Demography and morphometry of black-backed jackals *Canis mesomelas* in South Africa and Namibia

by

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Summary
The black-backed jackal *Canis mesomelas* is an important mesopredator in South Africa and Namibia and non-lethal and lethal methods are used to mitigate its negative impact on livestock and wildlife. Despite widespread lethal management over decades, for both official and private activities, little is still known about the demography and morphometry of this species. Information is provided on 918 black-backed jackals hunted in South Africa and Namibia over the period 12 May 2009 to 1 February 2011; including 455 males, 411 females and 52 individuals of unknown gender. In addition to the time of year being hunted and thus age relative to whelping time, eruption of the permanent teeth and the wear of incisors were used to categorise 4 age groups. Females weighed consistently less than males of the same age; the heaviest adult male and female weighed 12.5 kg and 11.5 kg respectively. Body mass of 641 specimens was pooled over years to categorise 4 age groups: <0.5 years (pups), 0.5–1 years (juveniles), between 1–2 years (yearlings), and ≥2 years (adults). Both main effects (Sex and Age) differed with no interaction effects. Except for the 1-2 years (yearlings) age group, where females were significantly more than males, the data of 722 individuals did not display a skewed sex ratio. Growth and development of young black-backed jackals mostly occur in the first 6 months of their lives, thereafter decreasing gradually. Males were consistently larger than females for three measured variables, namely total body length, body length and tail length. Predation management of black-backed jackals requires good knowledge of the interface between its biology and management. It is feasible to obtain large sets of data on reproduction with this approach.

Key-words: body length, body mass, human-carnivore conflict, hunting, mesopredator, morphometric measurements, predation, sexual dimorphism.

Introduction
Human-carnivore conflict is a global phenomenon (Du Plessis, Avenant & De Waal, 2015; Minnie, Gaylard & Kerley, 2015; 2016a,b; 2017). Predation management is a necessary but sometimes controversial activity and the role of the government is as much to provide oversight as it is to save livestock and protect wildlife (Bodenchuk, 2013). Non-lethal and specifically lethal management of black-backed jackals *Canis mesomelas* are widely used in South Africa and Namibia to manage the negative impact on livestock and wildlife, yet little is known about the demography and morphometry of this species.

Black-backed jackals were mostly studied in protected areas, with little information from farming areas; these aspects extensively reviewed by Du Plessis *et al*. (2015). Current knowledge regarding the social and feeding behaviour is extrapolated from protected areas where, according to Minnie *et al.* (2015; 2016a,b; 2017), the normal stable social structure has not been disrupted. Citing from limited and dated publications, such inferences may not be justified; only 51 peer-reviewed publication and seven dissertations or theses have reported on black-backed jackal ecology (Du Plessis *et al*., 2015), which is about 10% of the

wealth of comparable literature on coyote *Canis latrans* in North America. It may be unintentional, but the limited number of South African studies, which were mostly done in protected areas, may invariably have been biased towards conservation ecology rather than livestock production.

Despite the relatively small number of scientific publications on black-backed jackals (Du Plessis *et al.*, 2015), these predators have a marked impact on livestock (Gunter, 2008; Strauss, 2009; Van Niekerk, 2010; Bergman *et al*., 2013; Badenhorst, 2014; Minnie *et al*., 2015; 2016a,b; 2017). While recognising the importance of black-backed jackals as part of the incomparable African wildlife, Hey (1964) noted they are "public enemy No. 1 of the sheep farmer" and estimated the annual losses in South Africa as a result of predation to range from 400 000 to 500 000 sheep. Lombaard (1970) reflected similarly on the predatory habits of black-back jackals on sheep in South Africa. After an interval of more than 40 years, Van Niekerk (2010) estimated that 2.285 million sheep and goats are lost annually to black-backed jackal and caracal *Caracal caracal* in the five major small livestock provinces of South Africa. Strauss (2009) reported on the devastating impact of black-backed jackals on a sheep enterprise at the Glen Agriculture Institute (Free State Province, South Africa): a well-designed trial with Merino sheep was brought to a standstill when it became impossible to replace breeding ewes with their offspring over a period of nine years; the offspring were killed, predominantly by black-backed jackals.

Although information is not publicly available, large numbers of black-backed jackals are lethally controlled (De Waal, 2009; Bergman *et al*., 2013). The long period of more than 40 years between the reports of Hey (1964) and Lombaard (1970) and the reports by Strauss (2009) and Van Niekerk (2010), suggests little has been achieved in reducing the impact of predation on sheep and goats. Badenhorst (2014) also reported on the large impact of black-backed jackals, and to a lesser extent other predators, on the beef cattle industry of South Africa. Recently Schepers (2016) also reported on the impact of predation on the wildlife ranching industry in South Africa.

