The robustness of self-report data on predation: A comparison of two Karoo surveys

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Abstract

This paper compares estimates of losses to predators from two questionnaire surveys of sheep farmers in the Central Karoo. The first questionnaire, in 2008, was administered as a cross-section telephonic survey. The second was a panel study involving face-to-face interviews, conducted from 2012 to 2014. We compared the two estimates to see if there was any evidence that farmers may have overestimated reported losses to predators in 2008, as this was at the height of the conflict over predator management policy in the Western Cape. This first estimate valued predation at R1.39 billion (US$ 100 million) per year, 30% of industry turnover. While a refined estimate is presented for the Karoo, the main contribution is not 'a' number, but rather an analysis of how predation rates differ depending on how they are calculated. We show that, when the same methodology is applied to both datasets, the figures for the Central Karoo converge on 5% (4.85% in 2008 and 4.7% in the period 2012 to 2014). This suggests that farmers were providing consistent estimates, irrespective of interview method or the timing of the survey. In this work, an important decision in estimating predation rates is whether to assign all, some or no perinatal losses to predation, because lamb remains are usually not recovered in a good enough condition to be sure of cause of death, and because predators probably target lambs that would have died anyway. For longitudinal monitoring, it is important to standardise calculations and it would be good for industry to encourage the adoption of ultrasound scanning to confirm conception.

Key words: human-wildlife conflict; questionnaire surveys; panel data; self-reports

1. Introduction

Carnivore management can be political and adversarial (Wilson 1997; Treves & Karanth 2003; Treves *et al*. 2006; Nattrass & Conradie 2015; Skogen 2015), hence farmers might have an incentive to overestimate losses to predation, depending on the context and on who is asking about losses. This paper considers two estimates of predation rates in the South African Karoo, where there has been considerable debate over how best to manage predation by jackals and caracals. The first estimate, made in 2008 when the conflict was at its height, produced the often-quoted estimate of R1.39 billion (US $100 million) per year (Van Niekerk 2010), a figure equal to the small-stock industry's annual meat production (Abstract 2016). The other estimate is based on a three-wave panel study that ran from 2012 to 2014 in the Central Karoo. The two estimates converge on the same predation rate, implying that interview method and timing did not play a role in shaping the estimates provided by the farmers. Rather, the apparently different predation rates were a function of different ways of estimating predation rates on the part of the researchers.

Like many human-wildlife conflicts, the Karoo predator conflict grew out of the waning political importance of the wool industry and the rise of environmentalism in South Africa (Nattrass & Conradie 2015; Nattrass *et al*. 2017a). Having devoted a great deal of support to sheep farmers in the form of fence subsidies, the provision of poison at cost to farmers and assistance to hunting clubs, by the mid-1980s the South African state had largely withdrawn from these activities. The Cape Nature Conservation Department closed its problem animal unit in 1987 (its hound-breeding and training facility in 1989) and withdrew funding for hunting clubs (between 1988 and 1993).

Within two years, farmers in the Karoo started reporting problems with jackals and, by 1999, they were regarded as a serious problem on the plains of the Central Karoo. As livestock losses rose, a new generation of farmers scrambled for old-fashioned solutions that were unpalatable to environmental activists and wildlife managers. To intervene, CapeNature, the Cape Nature Conservation Department in a new guise, held a conference entitled 'Resolving human-wildlife conflict: Prevention is cure', which aimed to promote 'holistic livestock management' (2006). When an endangered Cape leopard was then caught in a gin trap allegedly set for jackal in the Kammanassie (2007), CapeNature entered into collaboration with the Landmark Foundation, an NGO involved in leopard conservation, to ban gin traps in the Western Cape and to promote non-lethal forms of dealing with predation (Nattrass & Conradie 2015). In 2008, CapeNature announced that, with effect from January 2009, a range of lethal methods would no longer be allowed. Farmers and their industry representatives objected vociferously, and CapeNature eventually relented in 2009, allowing farmers to obtain permits to shoot up to five caracals and jackals a night (Nattrass & Conradie 2015).

It is against this background that the question about the reliability of self-reported predation rates is asked. Section 2 describes the two sources and reviews the calculation. Section 3 revisits the 2008 data to extract a figure for the Karoo and contrasts this with the estimate provided by the researchers. Section 4 concludes with some reflections on how best to standardise estimates of predation rates.

