NATURAL SCIENCES *Indago*, Vol. 37, 2021, pp. 17–30

The contribution of historical hunt club records to inform the management of damage-causing animals in South Africa

Quinette Kruger[1,*], Nico L. Avenant[2] and HO de Waal[1]

[1]African Large Predator Research Unit (ALPRU) and Predation Management Centre (PMC), Department of Animal, Wildlife and Grassland Sciences, PO Box 339, University of the Free State, Bloemfontein, 9300, South Africa
ORCID: Avenant, N.L: https://orcid.org/0000-0002-5390-9010
[2]Department of Mammalogy, National Museum, PO Box 266, Bloemfontein, 9300, and Centre for Environmental Management, University of the Free State, Bloemfontein, South Africa
ORCID: de Waal, HO: http://orcid.org/0000-0002-1748-959X
**Corresponding author: PredationMC@ufs.ac.za*

Abstract

South Africa has a long record of depredation. Since 2004, renewed awareness of this conundrum has markedly increased. The question arose as to what was learnt from historic management efforts, and how farmers, managers and conservation officials can best include it in management programs. Historical reports of two government-subsidised hunt clubs that operated in the Mossel Bay district of South Africa during the late 1970s to early 1990s were analysed to determine their contribution in managing the effects of specific predators on small livestock. District-level and farm-level analyses highlighted the value of such data in depicting the extent and distribution of predation and predator control and the role of government as an authoritative body to coordinate predation management and research efforts. However, the format of hunt reports, inaccurate or incomplete data recorded by hunters and untraceable hunt reports did not provide a clear understanding of predation and predator control relationships and patterns. Detailed data will enable meaningful analyses on predation management, such as cause-and-effects of predation incidences and predator control. Detailed spatiotemporal information on each predation incident and predator control activity, background information on club membership, the extent to which farmers depended on technical aid from the clubs, as well as physical and managerial aspects of each farm, may aid in interpreting the effect of predators on livestock. It may also aid in determining the effect of different control methods and management practices on predators and future predation, as well as factors which may influence these effects. Although information from the reports investigated was, therefore, not as useful for management purposes, it illustrated the potential value of the well-coordinated collection of standardised data for research on a local, regional, and national level. However, a framework needs to be developed that should be informed by multi- and interdisciplinary research approaches.

KEYWORDS: historical hunt reports, government-subsidised hunt clubs, livestock predation, predator control, predation management.

INTRODUCTION

The Cape Department of Nature Conservation was instituted in 1952 (Carruthers & Nattrass 2018) in the erstwhile Cape Province of South Africa. Recognising the role and potential of basing predation management on scientific methods, it replaced the bounty system with a system based on methods used in the United States of America, but adapted for South African conditions (Hey 1964; Anonymous 1966; Gunter 2008; De Waal 2021). The role of the Cape Department of Nature Conservation was of a supportive and advisory nature, providing farmers with technical aid and training courses in the use of different control methods (Anonymous 1961; 1982/1983), and conducting research into more efficient problem animal control and the feeding habits of various species of damage-causing animals (Anonymous 1969/1970). The Department was further responsible for subsidising hunt clubs, breeding and training hunting hounds and selling these and problem animal control equipment to farmers and hunters from hunt clubs (Hey 1964). The primary responsibility for problem animal control, however, rested with the private farmers (Anonymous 1982/1983). Control measures employed by farmers included hunting with hounds, coyote getters, cage traps, poison (Anonymous 1961; Anonymous 1966; Anonymous 1974-1975, Anonymous, 1977/1978) and gin traps (Hey 1974).

Experienced and skilled problem animal hunters from the government-subsidised hunt clubs performed animal damage control when farmers reported damage caused to crops, infrastructure or livestock by wild animals. The hunters were required to record every hunt and submit a monthly report, specifying the date, the name of the farm on which each control operation was conducted, the name of the farmer or representative, the distance travelled during the operation, the damage reported by the farmer, the number, species and sex of animals removed during control operations, and control method used (Gunter 2008). Hunters could at times not attend to call-outs due to similar commitments in another part of the district.

 https://doi.org/10.38140/00679208/indago.v37.a1

Although seemingly well-coordinated, the success of predator control operations seems to have been measured in terms of numbers of predators killed or immediate discontinuation of livestock losses. Research efforts focused mainly on developing control methods, while the data from the hunt clubs were used primarily for assessing the damage caused by wild animals on farms (Anonymous 1977/1978). There appears to have been a lack of focus on the longer-term impact of specific control measures and methods on predators and livestock.

Withdrawal of government assistance to agriculture led to dismantling of the Problem Animal Control Division of the Cape Department of Nature Conservation in 1987 (Carruthers & Nattrass 2018; De Waal 2021). The responsibility of predation management shifted more toward the private sector, with no incentive to keep records of these activities. The Black-backed jackal (*Lupulella mesomelas*) and Caracal (*Caracal caracal*) are the most common damage-causing predator species in South Africa, with indications that predation has spread widely (Avenant & Du Plessis 2008; Van Niekerk 2010; Bergman *et al*. 2013; De Waal 2017; Turpie & Babatopie 2018). According to farmers, predation on livestock has reached unacceptable levels. Van Niekerk (2010) and Badenhorst (2014) showed the negative impact of livestock predation on the South African economy. Predation jeopardises the sustainability and economic viability of livestock production on some farms (Strauss 2009). However, detailed information on predation management as it is currently practised is not readily available. This lack of information limits our understanding of the impacts of predation on livestock farming, the direct and indirect effects of livestock farming and predator control on the numbers, distribution and behaviour of Black-backed jackal and Caracal, thus hampering attempts at formulating practical predation management strategies.

This study forms part of the Canis-Caracal Programme (CCP), which aims to find solutions to reduce the widespread impact of predation on livestock and wildlife in South Africa (De Waal 2021). In line with the CCP's goal of learning lessons from the past (De Waal *et al.* 2006), the focus is on analysing historical data from government-subsidised hunt clubs. Previous studies investigating the role of individual subsidised hunt clubs in managing predation concluded that predator control led to increased future predation (Conradie 2012; Bailey & Conradie 2013; Conradie & Piesse 2013), citing predator populations and demographic compensation, among others, to be responsible for the increase. Examining a more extensive set of data (including the data examined by Bailey & Conradie 2013), Gunter (2008) argued that although predation appeared to increase, sparse and inconsistent data in the data sets, as well as the lack of supplementary data such as farming practices in the area at the time impeded meaningful investigation into the cause-and-effect of predation and predator control.

MATERIALS AND METHODS

Study area

The Mossel Bay District falls within the winter rainfall region of South Africa. However, a proportion of the rainfall also occurred in summer during the 16 years covered by this study (Gunter 2008). Rainfall peaks were recorded in the study area in April, May, and again in August, October, and November (Gunter 2008). Annual rainfall in the study area varied from a minimum of 299 mm to 806 mm during the period covered by the hunt reports from the two hunt clubs (Gunter 2008). Mild temperatures are experienced throughout the year, with relatively hot days (30 – 40 °C) in summer, and frost being limited to about three days per year (Mucina & Rutherford 2006).

Rivers cut deep gorges into the landscape. The largest river in the study area, the Gourits River, forms the western boundary and the Great Brak River forms the eastern boundary of the Mossel Bay district. The Langeberg mountain range forms the northern boundary. The vegetation in the gorges is characteristically different from that of the surrounding level country (Wicht 1945; Acocks 1988).

Procedures

Hunt reports from the Mossel Bay Central and Cooper hunt clubs in the Mossel Bay district of the Western Cape Province of South Africa (Fig. 1) were selected because they represented the most complete set of data retrieved from official sources in the erstwhile Cape Province of South Africa (De Waal 2021). These hunt clubs provided technical assistance in the control of damage-causing animals to farmers in the Mossel Bay district, as well as at five individual farms in the neighbouring Riversdale district to the west. The hunt reports available for the Mossel Bay Central hunt club covered the period October 1976 to May 1992, while hunt reports available for the Cooper hunt club covered the period October 1976 to March 1988.