Until fairly recently, government sponsored predator control were common practice in South Africa (Hey, 1967; Ferreira, 1988; Olivier, 1993; Stadler, 2006; Gunter, 2008; De Waal, 2009; Bergman *et al*., 2013; Du Plessis *et al.*, 2015). The official predator control systems (Stadler, 2006; Gunter, 2008; De Waal, 2009) were operating along similar lines to the situation in the USA (Miller, 2007). The bounty principle was an integral part of official policies (Stadler, 2006); for example, during the period 1 January to 31 December 1956, the Provincial Administration of the Province of the Cape of Good Hope (then known as the Cape Province) paid bounties on 20 084 black-backed jackals killed in an area covering about 60% of South Africa (Hey, 1964); this area is about the size of Texas, USA. Lensing and Joubert (1976) also referred to black-backed jackals as a problem throughout South Africa and Namibia, being responsible for heavy losses to sheep flocks in the arid and semi-arid farming regions.

As a natural evolution the bounty system was gradually abolished in favour of officially sanctioned and subsidised problem animal hunt clubs which operated until 1994 in various parts of South Africa (Hey, 1967; Olivier, 1993; Ferreira, 1988; Stadler, 2006; Gunter, 2008; De Waal, 2009). The Department of Nature Conservation in the Cape Province rendered reasonable assistance to clubs by subsidising the clubs and furnishing technical aid in the form of equipment, trained hounds and training of the hunters, but the actual elimination of problem animals was the responsibility of the individual farmers and the hunt clubs (Hey,

1967). An official provincial problem animal control system ("Die Oranje-Vrystaat Vereniging vir die Bestryding van Skadelike Diere", commonly known as Oranjejag) was also operating in the erstwhile Orange Free State Province, where official huntsmen killed predators (Ferreira, 1988; De Waal, 2009). At its peak, Oranjejag employed 20 full time hunters with about 1 000 hounds (Ferreira, 1988). An official system also operated in KwaZulu-Natal Province (Bigalke & Rowe-Rowe, 1969).

The official focus in South Africa has since been lost on the negative impact caused by a major medium-sized predator on livestock (De Waal, 2009), commensurate with the geopolitical change in South Africa in the early 1990s; hence the official institutional memory on predation became fragmented and has been lost (De Waal, 2009; Bergman *et al*., 2013). Despite the official support and status of predation control over several decades in South Africa, Gunter (2008) suggested very little information can be gleaned from the historical records regarding the demography and morphometry of predators.

Currently black-backed jackals are still culled by specialist predator hunters, livestock farmers, and wildlife ranchers in South Africa and Namibia. They are "called-and-shot" at night, but many are also removed by traps, hound packs, denning, aerial hunting, and poison. Little is known about these specimens, but personal notes are kept by individuals on the gender, dates, name of farms and coordinates where hunted. This important source of mammalian specimen constitutes valuable scientific information and must be exploited (De Waal *et al*., 2004; De Waal & Combrinck, 2004). In this regard Smithers (1973) stated: "In our endeavours to contribute to our knowledge of our mammalian fauna there is an ethical responsibility on those of us who collect mammals to ensure that the best possible use is made of these by ensuring that as much data as possible is obtained from each and every specimen handled."

Without official recognition or support, a network of specialist predator hunters and livestock farmers operate in South Africa and Namibia. Having been made privy to the network of hunting activities and electronic communication, the opportunity was exploited to report on a wealth of untapped information. The first challenge was to improve the limited fashion of recording the minimum information on every specimen. Training was provided electronically to the broad network and data and information was received in the same way. Herein is reported on the body mass and body measurements obtained post-mortem from a large number of black-backed jackals.

Materials and methods

STUDY AREA

Records of hunted black-backed jackals were provided by e-mail by 51 collaborators operating over large areas in South Africa and Namibia; hunted from as far afield north as central Namibia to the southern parts of the Eastern Cape Province, South Africa.