2. Data and methods

The Karoo is South Africa's arid north-western interior, bordered in the south and west by the Cape Fold Mountains and in the north and east by major rivers (Orange and Great Fish). It fell within the Cape Province until 1994, when it became three new provinces. At the same time, its 29 magisterial districts were amalgamated into just four, the Central Karoo, Cacadu, Pixley ka Seme and Namakwa Districts (Figure 1), whose losses are considered in this study.

The 2008 survey drew a sample of 1 500 farms from the five provinces that account for 80% of sheep and goat farming in South Africa. The 3.34 million sheep and goats on which it reported represent 12% of the small stock inventory for February 2006 (Abstract 2016). This national sample was stratified by province and district according to livestock numbers reported in the farm census (Statistics South Africa 2006). The provincial strata are described in Van Niekerk (2010) and are correct, but there is no detail on the district-level subsamples. If these were correctly stratified too, the Central Karoo subsample ought to include 90 000 sheep and goats on approximately 37 farms, while the subsamples for the three surrounding Karoo district should have a total of 850 000 head of livestock on 343 farms (Table 1).

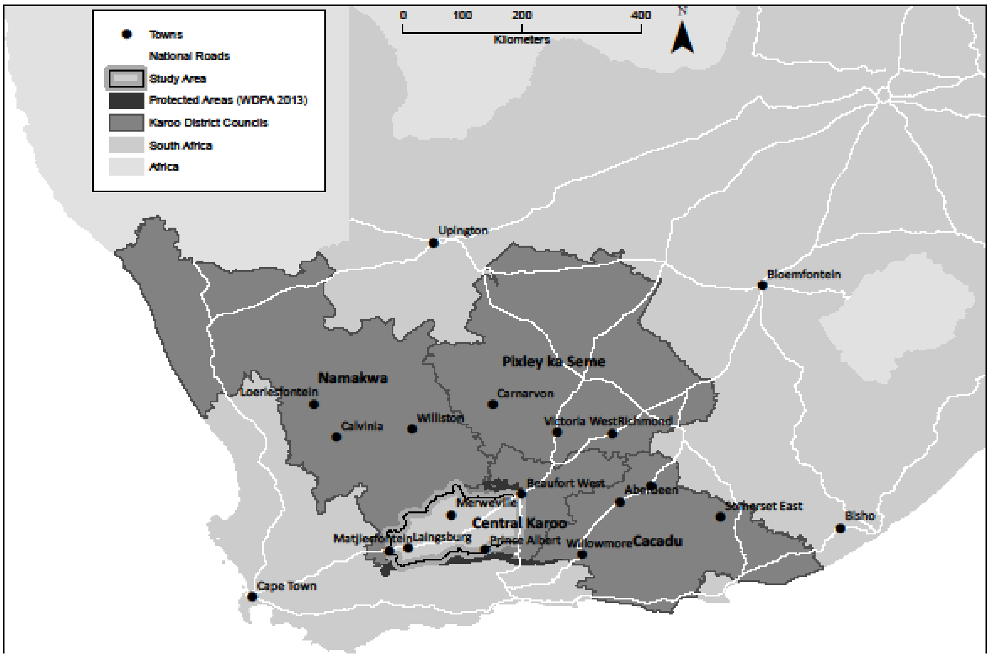

Figure 1: The Central Karoo district and panel survey in their broader context

Table 1: The Karoo portion of the national sample

	Central Karoo	Cacadu	Pixley ka Seme	Namakwa
District as percentage of its province	19.2%	26.9%	36.9%	21.7%
Farms in provincial sample	192	350	426	426
Estimated farms in district stratum	37	94	157	92
Livestock in provincial sample	468 453	794 028	1 085 714	1 085 714
Estimated livestock in district stratum	89 943	213 594	400 628	235 600

Contact details for the original survey were obtained from a wool buyer and the Red Meat Producers' Association. Its response rate of 94.9% was very high for a telephonic survey, but attributable to a combination of industry endorsement and the researcher's identity, which is that of an Afrikaans-speaking male attached to an agriculturally orientated Afrikaans university. While the survey instrument was not made available, the analysis indicates that the standard inventory variables were collected (Andelt 1992). Livestock losses were recorded by age group (0 to 1 month, 1 to 6 months and adult), cause of death (black-backed jackals, caracals, dogs, theft and "other"), and per year for the 2006 and 2007 seasons, probably in some cases as a percentage instead of as raw numbers. Sheep and goats lost were pooled and one additive predation rate was calculated, which was then applied separately to sheep and goat inventories to scale losses from the sample to the province. The only variable reported at the district level was the percentage of jackal and caracal kills in each year.