Predation data in the reports were used to investigate whether it was possible to establish the level of success of predator control conducted by subsidised hunt clubs and to reflect on whether such data could provide insights into predation-predator control relationships or patterns. The data were analysed on both a district level and farm level, to illustrate the differences between data at different scales. Hunting activities were plotted on a map of the study area and scrutinised for spatio-temporal patterns to investigate cause-and-effect of predation management and future predation incidents. The data were subjected to Spearman Rank correlations to assess the relationships between predation by each predator species and hunting activities to control that species.

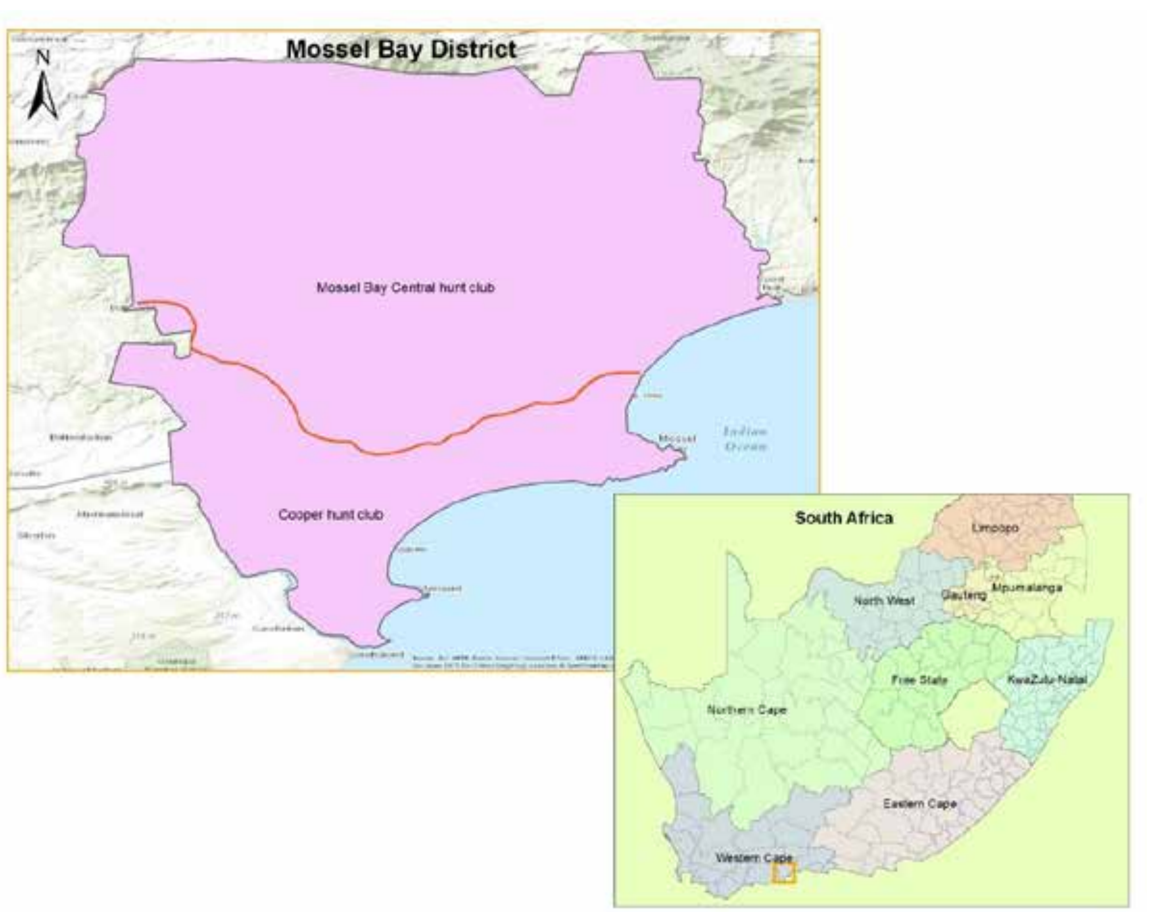

Figure 1. Areas covered by the Mossel Bay Central and Cooper hunt clubs, Western Cape Province, 1976 to 1992. The red line indicates the approximate boundary between the areas of activity of the two clubs.

Predation problems are not uniform across all livestock farming systems (Strauss 2009), and in areas where grazing camps are fenced, and sheep are not kraaled at night, predation may be a bigger problem than in areas where herding is practiced (Hawkins 2012). However, information on the farming systems and general farm or livestock management practiced in the area during the study period is not readily available (Q. Kruger personal observation; S. Cloete, specialist scientist, Western Cape Department of Agriculture, personal communication to Q. Kruger, July 2021). Such data was also not available for individual farms and could therefore not be included in analyses. Factors impeding analysis of such historical data are discussed to highlight specific data necessary for future studies aimed at formulating effective predation management strategies.

Each farm name identified in the hunt reports was assigned a unique number. Analysis only included instances when actual or suspected predation on small livestock was reported, excluding instances of livestock reported as missing (≈ no indication if predation was suspected), died of natural or unknown causes, or where the number of predation losses was not specified.

Specific criteria were applied to isolate farms for investigating the long-term effects of predation and subsequent predator control operations undertaken on farm level, namely: (a) farms with the largest continuous set of available data covering the entire period during which each hunt club was operational; (b) farms that were associated with a single farmer's name throughout the dataset suggesting that the farmer was a member of the hunt club throughout the study period; (c) farms with the most complete (detailed) set of consistently recorded data; and d) farms that could be positively identified from maps in the possession of the hunt clubs, 1:50 000 topographic maps, or ArcGIS geospatial information available from the University of the Free State Geography Department.

Based on these criteria, data were isolated for only two farms for farm-level analysis, namely: (a) Farm 66 (Mossel Bay Central hunt club; size: *ca* 1200 ha) was recorded in the hunt reports from November 1976 to September 1990, and (b) Farm 92 (Cooper hunt club; size: *ca* 1500 ha) appeared in the hunt reports from October 1976 to December 1987.

RESULTS

Limitations of the data set

Several issues and shortcomings impeded analysis of the data. The first and main challenge in using historical data was determining the location of farms (see also Gunter 2008). Farm names recorded in combination with multiple owner names further complicated identification of farms. In these cases, it was unclear whether (a) the farm names referred to the same farms, (b) a farm may have changed owners over time, (c) the "owner name" referred to the name of the owner or a representative (such as the farm manager) reporting livestock losses, (d) whether farms were, in fact, different farms, or (e) whether the farms were subdivisions of the same farm. Furthermore, some farm names appeared infrequently in the hunt reports of these two hunt clubs, and it was not always clear whether the owners of these farms were "permanent" members or non-members occasionally requesting support from the hunt clubs.

Hunt reports were not available for each month of the respective periods covered by each hunt club, creating the impression of reduced predation and predator control at times. Failure of numerous hunt clubs to submit hunt reports on a regular basis was a major concern since the 1970s (Anonymous 1977/1978). Furthermore, besides the inadequate format of hunt reports for scientific analysis of the recorded data (see Gunter 2008), interpretation of the results remains open to speculation due to incomplete or inconsistently completed hunt reports, as well as the fact that the efforts and results of private control by farmers and their neighbours have not been included, nor all their losses.

Hunt clubs operated across boundaries (Fig. 1; Fig. 2; Stadler 2006). District-level analysis revealed that some farms were serviced by hunters from both hunt clubs during the period in which both hunt clubs were active (Gunter 2008). Therefore, analysing the data on farm-level separately for each hunt club (as in Conradie 2012; Bailey & Conradie 2013) may be of limited value.