COLLECTING DATA

Considerable variation is shown by the body mass and size of animals (Sachs, 1967; Smuts *et al*., 1978; 1980; Mills, 1982; De Waal *et al*., 2004; De Waal & Combrinck, 2004). Some body measurements can be taken with greater accuracy (Bertram, 1975; Skinner & Smithers, 1990), but differences in measuring techniques may contribute to the variation which can be reduced by applying standard procedures when collecting morphometric data for analysis (Ansell, 1965; Sachs, 1967; Smithers, 1973; Mills, 1982). Measuring the body of dead or immobilised animals, particularly large African predators, is time consuming (De Waal *et al*.,

2004; De Waal & Combrinck, 2004) and often has to compete in priority with other activities such as collecting biological samples (e.g. blood) or fitting radio collars. Limited numbers of live animals or dead specimens are also available at irregular intervals and subjected by different operators to a range of measuring techniques (De Waal *et al*., 2004). In the case of the private specialist predator hunters it is a priority to get quickly indoors after the hunt with little interest in the predator carcass except to drop it at a predetermined spot as evidence of a successful hunt to collect payment from the farmer. Some convincing was required to persuade individuals to make an effort to record the required information.

Hunters are accustomed to recording trophies, for example weighing the carcasses of game animals or measuring the horns of antelope. However, the skills required for more detailed measuring techniques of freshly hunted specimen had to be established: first to weigh the dead black-backed jackals accurately, followed by introducing a procedure to measure the body dimensions of large African predators (De Waal & Combrinck, 2004; De Waal *et al*., 2004). Based on interactive electronic feedback from collaborators via the network, recording was made easier by reducing the list of variables (De Waal *et al*., 2004) to collect some basic information on body mass and a few body measurements, namely: date; time hunted; male/female; age (years/months); mass (kg); body length A-T (mm); tail length T-Z (mm); hunter; and GPS coordinates.

Considering the vast land area over which the network of specialist predator hunters and farmers operate in South Africa and Namibia, the training of potential collaborators to collect the morphometric data had to be conducted electronically.

AGE DETERMINATION

Body mass and body measurements must be linked to the age of the black-backed jackals. Linhart and Knowlton (1967) developed a technique to determine the age of coyotes based on tooth cementum layers, but Gier (1968) showed that it is fairly easy to estimate the age of coyotes visually from their teeth. A similar approach was proposed by Lombaard (1970; 1971) for black-backed jackal and the age of specimens were estimated by the collaborators from tooth eruption sequences and wear on the incisors.

They were also asked to provide digital photographs showing the incisors and canines of the specimens. This information on teeth was used to adjust the estimated ages of the specimens for the time of year hunted, in relation to the annual whelping time. It was assumed that whelping occurred from July to October (Bernard & Stuart, 1992), although Lombaard (1970) and Ferguson *et al*. (1983) suggested a shorter whelping time from August to September. According to Rowe-Rowe (1978), July was the peak whelping time in the Drakensberg, while Fairall (1998) suggested the whelping season in the Kruger National Park ranges from August to October.

The data were statistically analysed using GLM procedures of SAS (2004).

Results

Information on 918 black-backed jackals was collected over a period of about 21 months, namely from 12 May 2009 to 1 February 2011 (Table 1). The first part of the study covered an open period of 9 months and a substantial portion of the data was submitted during four much shorter and concerted periods, designated Periods I to IV.

Table 1 - Number and gender of 918 black-backed jackals recorded from 12 May 2009 to 1 February 2011 in South Africa and Namibia

Period	Dates	Black-backed jackals (n)			
		Total	Males	Females	Gender not stated
-	12 May 2009 – 17 Feb 2010	224	97	94	33
Period I	19 – 28 Feb 2010	82	34	42	6
-	1 Mar – 5 May 2010	94	52	42	-
Period II	6 – 31 May 2010	125	70	55	-
-	1 Jun – 24 Jul 2010	49	28	21	-
Period III	28 Jul – 31 Aug 2010	131	62	69	-
Period IV	1 Nov – 12 Dec 2010	170	91	70	9
-	13 Dec 2010 – 1 Feb 2011	43	21	18	4
	Total	918	455	411	52

The 918 black-backed jackals (Table 1) comprised 455 males and 411 females of different ages. Of the 52 specimens of unknown gender, 39 were recorded during the earlier phase of the study with some collaborators showing lack of observational capacity or merely failing to note all information as requested. The quality of data submitted improved substantially as the study progressed, because collaborators gained confidence and became more experienced in collecting and submitting data. In the later phases of the study, the few specimen of unknown gender were mostly pups or young black-backed jackals.

DEMOGRAPHY

The data (Table 1) comprise information on a large number (n = 918) of black-backed jackals, but it constitutes only information that was submitted and not necessarily all specimens that have been hunted.

Except for the 1-2 years (yearlings) age group, where females were significantly more than males (Figure 1), the data of 722 individuals did not display a skewed sex ratio.