2.1 Central Karoo panel study

The Central Karoo panel study forms part of the Karoo Predator Project, an ongoing investigation of the behavioural ecology of black-backed jackals (*Canis mesomelas*) and caracals (*Caracal caracal*) on farmland and protected areas in the Central Karoo. The farmland site for the ecology work, an area of about 80 000 hectares, lies on the western bank of the Dwyka River, mostly north of the N1 road, and in the middle of the Central Karoo Municipality. An important aspect of the work was to capture, collar and release damage-causing predators. This ecology project was embedded in a district-wide management survey, which ran as a panel study (where the same farmers were interviewed across time) from November 2012 onwards. Wave 2, on the 2013 season, ran in September 2014 and Wave 3, on the 2014 season, was taken a year later (Table 2).

Table 2: Sample size, representativeness and attrition in the Central Karoo Panel Study

			Useable responses		
Description	**Study area**	**Sample**	**2012**	**2013**	**2014**
Farms (Stats SA 2006)	193	98 51%	71 37%	67 35%	62 32%
Stock sheep (Stats SA 2011)	161 429		69 908 43%	70 775 44%	71 308 44%
Land (ha)	1 619 404		774 783 48%	707 966 44%	681 022 42%
Response rate (completed / sample)			72%	69%	63%
Attrition (attritors / sample)				4%	5%
Cumulative attrition				4%	9%

A snowball sampling method seemed most appropriate, given the objectives of the management survey. As new farmers were recruited they were asked to provide data for the key management variables from the 2012 season onwards. Wave 1 approached 66 farmers, of whom 18% were not re-interviewed in Wave 2 due to refusals to release financial data and/or inadequate farm records. Seven farmers were added in Wave 2, and 24 more in Wave 3: only eleven of these were willing to give three sets of financial data. The expansion in Wave 3 was needed because the collared carnivores had dispersed over bigger areas than anticipated. The 72% response rate in Wave 1 fell to 69% in Wave 2 and to 63% in Wave 3, to give an unbalanced panel of 234 observations.

There are some 193 farms (Statistics South Africa 2006) and 161 429 stock sheep (Statistics South Africa 2011) in the enlarged study area, which means that the panel sample represents 51% of farms in the area. Despite 9% cumulative attrition, Wave 3 still has data on 32% of the farms, 42% of the farmland and 44% of the stock sheep in the study area. The panel study has a similar number of livestock as the Central Karoo subsample in the national survey, but twice the number of farming operations.

The survey instrument was a semi-structured questionnaire that collected demographic data, details of the production system, attitudes to wildlife, predator management and farm financial records. The questionnaire was administered in face-to-face interviews in the homes and home language of the respondents. In this case the interviewer was associated with an English university that does not have the same pro-agriculture reputation as the institution that conducted the baseline survey, although the identity of the interviewer in the follow-up study is that of agricultural insider too.

The livestock module of the panel survey recorded the number of ewes and wethers by breed as well as the number of lambs tagged at six weeks old, and what happened to each of them (retained as replacement breeding stock or wethers, sold, or died). Raw numbers extracted from written records were insisted on where possible. Despite the precautions, not all the variables are of equal quality. Stock sheep numbers are solid and the number of lambs tagged and sold are judged to be reasonably accurate. The difference between lambs tagged and sold are losses of various kinds, primarily predation, although some predation is assumed rather than confirmed. Large events, such as theft or death, were reported separately from predation, whereas the same type of loss on a smaller scale was usually indistinguishable from predation.

While some farmers claimed that they could differentiate between the signs of jackal and caracal predation, the survey found nobody that kept records in this way, since remains are rarely found in a good enough state to allow cause of death be determined (Windberg *et al*. 1997; Stoddart *et al*. 2001). Live births cannot be recorded either, because in the Karoo lambs are born in paddocks of a thousand hectares or more each and are only counted when they are tagged and tail-docked at around six weeks. While it is possible to estimate the number of live births from conception records established with ultrasound scanning, this technique is not widely used. Since it is not always possible to tell the difference between hunting and scavenging (Greentree *et al*. 2000; Nattrass *et al*. 2017b), it was considered more prudent not to claim any perinatal predation.