Since predation losses and predator control was linked only to a farm name in the hunt reports, these numbers are collectively represented by a single pair of GPS co-ordinates (see Fig. 2; Gunter 2008). Therefore, individual instances of livestock losses and predator control could not be investigated on farm level to determine specific habitat and vegetation types where the incidences occurred, or how it influences livestock losses or predator control.

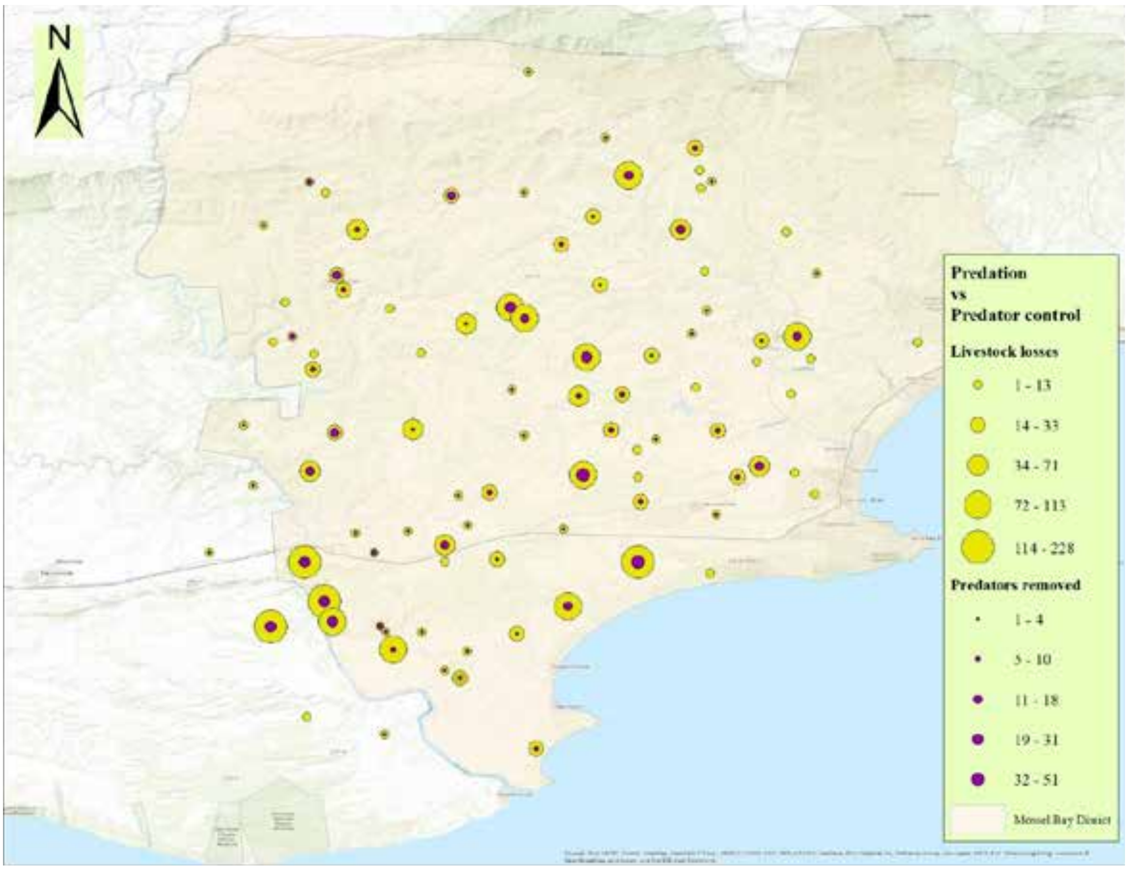

Figure 2. The extent and distribution of small livestock losses and predator control reported by the two hunt clubs in the Mossel Bay district, from 1976 to 1992. Some farms in the data set could not be positively identified, and the data therefore not represented in the map.

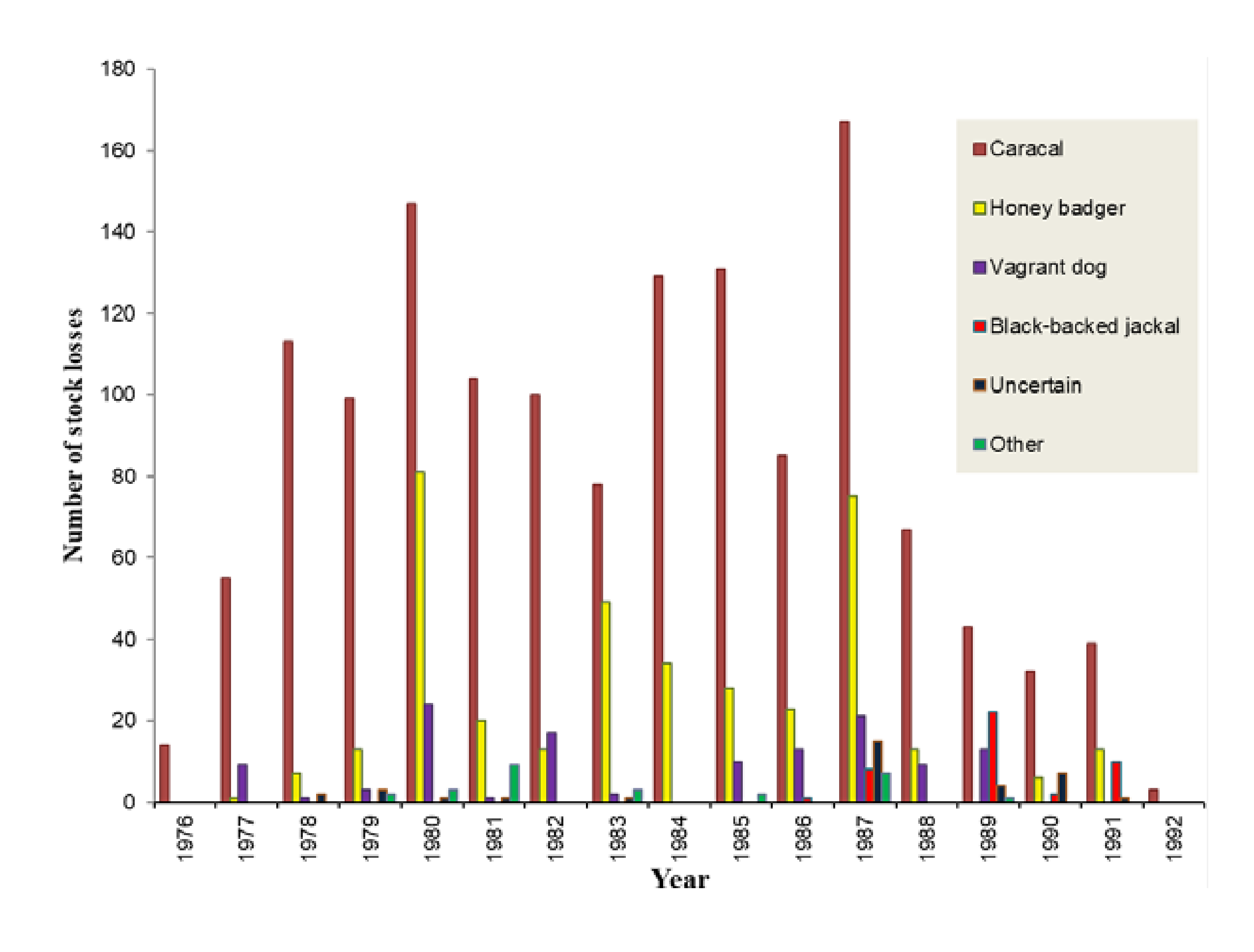

Figure 3. Annual livestock losses caused by the different predator species as reported by the Mossel Bay Central and Cooper hunt clubs, 1976 to 1992.