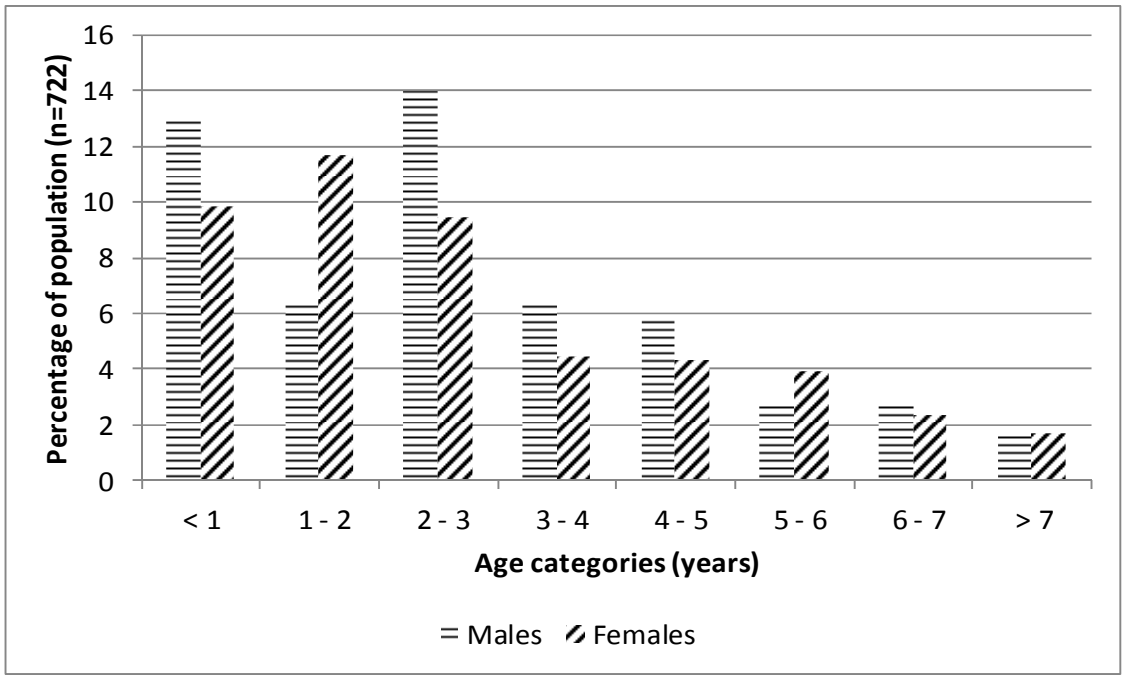

Figure 1 - Percentage of black-backed males and females per age group

GENDER AND AGE

Young females reach sexual maturity at 11 months (Ferguson *et al*., 1983; Moehlman, 1979) and given favourable conditions can start reproducing from the age of 1 year. It was assumed that black-backed jackals breed from the age of about 2 years. After omitting records with missing information on age and gender, data were available on 866 black-backed jackals (Table 2).

BODY MASS

The composition and social structure of the young black-backed jackals were established by pooling data over years and categorising 4 age groups, namely: <0.5 years (pups), 0.5–1 years (juveniles), between 1–2 years (yearlings), and ≥2 years (adults). Records with missing information were omitted and the body mass of 641 specimen categorised in the 4 age groups (Table 3).

BODY MEASUREMENTS

The data on body measurements were also pooled over years and, similar to the procedures described previously for body mass, categorised in 4 age groups (Table 4).

Many collaborators provided only the total body length (A-Z). In some cases body length (A-T) and tail length (T-Z), or total body length (A-Z) and tail length (T-Z), were provided. When 2 of the 3 variables were provided, the third variable was calculated by simple arithmetic.

Discussion

The number of adults (≥2 years old) was consistently higher than for younger animals, except during the period 1 November to 12 December 2010 (Table 2). This period (designated as Period IV in Table 1) was specifically included with a view to focus on the demography of the black-backed jackal population immediately post-whelping. Therefore, the specimen reported during this period included a substantial number of pups who were already large enough to start wandering from the dens.

Method of harvesting may affect data and introduce some bias; for example, Bigalke and Rowe-Rowe (1969) suggested that hunting with hounds may be selective in taking more black-backed jackal males who tend to be aggressive and more reluctant to flee from the hounds than females. Knowlton (1972) also reported that among samples taken during spring (the whelping season for coyote in the USA), male coyote typically predominate, presumably as a result of limited activity on the part of gravid females.

The observations reported by the collaborators suggest that the majority of females whelped from early in July to October. Therefore, the seasonal breeding of black-backed jackal bitches reported by Bernard and Stuart (1992), and which is also substantiated by observations in this study, suggests it is a monoestrus species, similar to the coyote (Bekoff, 1977). Walton and Joly (2003) reported that parturition in black-backed jackals varies regionally and is likely related to habitat and food availability; however, they did not characterise them as being monoestrus.