2.2 Calculating predation rates and the cost of predation

The US Fish and Wildlife Service and Department of Agriculture periodically publish estimates of the impact of predation on the livestock industry (e.g. US Fish and Wildlife Service 1978; National Agricultural Statistical Service 1995). In each case, a sample predation rate is applied to national inventory data to estimate total losses, which are then valued at a reference market price to compute the financial impact of predation on the industry (Connolly 1992). Since predation disproportionately affects lambs, it is common practice in agriculture to report separate predation rates for stock sheep and lambs (Pearson 1986; Knowlton *et al*. 1999). For this, the number of lambs lost is expressed as a percentage of the lamb inventory, and the number of stock sheep lost as a percentage of the adult inventory. The alternative is a weighted average predation rate, in which total losses are given as a percentage of inventory of all ages (Graham *et al*. 2005). Pearson (1986) averaged the predation rates across 136 studies conducted between 1939 and 1985 to arrive at a representative predation rate, which was then scaled up in the usual way. When comparing this cost estimate with comparable later figures, Connolly (1992) concluded that the estimates were a function of price and inventory assumptions and of the geographic and ecological scope of each study, but that the treatment of perinatal losses made the biggest difference.

The 2008 survey took the American approach. In South Africa, stock inventories are not available by age group and therefore local analyses must make do with "additive" predation rates in which a given type of loss is expressed as a percentage of a combined inventory of all ages. While adequate in like-for-like comparisons, this procedure will underestimate lamb predation rates if lamb losses are divided by the total number of sheep rather than by the lamb inventory. Although the data exist in the 2008 survey to report perinatal predation and the predation of docked lambs separately, the original analysis published only an inclusive lamb predation percentage. The original calculations are reproduced faithfully below with and without perinatal losses for the three Karoo provinces.

The process of extracting district-level predation rates for the Karoo from the provincial totals involved several steps. Each calculation began with an estimate of provincial losses and was allocated across districts according to shares published with the original survey. District predation rates expressed the estimated number of losses per district by the 2002 district inventory. The panel survey was analysed in aggregate across the three waves. A pure lamb predation and tagging rate are also presented.

The original survey valued losses at R600 each, and Wave 1 of the panel study valued losses at R1 000 each. Since these two prices were close in real terms, the average real price in constant 2015 currency of R1 128 per slaughter lamb was used as the reference price for costing.

3. Results

3.1 The original provincial predation percentages revisited and refined

Table 3 reproduces the original predation percentages for the Western, Eastern and Northern Cape Provinces to reveal a troubling assumption in the 2008 study. Losses are reported by predator species and livestock age for two seasons. As explained above, dividing a given class of losses by the livestock inventory of all ages produces a set of additive predation percentages that can summed for an overall predation rate. The original contains one set of inventory data and two sets of loss data, and the reported rates vary from 5.95% for the Western Cape to 14.70% for the Northern Cape.

While it is correct to sum across predator species, summing across the two years also amounts to double counting. For example, in the original analysis it is reported that 2 780 docked lambs were caught by predators in the Western Cape sample in 2006. The figure for 2007 was 2 483, while the corresponding numbers caught by caracals were 4 349 in 2006 and 4 911 in 2007. This gave a total loss of 14 523 docked lambs, which, when divided by the sample inventory of 468 453, produced a predation percentage of 3.10% per year for docked lambs. The correct number is 1.55%, which is 7 261.5 divided by 468 453. Repeating the same calculation on data for the two other elements of predation resulted in the perinatal and adult predation in the Western Cape province being set at 2.73% and 0.10% respectively, which gave an overall predation rate of 5.95% for the province. Comparing the provinces reveals that the double counting was a consistent approach, rather than a once-off error, and therefore it was corrected by dividing by two in all cases, which lowered the Western Cape aggregate rate to 2.98% per year. This estimate was low compared to the refined 5.85% computed for the Eastern Cape. The refined figure for the Northern Cape was higher still, at 7.35% per year.

3.2 A predation rate and the cost of predation for the Karoo based on the original survey

Table 4 lays out the somewhat complex calculation for computing district-level predation. It was done to explore the effect of differences in meso-climate, terrain and land use on predation rates. The background data in the top half of the table is applied in two scenarios at the bottom. Scenario 1 includes perinatal losses in the predation estimate, while scenario 2 omits them. Both scenarios depart from the refined (net of double counting) estimates in Table 3. In scenario 1 a predation rate of 2.98%, multiplied by the Western Cape's inventory of 2 582 326 livestock of all ages, predicted a total loss for the province of 76 953 head of livestock. Since it was reported that the Central Karoo District accounts for 57.9% of livestock caught in the province, the district was assumed to have suffered a loss of 44 556 animals, including many new-born lambs. Expressed as a proportion of the district's inventory of 496 948 sheep of all ages, it produces a local predation percentage of 8.97% per year. Excluding perinatal losses in scenario 2 lowered the provincial rate to 1.61%, which resulted in a lower district rate of 4.85% and an associated district-level loss of 24 100 stock sheep and docked lambs.