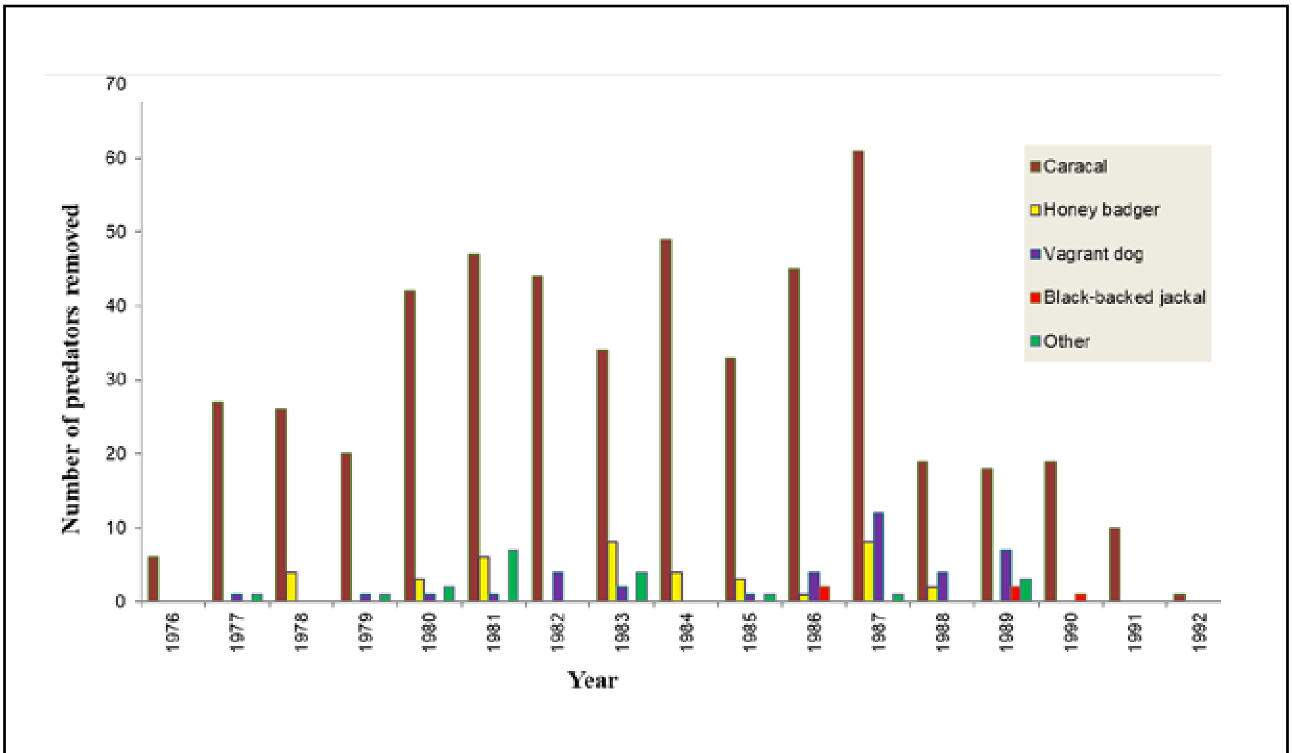

Figure 4. Number of predators removed annually in control operations by the Mossel Bay Central and Cooper hunt clubs, 1976 to 1992.

Subsequently, the relationship between predation and the control of predators per farm or between neighbouring farms could also not be investigated. Despite these shortcomings, however, the data provided valuable insight into major aspects of predation and predator control activities (see below).

District-level analysis

Nearly half (49.2%) of all small livestock losses were reported for 16 of the 132 farms identified from the hunt reports (Fig. 2). Each of these farms reportedly experienced losses of more than 50 head of small livestock (average: 63.7 losses per farm, range: 56–116) during the 16 years covered by the hunt reports. At the other end of the spectrum, on 36 of the farms only a single sheep or goat was reportedly killed during this period. Both the predation losses and predators removed on each of the farms are shown in Fig. 2.

The extent of damage and relative impacts of the various predators fluctuated markedly between years (Fig. 3). Generally, predation occurred throughout the year, with a peak during autumn and winter (April – August). However, there was considerable variation in monthly predation from one year to the next (Gunter 2008), and farm-level analysis revealed that seasonal predation varied between farms as well. The low numbers (Fig. 3 - livestock losses, and Fig. 4 - predator control) for 1976 and 1992 are due to only a few hunt reports being available for the Mossel Bay district during these years (Gunter 2008). Similarly, the sharp drop in numbers from 1988 to 1992 is because of only one hunt club being operational during this period.

Caracal was the primary damage-causing predator species in the Mossel Bay district, reportedly responsible for 70% of all small livestock losses (Fig. 3). Second to Caracals, Honey badgers (*Mellivora capensis*) were responsible for large numbers (18.7%) of small livestock losses, followed by vagrant Dogs (*Canis familiaris*) (6.1%) and Black-backed jackals (2.1%). Some hunt reports, especially during 1987 and 1989–1990, contained accounts of livestock losses in which the predator responsible for the losses was not specified, or the hunter indicated that it was not known which predator species was responsible for the loss. These cases are represented in Fig. 3 by “Uncertain” and comprised 1.7% of the total small livestock losses. A few individual instances were recorded in which other predators, such as African wild cats (*Felis silvestris lybica*) genets (*Genetta* spp.),

