large-horned individuals may entice poachers to enter a property, there is no evidence to suggest that any individuals should be considered more at risk than others. We suggest that the collateral deaths of calves orphaned by poaching and those lost in utero be clearly identified within the official poaching statistics to ascertain a full understanding of the potential future impact of poaching on rhino populations.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Laura A. Chapman https://orcid.org/0000-0001-7297-8006

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