Table 3: Aggregate predation rates for selected provinces reproduced from the earlier survey

	Western Cape			Eastern Cape			Northern Cape		
	2006	**2007**	**Aggregate**	**2006**	**2007**	**Aggregate**	**2006**	**2007**	**Aggregate**
Sample inventory			468 453			794 028			1 085 714
Stock sheep lost to jackals	123	85		1 199	982		179	80	
Stock sheep lost to caracals	135	124		747	697		177	51	
Stock sheep lost to predators	258	209	467	1 946	1 679	3 625	356	131	487
			0.10%			0.46%			0.04%
Docked lambs lost to jackals	2 780	2 483		13 694	13 188		22 611	19 549	
Docked lambs lost to caracals	4 349	4 911		9 705	8 956		14 513	3 525	
Docked lambs lost to predators	7 129	7 394	14 523	23 399	22 144	45 543	37 124	23 074	60 198
			3.10%			5.74%			5.54%
New born lambs lost to jackals	5 313	5 707		13 352	13 078		25 112	25 008	
New born lambs to caracals	823	965		6 473	6 486		8 530	6 767	
New born lambs to predators	6 136	6 672	12 808	19 825	19 564	39 389	33 642	31 775	99 059
			2.73%			4.96%			9.12%
Combined predation rate - original			5.95%			11.16%			14.70%
Combined predation rate - refined†			2.98%			5.85%			7.35%

† Including perinatal deaths assigned to predators but averaged across the years

Table 4: District-level and Karoo-wide predation based on the earlier survey

	Central Karoo	Cacadu	Pixley ka Seme	Namakwa	All Karoo
District's share of provincial predation †					
Jackals' share of provincial losses	59.6%	62.0%	68.4%	68.4%	
District's share of jackal losses	69.0%	38.5%	56.9%	16.0%	
Caracals' share of provincial losses	40.4%	36.8%	31.6%	31.6%	
District's share of caracal losses	39.0%	36.0%	49.3%	19.4%	
District's share of provincial predation	57.9%	37.2%	42.2%	17.0%	
Provincial inventory	2 582 326	5 634 208	6 898 565	6 898 565	
District inventory	496 948	1 517 912	2 543 752	1 498 687	6 057 299
Cost of predation when perinatal losses are counted as predation					
Provincial predation rates (all ages)	2.98%	5.85%	7.35%	7.35%	
Estimated loss to predators per province	76 953	329 601	507 045	507 045	
Estimated loss to predators per district	44 556	122 612	213 973	86 198	467 339
District predation percentage (all ages)	8.97%	8.08%	8.41%	5.75%	7.72%
Cost of predation per district ‡	R50.26 mil	R138.31 mil	R124.36 mil	R97.23 mil	R527.16 mil
Cost of predation with perinatal losses not counted as predation					
Provincial predation rates (all ages)	1.61%	3.37%	2.79%	2.79%	
Estimated loss to predators per province	41 624	189 873	192 470	192 470	
Estimated loss to predators per district	24 100	70 633	81 222	32 720	208 675
District predation percentage (all ages)	4.85%	4.65%	3.19%	2.18%	3.45%
Cost of predation per district	R27.18 mil	R79.67 mil	R91.62 mil	R36.91 mil	R235.39 mil

† Excludes livestock losses to theft, dogs and "other" problems. ‡ Price per slaughter lambs for 2012 to 2014 in constant 2015 currency gives unit cost of R1 128, ZAR14 = US$1.

Repeating this calculation for all four districts and summing across the region resulted in a further approximately 50% reduction in the estimated predation rate across the Karoo, whose regional predation was found to be 7.72% if perinatal losses are counted towards predation, and 3.45% if not. These two assumptions led to estimates that differed by as much as 258 664 head of livestock, worth R291.77 million (approximately US$188 242 at the current exchange rate).