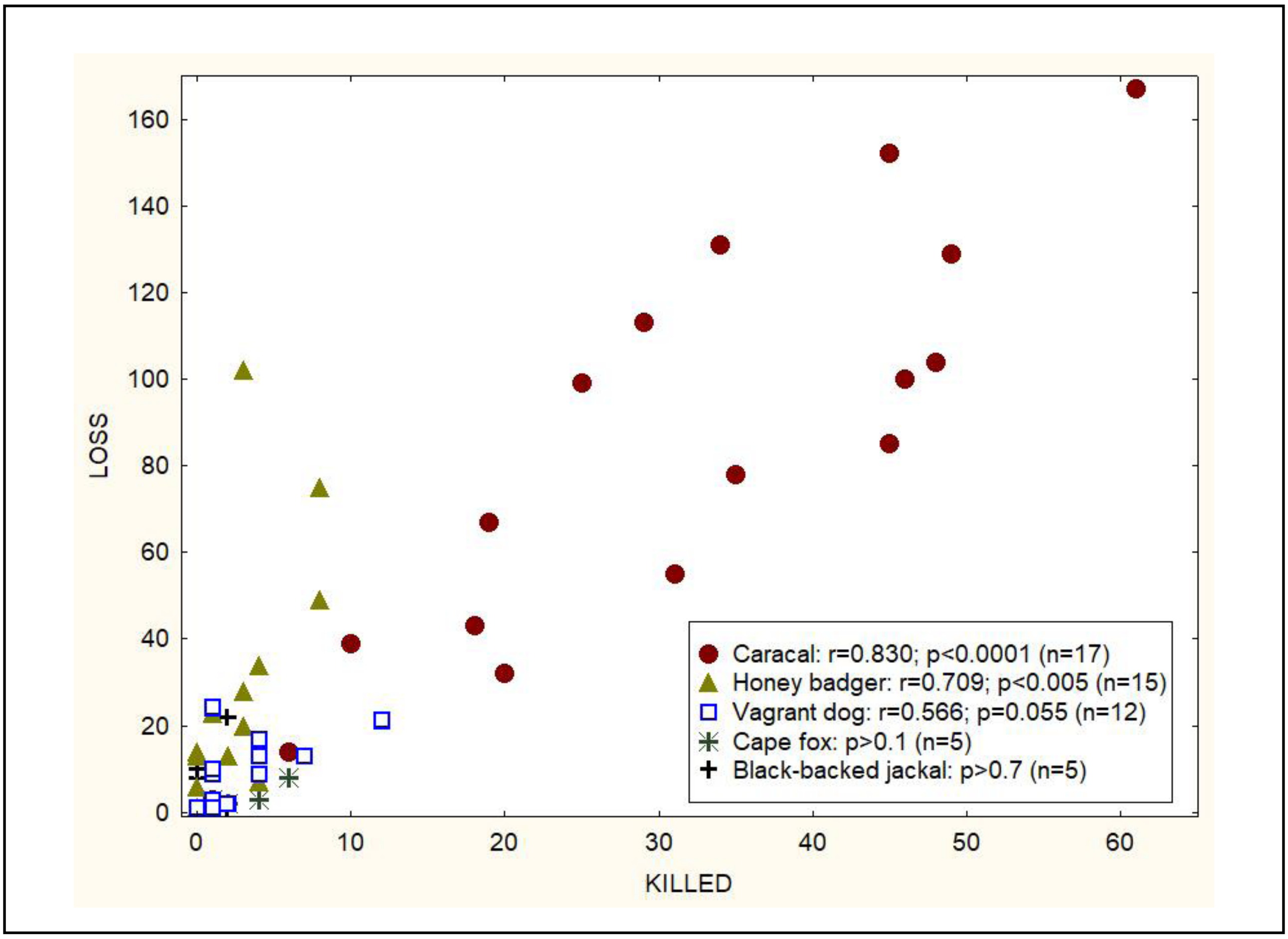

Figure 5. Spearman Rank correlations between livestock losses caused by specific carnivores and the number of the same carnivore species killed during the follow-up operations in the Mossel Bay Central and the Cooper hunt clubs (1976–1992).

Otters (presumably *Aonyx capensis*) and a Leopard (*Panthera pardus*), were reportedly responsible for killing small livestock. These losses were grouped as "Other" (Fig. 3) and comprised 1.3% of reported small livestock losses.

Throughout the study period, the two hunt clubs showed a high success in removing Caracals and Honey badgers during control operations in response to predation, as indicated by the positive correlations shown in Fig. 5 between the annual livestock losses and the number of caracal ($r=0.830$; $p<0.0001$), and honey badgers ($r=0.709$, $p<0.005$) killed. However, hunt clubs appeared to have had relatively little success in removing Cape foxes and Black-backed jackals (Figs 4 and 5). Fewer Honey badgers than Caracals were removed, proportional to the damage they caused (Fig. 5). According to comments recorded by hunters in the hunt reports, Honey badger control was more challenging than controlling Caracals, while hunting Black-backed jackals was markedly more difficult.

Farm-level analysis

Records available for Farm 66 covered a longer period than for Farm 92. Although only five more predation incidents were recorded for Farm 66, the number of losses were much higher (144 losses, vs 72 on Farm 92). On average 2.4 (range: 1–6) small livestock losses were reported per predation incident (Table 1), with an average of 84 days between predation incidents. Caracals were reportedly responsible for 70.7% of small livestock losses on Farm 66, with Honey badgers causing 18.1% of the losses. Caracal comprised 88.9% of all predators caught (Table 1). Considering only the small livestock losses ascribed to Caracal and subsequent control of Caracal for Farm 66, control seemed to be fairly effective, with an average of 236.1 days (*ca* eight months) between the removal of a Caracal and the next reported predation incident ascribed to Caracal.

On Farm 92, an average of 1.3 (range: 1–2) small livestock losses were reported per predation incident, with an average of 74.4 days between predation incidents. Caracal were reportedly responsible for 90.8% of livestock losses on Farm 92, followed by Honey badger (6.2%). Caracal comprised 94.2% of all predators caught (Table 1). Caracal control seemed effective in terms of the number of Caracals removed in response to reported livestock losses, yet less effective in terms of reducing future predation by Caracal, with an average of 86.7 days (2.9 months) between the removal of Caracal and the next livestock losses attributed to this predator species.

Despite reportedly being more difficult to control, removal of Honey badgers appeared to be more effective in reducing subsequent predation by this predator. When a Honey badger was removed, no further predation by this species was reported for *ca* 3.5 years for Farm 66 and Farm 92.

DISCUSSION

District-level analysis

Hunters from the government-subsidised hunt clubs only recorded livestock losses reported to the hunt club and the predator control activities conducted by the hunt club in response to these losses (Brand 1989; Gunter 2008; De Waal 2021). These efforts were in addition to farmers' own control measures (farmers W. Basson, W. de Villiers, J. Kirsten, F. Duckitt, P. Duckitt and R. Burger, Swartland District, personal communication to N. Avenant 1989; S. Hanekom, "problem animal hunter" for the Cape Provincial Administration, personal communication 1989 to N. Avenant; P. Geldenhuys, CPA Nature Conservation official, personal communication to N. Avenant 1990). The help of hunt clubs was often only called in when farmers had a specific problem that they could not solve themselves. Comments in the hunt reports support the findings of Brand (1989) of

Table 1. Small livestock losses ascribed to different predator species, the number of predation incidents reported, and predators removed during control operations on Farm 66 (Mossel Bay Central hunt club), and Farm 92 (Cooper hunt club).

	Farm 66 Nov 1976 – Sep 1990 (~14 years)					Farm 92 Oct 1976 – Dec 1987 (~11 years)			
Livestock losses	Total	Caracal	Honey Badger	Uncertain	Vagrant dog	Total	Caracal	Honey Badger	Cape Fox
Sheep	75	29	31	5	10	9	7	2	0
Lambs	69	67	0	0	2	63	59	2	2
Total	144	96	31	5	12	72	66	4	2
Predation incidents	61	44	12	3	2	56	51	3	2
Predators removed	28	25	3	-	0	53	50	1	2

higher predation losses in an area than that calculated from hunt reports. The data from the hunt reports therefore provide some valuable information on the extent of livestock losses and predator control in an area (Fig. 2), but do not provide a true reflection of the situation of losses or predators killed on a farm or district level; especially when taking into account the large distances that can be covered in one night and the large home ranges of *e.g.* caracal (ranging between *ca*. 20 and 300 km^2, depending on a range of environmental variables) (Avenant *et al*. 2016). This includes the calculation of livestock losses as a proportion of the total livestock herd or flock (as presented in Conradie 2012). Analysis of the records is thus affected (Brand 1989), rendering some conclusions questionable.

The finding that some farmers suffered high levels of predation while nearby farmers experienced few or no losses (Fig. 2) concurs with other studies in South Africa (Lawson 1989; Avenant 1993; Brand 1993; Deacon 2010; Van Niekerk 2010) and elsewhere (France - Stahl & Vandel 2001, as cited by Macdonald & Sillero-Zubiri 2002; Australia - Allen & Fleming 2004; USA - Breck & Meier 2004, Mitchell *et al*. 2004). However, it is possible that on at least some farms with low predation levels, the services of a club were only called in when predation persisted despite control efforts by the farmers, and external help was needed to control a specific problem. All predation incidents on a specific farm being linked to the same pair of GPS co-ordinates also precludes investigation into the influence of habitat and vegetation types on predation or predator control. Specific locations for each predation incident and predator removal, combined with detailed information on farm and husbandry practices on individual farms, is necessary to investigate the reasons for predation on some farms being much higher than on others.

The nature of the data in the hunt reports precludes possible explanation for the observed peaks in numbers (Figs 3 and 4) for 1980 and 1987. Rainfall does not appear to have a marked effect on livestock losses (Gunter 2008), as was also noted in the study by Brand (1989), suggesting that other environmental factors may also have been at play. The elevated predation levels during autumn and winter months (Gunter 2008) agree with the findings of other studies (Rowe-Rowe 1975; Stuart 1982; Avenant & Nel 2002; Melville *et al.* 2004). These studies coupled seasonal trends in predation losses to lambing season, low natural prey densities, and the time when Caracal young start to eat meat.

Hunters reported that conditions were unsuitable for hunting with hounds during dry periods (for example, May 1978 and June 1979), or hot and dry climatic conditions (September to February), in some cases preventing hunters from performing predator control. According to reports from the Cooper hunt club, inclement weather during 1979, 1981 and 1982 prevented the hunter from carrying out predator control on several occasions. These cases may explain the troughs in the numbers of predators removed during these years (Fig. 4).