3.3 A Karoo-wide predation rate based on the Central Karoo panel

Table 5 indicates that 98 stock sheep and 4 332 docked lambs out of a sample inventory of 111 960 animals were reported to be caught by predators in Wave 1 of the Central Karoo panel study, which produced a conservative estimate of predation of 3.96% per year. In Wave 2, total inventory rose by 0.2% and the number of lambs tagged by 1.29%. Stock sheep losses went up by 56%, although off a low base. The number of docked lambs reported lost went up by an alarming 29.8%, off a much higher base. The overall effect was a 27.5% increase in the overall predation percentage, which now stood at 5.05% per year. In the third wave, sample inventory held firm while the number of lambs tagged fell by 5.55%. Adult losses decreased by 13.7%, but lamb losses by only 0.50%, and since these numbers are divided by an unchanged inventory they result in an unchanged but still high predation percentage.

Table 5: The Central Karoo panel study's predation and performance data (n = 234)

	Wave 1	Wave 2	Wave 3	Cumulative
Stock sheep	68 908	70 775	71 308	
Ewes	58 124	57 588	57 929	
Lambs tagged	43 052	43 606	41 184	
Inventory	111 960	114 381	112 492	338 833
Tagging percentage †	74.07%	75.70%	71.09%	73.60%
Stock sheep lost to predators	98	153	132	383
	0.09%	0.13%	0.12%	0.11%
Tagged lambs lost to predators	4 332	5 623	5 595	15 550
	3.87%	4.92%	4.97%	4.59%
Aggregate predation rate	3.96%	5.05%	5.09%	4.70%
Lambs lost as % of tagged lamb crop	10.06%	12.90%	13.58%	12.16%
Karoo inventory (four districts)				6 057 299
Predicted Karoo-wide losses				284 693
Cost of predation (at R1 128 each)				R321.13 mil

† Lambs, kids as percentage of ewes

If these data are aggregated across the three waves, the total sample inventory becomes 338 833 head of livestock, of which 383 stock sheep and 15 550 docked lambs were lost. These figures give an overall predation percentage of 4.70% for the Central Karoo, i.e. very like the 4.85% estimated for the district by the 2008 survey. Applied to a Karoo-wide inventory of more than six million sheep, it points to regional losses in the order of 284 693 animals, worth R321.13 million in constant 2015 currency (US$ 23 million). Since the latter is more than a third higher than the refined figure based on the original survey, it appears that the Central Karoo District Municipality is a predation hotspot within the Karoo region. It is not yet clear why this might the case.

Two other numbers worth noting in Table 5 are the tagging or weaning percentage and the pure lamb predation rate. There was a marginal improvement of 2.2% in the reproductive performance of the aggregate flock between waves 1 and 2, followed by a 6.1% decrease between waves 2 and 3. The latter points to a worsening of growing conditions during the 2014 season, something that is confirmed by the grazing index plotted in Figure 2. Deteriorating conditions also manifest in an increase in the pure lamb predation rates, from 12.9% to 13.6% between waves 2 and 3, but growing conditions do not explain why the pure lamb predation rate rose by 28.23% between waves 1 and 2.

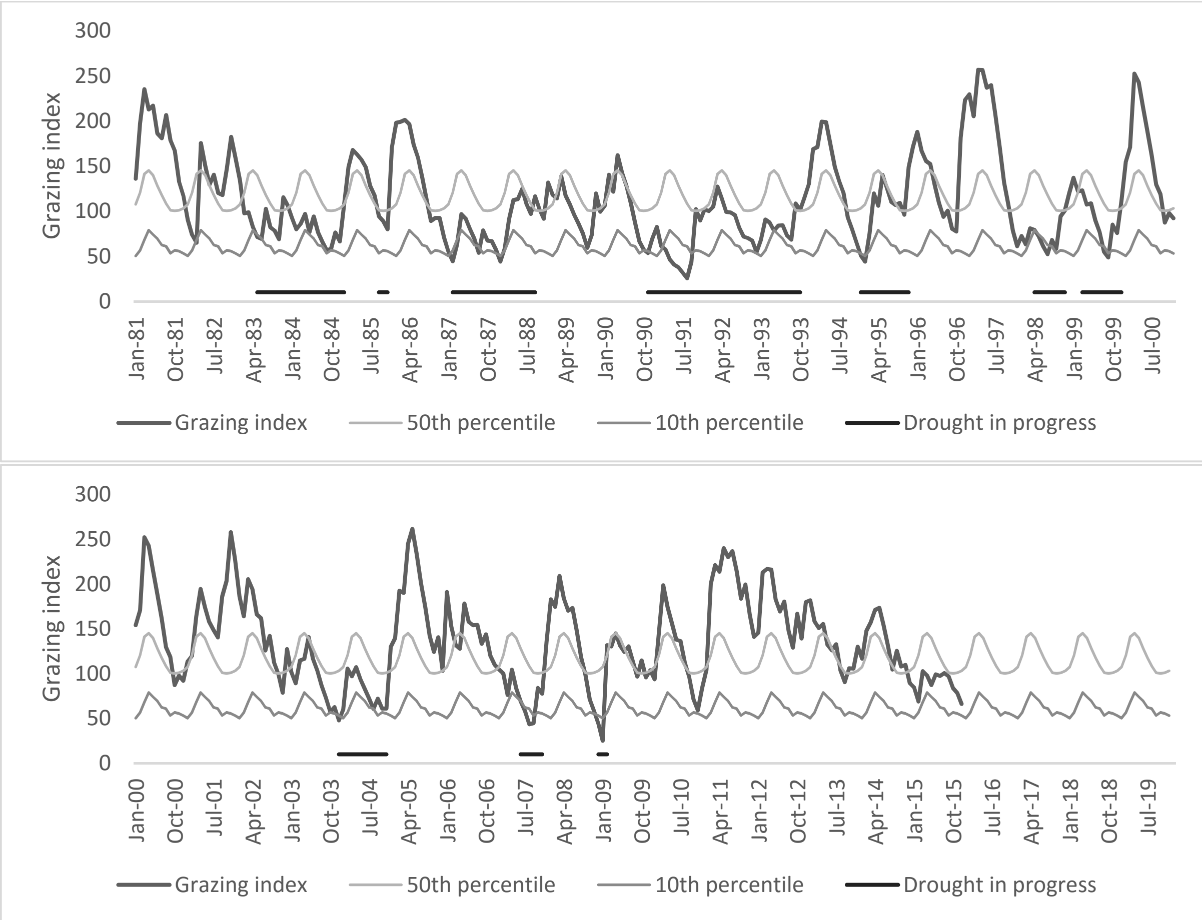

Figure 2: Index of grazing conditions at Beaufort West, according to Du Toit (2010)

Du Toit's (2010) grazing index coverts rainfall into grazing conditions by depreciating rainfall by one twelfth for every passing month since the event. The beginning of a drought is defined as the point at which the grazing index dips below the 10th percentile of observations on record, and its end as the point at which it breaks above the 50th percentile. The Kamferskraal weather station, fifty kilometres north of the town of Beaufort West, was chosen as reference site for grazing conditions in the Karoo because of its central location and its long coverage (1890). Grazing conditions during the last fifteen years have been much easier than during the last two decades of the twentieth century. There have only been three droughts over the last fifteen years, and all have lasted less than a year. The 2008 survey was taken during a good year and gathered data on years with favourable conditions, although 2007 ended in drought. The first three waves of the Central Karoo panel study took place under similarly favourable conditions. The 2012 season was above average, 2013 very close to the norm and 2014 mostly normal, but ended relatively poorly. This means that we do not have to worry too much about the possible effect of growing conditions on the farmers' predation estimates.

4. Discussion and conclusion

Although postal and telephonic surveys are still used to measure predation impacts (Andelt 1992; Andelt & Hopper 2000; Meadows & Knowlton 2000; Stoddart *et al*. 2001), self-reported questionnaire data is typically viewed with suspicion in the human-wildlife conflict literature. For example, following the US ban of toxicants for predator control (1972), the pro-carnivore side ignored or contested the sheep industry's data on increased losses because these data were not independently verified (O'Gara *et al*. 1983). This theme recurs.

Pearson's (1986) review of 136 predation studies published between 1939 and 1985 reported a lamb loss range of 4% to 9% for the 17 western states of the US. The Knowlton *et al*. (1999) review of this and later literature pointed out a bimodal distribution in the estimates, with the US Fish and Wildlife Service's 'biologically monitored' data placing losses at 1% to 6% of lamb inventory, and compensation scheme data producing estimates of 12% to 29% of lamb inventory. The implication was that self-reports lead to inflated estimates. In a theoretical treatment of the problem, Bulte and Rondeau (2005) have since put forward an alternative explanation for this difference, which is that compensation schemes create the incentive for farmers to save on husbandry, which leads to higher losses. If this is so, the non-overlapping ranges identified by Knowlton *et al*. (1999) tell us about outcomes under different sets of social preferences (lethal control vs. more habitat for carnivores), but shed little light on whether or not farmers inflate losses for strategic reasons. Even though Cozza *et al*. (1996) found a tendency amongst farmers to pass off feral dog damage to sheep flocks as wolf kills to qualify for compensation, it too cannot tell us what farmers would do if they were asked about their losses when no monetary compensation was at stake.