Information such as the sex of predators removed during control operations has provided valuable insights into the biology and ecology of different species of damage-causing animals, which may, in turn, facilitate species management (Bothma 1971; Knowlton 1972; Bernard & Stuart 1987; Brand 1989). However, although the hunt reports made provision for recording the sex of predators, hunters often neglected recording such specifics. The fact that reproductive status, condition, and age were also not documented, prevents investigation into possible underlying reasons for predation, or methods more successful in controlling predators in a particular phase of their annual life cycle (Brand 1989; Kruger 2019).

The positive correlations between the annual livestock losses and the number of Caracal and Honey badgers killed (Fig. 5) may suggest that livestock losses increased with caracal and Honey badger control (see Conradie 2012, Bailey & Conradie 2013 and Conradie & Piesse 2013) or vice versa. However, correlation does not indicate causation, especially in this case where there are so much missing data and many uncertainties. Earlier research from different areas in South Africa (Stuart 1982; Moolman 1986; Deacon 2010) noted an apparent increase in predator numbers, even though intensive control efforts were implemented. Increased predator numbers may be attributed to non-selective or intensive control efforts or compensatory breeding and immigration (see Avenant & Du Plessis 2008; Minnie 2016). However, a better understanding of the ecological outcome of different management strategies is essential for formulating more targeted, effective predation management tools and strategies (Wilkinson *et al.* 2020) and reasons for increased predation losses. Lack of supporting ecological data (e.g. estimates of predator population size and trends for the period covered by this study) also precludes any conclusions being drawn about such direct influences on predators in the area. Furthermore, it is unclear whether the increase in predators killed noted in this study may be because of farmers increasingly relying on hunt clubs for predator control instead of controlling predators themselves.

In this study, the first account of damage caused by Black-backed jackal was recorded during 1986 by the Cooper hunt club. During 1989, the hunter reported that Black-backed jackals started causing a great deal of damage. During the same time, the damage due to Caracal decreased markedly, as did the number of Caracal killed. Once again, it appears to lend support to other reports which state that the numbers of one intra-guild predator species, such as

Caracal and Black-backed jackal, increase where the numbers of the other are reduced (Hey 1964; Pringle & Pringle 1979; Stuart 1982; Avenant 1993). But with the many unknowns, the influence of each of these predator species on the numbers and distribution of the other cannot be confirmed. Reports from the Cape Department of Nature Conservation confirmed the presence of Black-backed jackals in adjacent districts and districts further inland (Anonymous 1961; 1964; 1966; 1969–1970). But the lack of location data for farms on which Black-backed jackal predation was reported (1986–1991), as well as the relatively short data period, precludes investigation into possible influx of this species into the study area as a result of Caracal control.

Capture rate can be calculated if the start and end dates of each control operation are known (Brand 1989). Gunter (2008), Conradie (2012) and Bailey & Conradie (2013) calculated hunt success from the number of hunts and the number of predators caught, as recorded in the hunt reports. However, with the limitations of the data sets (notably the absence of specific dates in some hunt reports, and the fact that farmers' own control methods could not be taken into account while the official hunter could not attend to all incidents), it is doubtful that hunt success can be accurately depicted. Therefore, considering hunting effort recorded in historical hunt reports to draw correlations between livestock losses and predator control, as in Bailey & Conradie (2013) and Conradie & Piesse (2013), is not advisable.

Farm-level analysis

Farm 66 (Mossel Bay Central hunt club) lies in an area with more slopes, valleys and denser vegetation than the area in which Farm 92 (Cooper hunt club) is located. Such habitat features are known to be preferred by predators, including Caracal (Stuart 1982; Moolman 1986; Brand 1989; Deacon 2010; Minnie *et al*. 2015), which may explain the higher livestock losses reportedly experienced on Farm 66 than on Farm 92. The distribution of livestock losses attributed to predation has been linked to topography, climate, farming practices in an area, and in adjacent areas (Lensing & Joubert 1976). The lack of detailed location and supporting data on these and other factors that may influence predation precludes further investigation into possible reasons for higher predation in some areas vs others, or during certain times (Treves *et al*. 2004).

The disproportionate removal of predators relative to predation losses reported for Farm 92 (1 removed: 1.36 losses) vs Farm 66 (1:5.14), creates the impression that hunt success on Farm 66 was lower. However, the use of a variety of control methods, namely hounds, cage traps and foothold traps by the Cooper hunt club, may have contributed to the higher numbers of predators removed by its hunter. Predation losses were reduced considerably more, and for longer periods, on Farm 66 compared to Farm 92. Hunters from the Mossel Bay Central hunt club may have been more selective in their approach to predator control through swift response to damage reported and the use of mainly hounds for predator control (Gunter 2008). This method can be selective, provided that fresh scent be picked up close to a freshly killed prey carcass (Van der Merwe 1953; Stuart 1982; Brand 1989). Differences in hunt success can also be ascribed to differences in habitat and (therefore) predator home range sizes (Brand 1989), but is further influenced by the training, experience, motivation and preference of the hunter (Stuart 1982; Ferguson 1986; Brand 1989). In the present study, it is evident that the method of predator control used depended on the preferences of the different hunters.

CONCLUSIONS

Hunt reports used by the Cape Department of Nature Conservation present a consistent method of data collection, which is crucial to researching human-predator conflict (Graham *et al*. 2005). However, although research was an important function of the Cape Department of Nature Conservation, hunt reports were not used for this purpose.

On the district level, hunt club data are partially useful to determine the extent and distribution of predation and predator control, which may aid in identifying predation hotspots (Gunter 2008). However, due to hunt reports not covering all predation incidents, nor any private predation management activities, failure of numerous hunt clubs to submit hunt reports regularly, and the inconsistent manner in which individual hunters completed hunt reports (Gunter 2008), such data do not provide an accurate portrayal of the situation. Also, as predation and predator control due to predation cannot be linked to accurate GPS coordinates, and information on predation management on farms is lacking, the data are not suitable for determining cause-and-effect of predator control.

Farm-level data illustrates the differences in the predation and predator control situation from one farm to the next. Differences between results on district and farm levels also highlight the crucial role that farm-level data may play in informing sound predation management practices. However, long-term spatiotemporal data collected over large areas, covering the myriad factors affecting predation and the management or control of predators, are necessary to allow better analyses and modelling predation risk (Treves *et al*. 2004; Graham *et al*. 2005; Kolowski & Holekamp 2006; Gunter 2008; Dar *et al.* 2009; Behdarvand *et al*. 2014; Davie *et al*. 2014; Pimenta *et al*. 2018), and ultimately inform practical predation management strategies. Information on the physical and managerial characteristics of farms and other non-lethal predation management strategies (Brand 1989; Thorn *et al.* 2012; Du Plessis 2013; Du Plessis *et al*. 2018; Kruger 2019) is crucial, since human-predator conflicts do not constitute simple predator-prey interactions (Graham *et al*. 2005).

With the latest computer, GPS and cell phone technology, it has become possible to collect continuous spatiotemporal data over large areas and in real-time (Kruger 2019). Therefore it is also possible to determine and benchmark the current situation regarding predation over large areas in South Africa, monitor predation management, identify trends, and ultimately formulate more effective predation management strategies (Kruger 2019). Future efforts at predation management, which also includes stronger focus on farm and livestock management practices, will benefit from a national framework driven by an authoritative body. The framework applied by the Problem Animal Division of the Cape Department of Nature Conservation to manage damage-causing wildlife could, for example, be revisited to ensure that more extensive data are collected, preserved, and made available for research to improve predation management in South Africa. The human-predator conflict in South Africa is part of a complex ecological and economic process (Graham *et al*. 2005), and requires a strong focus on social aspects of human-wildlife conflict and, especially, cooperation between stakeholders (Avenant *et al*. 2006; Du Plessis 2013; Kruger 2019; Terblanche 2020).