This article posed that question. It checked for the reliability of self-report data across different methods of data collection under peak (2008) and calmer conflict conditions (2012 to 2014) and discovered consistency on the part of farmers responding to the survey. The latter survey was more inclusive than the former, but since national and local industry contacts provided access to the community in both cases, it is likely that the same individuals participated in both studies. It seems that, if there is no monetary compensation involved and the community trusts the goodwill of the researchers, the predation number put forward is robust to survey method. Since the point estimates are surrounded by a notional confidence interval that could be quite wide, panel survey designs are still preferred to cross-section designs because they allow trust to develop, which gives a better sense of the uncertainties.

This article has also revealed that a lamb predation percentage could be calculated in a variety of ways, with each leading to a different answer. Since lambs are much more likely to be killed by predators than stock sheep (Nunley 1995), the applied ecology literature routinely reports separate lamb and ewe loss rates (Dorrance & Roy 1976; Pearson 1986; Windberg *et al*. 1997; Andelt & Hopper 2000; Meadows & Knowlton 2000; Warren *et al*. 2001). In the pure ecology literature, a weighted average predation rate of stock of all ages is more common (Graham *et al*. 2005). Due to limited inventory data, we are forced to use a hybrid system in South Africa that expresses a category of losses (e.g. lambs) as a proportion of total inventory of all ages. Since predation percentages vary with method used, one standardised calculation should be decided on for future monitoring.

With pure lamb losses of 10% to 14% of tagged lamb inventory, the Central Karoo panel study falls on the high side of the Pearson (1986) bracket, well above the range indicated for situations where there is systematic control and on the low side of self-reports to compensation schemes (Knowlton *et al*. 1999). Arguably, this is what one would expect, since there are no co-ordinated control efforts or compensation schemes in place in South Africa, although most individual farmers do their best to keep on top of the situation. The tagging percentages of 71% to 76% are equally reassuring; the Merino control flock at Carnarvon Experiment Station in Pixley ka Seme District achieved 2.2 live births per ewe over every three attempts during the period 1964 to 1983 (Olivier *et al*. 2001). Since 86% of these lambs survived to weaning age, 63% of ewes weaned a lamb in every attempt. Small-scale studies show that Dorpers are supposed to do better (Snyman & Herselman 2005), but we do not have comparable longitudinal data to know how much better. With the preponderance of Dorper sheep in the sample, the reported tagging percentages are what one would expect, and do not reflect especially high levels of perinatal predation.

Whether to assign some, none or all perinatal deaths to predation can make a big difference to the final number (Connolly 1992). While it might be reasonable to blame some losses on predators if ewes were sonar scanned (Greentree *et al*. 2000) and there is no other obvious cause for concern (Stoddart *et al*. 2001), it is well known that new-born lambs die for many reasons (Dorrance & Roy 1976; Nunley 1995; Greentree *et al*. 2000). Diagnosis is problematic because usually only a small portion of remains are recovered in a good enough condition to diagnose cause of death (O'Gara *et al*. 1983; Stoddart *et al*. 2001; Snyman 2010), and even where a sample of remains is available, predators tend to systematically go for weaker lambs (Greentree *et al*. 2000; Graham *et al*. 2005) and it is often impossible to tell whether a predator was scavenging or eating a hunted lamb. The Greentree *et al*. (2000) study of perinatal Merino lamb deaths in South Australia was designed to separate proximate from ultimate causes of death, but it too failed because the viscera needed to make the diagnose was missing in 60 of the 81 suspected predation cases. In this study, disease, mismothering, deformities and exposure accounted for 92% of identifiable deaths.

In the Karoo, where ultrasound scanning is not widely adopted and live births are unobserved in large paddocks, it was concluded that, although farmers feel that there is no other obvious problem besides predation, the industry should be careful not to claim losses as predation when they are due to other causes. For example, Snyman (2010) attributed only 39% of the 40% of identifiable deaths to predation in a study of losses amongst suckling angora kids.

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