ACKNOWLEDGEMENTS

The authors would like to thank the late Mr. Hannes Stadler of Cape Nature for providing access to official documents from the former Cape Department of Nature Conservation and the various hunt clubs that operated under its Problem Animal Control Division.

REFERENCES

ACOCKS, J.P.H. 1988. *Veld types of South Africa.* Botanical Research Institute, Department of Agriculture and Water Supply, Pretoria.

ALLEN, L.R. & FLEMING, P.J.S. 2004. Review of canid management in Australia for the protection of livestock and wildlife – potential application to coyote management. *Sheep & Goat Research Journal* **19**: 97–104.

ANONYMOUS 1961. The Hound Breeding Station. *Department of Nature Conservation.* Report No. 18: 86–91.

ANONYMOUS 1964. Predator Control Research Farm, Vrolijkheid. *Department of Nature Conservation. Report* No. 21: 58–66

ANONYMOUS 1966. Algemene verslag van die Afdeling Ongediertebeheer. *Department van Natuurbewaring.* Verslag Nr. 23: 82–106.

ANONYMOUS 1969–1970. Afdeling Ongediertebeheer. *Departement van Natuurbewaring.* Verslag No. 26: 134–149.

ANONYMOUS 1974–1975. Vrolijkheid Nature Conservation Station, Robertson. *Cape Department of Nature Conservation and Museum Services.* Report No. 31: 31–35

ANONYMOUS 1977/1978. Probleemdierbeheer. *Kaapse Departement van Natuurbewaring en Museumdienste.* Verslag Nr. 34: 57–65.

ANONYMOUS 1982/1983. Probleemdierbeheer. *Kaapse Departement van Natuurbewaring en Museumdienste.* Verslag Nr. 39: 25–26.

AVENANT, N.L. 1993. *The caracal,* Felis caracal *Schreber, 1776, as predator in the West Coast National Park*. M.Sc. thesis. University of Stellenbosch, Stellenbosch, South Africa.

AVENANT, N.L., DE WAAL, H.O. & VAN DER MERWE, S.J. 2006. Canis-Caracal Programme: the way forward. Internal document, African Large Predator Research Unit (ALPRU), University of the Free State, Bloemfontein.

AVENANT, N.L., DROUILLY, M., POWER, R.J., THORN, M., MARTINS, Q., NEILS, A., DU PLESSIS, J. & DO LINH SAN E. 2016. A conservation assessment of *Caracal caracal*. **In** Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, eds. *The Red List of Mammals of South Africa, Swaziland and Lesotho.* South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

AVENANT, N.L. & DU PLESSIS, J.J. 2008. Sustainable small stock farming and ecosystem conservation in Southern Africa: a role for small mammals? *Mammalia*, **72**: 258–263.

AVENANT, N.L. & NEL, J.A.J. 2002. Among habitat variation in prey availability and use by caracal, *Felis caracal*. *Mammalian Biology* **67**:18–33.

BADENHORST, C.G. 2014. *The economic cost of large stock predation in the North West Province of South Africa.* M.Sc. Agric. dissertation. University of the Free State, Bloemfontein, South Africa.

BAILEY, A. & CONRADIE, B. 2013. The effect of predator culling on livestock losses: Caracal control in Cooper hunting club, 1976–1981. *Centre for Social Science Research Working Paper* No. 320, January 2013.

BEHDARVAND, N., KABOLI, M., AHMADI, M., NOURANI, E., MAHINI, A.S. & AGHBOLAGHI, M.A. 2014. Spatial risk model and mitigation implications for wolf–human conflict in a highly modified agroecosystem in western Iran. *Biological Conservation* **177**: 156–164.

BERGMAN, D.L., DE WAAL, HO, AVENANT, N.L., BODENCHUK, M.J., MARLOW, M.C. & DALE, D.L. 2013. The need to address black-backed jackal and caracal predation in South Africa. *Proceedings of the 15th Wildlife Damage Management Conference*, 25–28 March 2013, Clemson, South Carolina (J.B. Armstrong, G.R. Gallagher, Eds.).

BERNARD, R.T.F. & STUART, C.T. 1987. Reproduction of the caracal *Felis caracal* from the Cape Province of South Africa. *South African Journal of Zoology* **22**(3): 177–182.

BOTHMA, J. Du P. 1971. Control and ecology of the black-backed jackal *Canis mesomelas* in the Transvaal, *Zoologica Africana* **6**(2): 187–193.

BRAND, D.J. 1989. *Die beheer van rooikatte (Felis caracal) en bobbejane (Papio ursinus) in Kaapland met behulp van meganiese metodes*. M.Sc. thesis. University of Stellenbosch, South Africa.

BRAND, D.J. 1993. *The influence of behaviour on the management of black-backed jackal*. Ph.D. dissertation. University of Stellenbosch, South Africa.

BRECK, S. & MEIER, T. 2004. Managing wolf depredation in the United States: past, present, and future. *Sheep & Goat Research Journal* **19**: 41–46.

CONRADIE, B. 2012. Are hunting clubs the solution to small stock depredation? The case of Ceres, 1979 and 1980. *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa* **51**(1): 96–113.

CONRADIE, B. & PIESSE, J. 2013. The Effect of Predator Culling on Livestock Losses: Ceres, South Africa, 1979–1987. *Centre for Social Science Research Working Paper* No. 319. January 2013.

CARRUTHERS, J. & NATTRASS, N. 2018. History of Predator-Stock Conflict in South Africa. **In:** Kerley, G.I.H., Wilson, S.L. & Balfour, D. (Eds). *Livestock predation and its management in South Africa: a scientific assessment. Centre* for African Conservation Ecology, Nelson Mandela University, Port Elizabeth, p. 30–52.

DAR, N.I., MINHAS, R.A., ZAMAN, Q. & LINKIE, M. 2009. Predicting the patterns, perceptions and causes of human–carnivore conflict in and around Machiara National Park, Pakistan. *Biological Conservation* **142**: 2076–2082.

DAVIE, H.S., MURDOCH, J.D., LHAGVASUREN, A. & READING, R.P. 2014. Measuring and mapping the influence of landscape factors on livestock predation by wolves in Mongolia. *Journal of Arid Environments* **103**: 85–91.

DEACON, F. 2010. *Aspekte rakende die ruimtelike ekologie van die rooijakkals* (Canis mesomelas) *as probleemdier in die Suid-Vrystaat.* M.Sc. dissertation. University of the Free State, Bloemfontein, South Africa.

DE WAAL, HO 2017. Demography and morphometry of black-backed jackals *Canis mesomelas* in South Africa and Namibia. *ALPRU - Occasional Paper*, September 2017. University of the Free State, Bloemfontein, South Africa.

https://www.ufs.ac.za/docs/librariesprovider22/animal-and-wildlife-and-grassland-sciences-documents/alpru-documents/all-documents/alpru/de-waal_2017_demography-and-morphometry-of-black-backed-jackals-canis-mesomelas-in-south-africa-and-namibia.pdf?sfvrsn=4b68a621_0

DE WAAL, HO 2021. Predation management in South Africa – historical milestones. *ALPRU Occasional Paper, version 5.5, November 2021.* https://www.ufs.ac.za/docs/librariesprovider22/pmic-documents/predation-management-in-south-africa--historical-milestones-november-2021.pdf?Status=Master&sfvrsn=465b7520_3/

DE WAAL, HO, AVENANT, N.L. & COMBRINCK, W. 2006. The Canis-Caracal Programme - the initiative and a holistic approach. **In**: *Holistic Management of Human-Wildlife Conflict in South-Africa - Briefing Book*. Ganzekraal Workshop, Western Cape, South Africa. 10–13 April. p 32.

DU PLESSIS, J.J. 2013. *Towards the development of a sustainable management strategy for Canis mesomelas and Caracal caracal on rangeland.* Ph.D. thesis. University of the Free State, Bloemfontein, South Africa.

DU PLESSIS, J.J., AVENANT, N.L., BOTHA, A.J., MKHIZE, N.R., MÜLLER, L., MZILENI, N., O'RIAIN, M.J., PARKER, D.M., POTGIETER, G., RICHARDSON, P.R.K., RODE, S.C., VILJOEN, N., HAWKINS, H–J. & TAFANI, M. 2018. Past and current management of predation on livestock. **In:** Kerley, G.I.H., Wilson, S.L. & Balfour, D. (Eds). *Livestock predation and its management in South Africa: a scientific assessment.* Centre for African Conservation Ecology, Nelson Mandela University, Port Elizabeth. pp 125-177.

FERGUSON, J.W.H. 1986. Human-Factors Affecting the Efficiency and Selectivity of the Coyote-Getter in Jackal Control. *South African Journal of Wildlife Research* **16**(4), 145–149.

GRAHAM, K., BECKERMAN, A.P. & THIRGOOD, S. 2005. Human-predator-prey conflicts: ecological correlates, prey losses and patterns of management. *Biological Conservation* **122**: 159–171.

GUNTER, Quinette 2008. *A critical evaluation of historical data on two damage causing predators,* Canis mesomelas *and* Caracal caracal. M.Sc. dissertation. University of the Free State, Bloemfontein, South Africa.

HAWKINS, H-J. 2012. *A year of EcoRangers: Does the EcoRangers model have the potential to reduce livestock losses while improving farm management and skills in arid rangelands?* Unpublished report. Cape Town, South Africa: Conservation South Africa.

HEY, D. 1964. The control of vertebrate problem animals in the Province of the Cape of Good Hope, Republic of South Africa. *Proceedings of the 2nd Vertebrate Pest Control Conference*, University of Nebraska, Lincoln, U.S.A.

HEY, D. 1974. Vertebrate pest animals in the Province of Good Hope, RSA. *Sixth Vertebrate Pest Conference, March 5–7, 1974.* Anaheim California.

KNOWLTON, F.F. 1972. Preliminary interpretations of coyote population mechanics with some management implications. *Journal of Wildlife Management* **36**(2): 369–382.

KOLOWSKI, J.M. & HOLEKAMP, K.E. 2006. Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. *Biological Conservation* **128**: 529–541.

KRUGER, Quinette 2019. *Developing a management information system for coordinated predation management in South Africa*. Ph.D. thesis. University of the Free State, Bloemfontein, South Africa.

LAWSON, D. 1989. The effects of predators on sheep farming in Natal: An opinion survey. *South African Journal of Wildlife Research* **19**(1): 4–9.

LENSING, J.E. & JOUBERT, E. 1976. Intensity distribution patterns for five species of problem animals in South West Africa. *Madoqua* **10**: 131–141.

MACDONALD, D.W. & SILLERO-ZUBIRI, C. 2002. Large carnivores and conflict: Lion conservation in context. **In**: A.J. Loveridge, T. Lynam and D.W. Macdonald (Eds.), *Lion Conservation research. Workshop 2: modelling conflict.* Pp. 1–8. Wildlife Conservation Research Unit, Oxford University.

MELVILLE, H.I.A.S., BOTHMA, J. Du P., & MILLS, M.G.L. 2004. Prey selection by caracal in the Kgalagadi Transfrontier Park. *South African Journal of Wildlife Research* **34**(1): 67–75.

MINNIE, L. 2016. *Effects of lethal management on black-backed jackal population structure and source-sink dynamics.* PhD thesis. Nelson Mandela Metropolitan University, Port Elizabeth.

MINNIE, L., KERLEY, G.I.H. & BOSHOFF, A.F. 2015. Vegetation type influences livestock predation by leopards: implications for conservation in agro-ecosystems. *African Journal of Wildlife Research* **45**: 204–214.

MITCHELL, B.R., JAEGER, M.M. & BARRETT, R.H. 2004. Coyote depredation management: current methods and research needs. *Wildlife Society Bulletin* **32**: 1209–1218.

MOOLMAN, L.C. 1986. *Aspekte van die ekologie en gedrag van die rooikat Felis caracal Schreber, 1776 in die Bergkwagga Nasionale Park en op die omliggende plase.* M.Sc. thesis. University of Pretoria.

MUCINA, L. & RUTHERFORD, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

PIMENTA, V., BARROSO, I., BOITANI, L. & BEJA, P. 2018. Risks *a la carte*: Modelling the occurrence and intensity of wolf predation on multiple livestock species. *Biological Conservation* **228**: 331–342.

PRINGLE, J.A. & PRINGLE, V.L. 1979. Observations on the lynx *Felis caracal* in the Bedford district. *South African Journal of Zoology* **14**: 1–4.

ROWE-ROWE, D.T. 1975. Predation by black-backed jackals in a sheep-farming region of Natal. *Journal of the South African Wildlife Management Association* **5**: 79–81.

STADLER, J.C. 2006. The history of "Problem Animal Control" in the Cape Province. *Proceedings of a workshop on Holistic Management of Human-Wildlife Conflict in the Agricultural Sector of South-Africa. Ganzekraal Conference Centre, Western Cape, South Africa.* pp. 8–26.

STRAUSS, A.J. 2009. *The impact of predation on a sheep enterprise in the Free State Province*. M.Sc. Agric. dissertation. University of the Free State, Bloemfontein, South Africa.

STUART, C.T. 1982. *Aspects of the biology of the caracal (*Felis caracal *Schreber, 1776) in the Cape Province, South Africa.* M.Sc. Dissertation. University of Pretoria.

TERBLANCHE, R. 2020. *Ongediertes*: *A critical qualitative study of farmer–black-backed jackal conflict and its management around the Square Kilometre Array core site in the Northern Cape, South Africa.* PhD Thesis. Stellenbosch University, Stellenbosch.

THORN, M., GREEN, M., DALERUM, F., BATEMAN, P.W. & SCOTT, D.M. 2012. What drives human-carnivore conflict in the North West Province of South Africa? *Biological Conservation* **150**: 23–32.

TREVES, A., NAUGHTON-TREVES, L., HARPER, E.K., MLADENOFF, D.J., ROSE, R.A., SICKLEY, T.A. & WYDEVEN, A.P. 2004. Predicting human-carnivore conflict: a spatial model derived from 25 years of data on wolf predation on livestock. *Conservation Biology* **18**(1): 114–125.

TURPIE, J.K. & BABATOPIE, A. 2018. The socio-economic impacts of livestock predation and its prevention in South Africa. **In:** Kerley, G.I.H., Wilson, S.L. & Balfour, D. (Eds). Livestock predation and its management in South Africa: a scientific assessment (Eds Kerley, G.I.H., Wilson, S.L. & Balfour, D.). Centre for African Conservation Ecology, Nelson Mandela University, Port Elizabeth, 53–81.

VAN DER MERWE, N.J. 1953. The Jackal. *Fauna and Flora, Pretoria* **4**: 3–83.

VAN NIEKERK, H.N. 2010. *The cost of predation on small livestock in South Africa by medium-sized predators.* M.Sc. Agric. dissertation. University of the Free State, Bloemfontein, South Africa.

WICHT, C.L. 1945. Preservation of the vegetation of the south western Cape. Royal Society of South Africa, Cape Town.

WILKINSON, C.E., MCINTURFF, A., MILLER, J.R.B., YOVOVICH, V., GAYNOR, K.M., CALHOUN, K., KARANDIKAR, H., MARTIN, J.V., PARKER-SHAMES, P., SHAWLER, A., VAN SCOYOC, A., & BRASHARES, J.S. 2020. An ecological framework for contextualizing carnivore–livestock conflict. *Conservation Biology*. https://doi.org/10.1111/cobi.13469