Eruption of the permanent set of teeth and the wear of incisors, relative to whelping time were used to categorise 4 age groups (Tables 2 and 3). According to Lombaard (1970) the last permanent teeth of black-backed jackals appear at the age of about 23.5 weeks; hence the cut-off point of <0.5 years was chosen in this study for the youngest defined age group. It

appears (Table 3) that the growth and development of young black-backed jackals mostly took place in the first 6 months of their lives, thereafter decreasing gradually. Cypher (1995) reported a similar pattern of rapid growth during the early stage of life for coyotes. Young black-backed jackals may start dispersing at this stage over long distances (Bothma, 1971) in search of own territories and are quite capable of predating on small animals as well as livestock (personal communications, specialists predator hunters).

Table 2 - Number, age, and gender of 866 black-backed jackals recorded from 12 May 2009 to 1 February 2011 in South Africa and Namibia

Dates	Age groups	Males	Females	Totals
12 May 2009	<2 years	32	37	69
- 17 Feb 2010	>2 years	65	57	122
	Totals	97	94	191
Period I	<2 years	15	18	33
19 Feb 2010	>2 years	19	24	43
- 28 Feb 2010	Totals	34	42	76
1 Mar 2010	<2 years	16	22	38
- 5 May 2010	>2 years	36	20	56
	Totals	52	42	94
Period II	<2 years	20	22	42
6 May 2010	>2 years	50	33	83
- 31 May 2010	Totals	70	55	125
1 Jun 2010	<2 years	4	8	12
- 24 Jul 2010	>2 years	24	13	37
	Totals	28	21	49
Period III	<2 years	12	24	36
28 Jul 2010	>2 years	50	45	95
- 31 Aug 2010	Totals	62	69	131
Period IV	<2 years	50	31	81
1 Nov 2010	>2 years	41	39	80
- 12 Dec 2010	Totals	91	70	161
13 Dec 2010	<2 years	2	6	8
- 1 Feb 2011	>2 years	19	12	31
	Totals	21	18	39
	Totals	455	411	866

In all 4 age groups defined in this study, sexual dimorphism is evident for body mass of black-backed jackals: females weighing consistently less than males at the same ages (Table 3). The heaviest males and females weighed 12.5 kg and 11.5 kg respectively (Table 3). Within the 4 age groups considerable variation was observed in body mass and also overlapping in body mass ranges between the age groups.

Phenotype (physical appearance) of animals is a function of genotype and environment. In this regard Way (2007) reported north-eastern coyotes are the largest extant version of coyote; female coyotes from north-eastern North America were heavier than all male and female western coyotes. This is contrary to previous literature concluding that body size of coyotes does not increase in North America with decreasing longitude (Way, 2007). It is often claimed that black-backed jackals culled in specific areas are larger or smaller than those found elsewhere, but in this study geographical differences were not established for body size.

Table 3 - Body mass (kg ± *SD*) of 641 black-backed jackals recorded from 12 May 2009 to 1 February 2011 in South Africa and Namibia

	Age groups							
	<0.5 years (pups)		0.5-1 years (juveniles)		Between 1-2 years (yearlings)		≥2 years (adults)	
Sex	M	F	M	F	M	F	M	F
n	40	23	37	39	41	78	216	167
$\bar{X}$ kg	4.62	4.21	6.46	5.91	7.71	6.74	8.29	7.34
SD	1.03	0.83	0.79	0.97	1.16	0.87	1.23	1.12
Min kg	1.8	3.0	4.5	3.5	5.5	4.5	6.0	4.8
Max kg	6.0	5.6	7.5	7.5	11.0	8.5	12.5	11.5

Both main effects (Sex and Age groups) differed ($P \leq 0.05$), with no ($P > 0.05$) interaction effects.

Table 4 - Body measurements (mm ± *s.e.*) of black-backed jackals recorded from 12 May 2009 to 1 February 2011 in South Africa and Namibia

	Age groups							
Variables	<0.5 years (pups)		0.5-1 years (juveniles)		Between 1-2 years (yearlings)		≥2 years (adults)	
mm	M	F	M	F	M	F	M	F
Total body length*								
n	38	20	28	28	37	64	155	112
$\bar{X}$ A-Z	882[a]	841[1]	1011[b]	998[2]	1055[b]	1002[2]	1071[c]	1028[3]
s.e.	10.8	18.1	12.3	9.6	9.7	10.4	4.5	6.1
SD	66.5	81.0	65.2	51.0	58.9	53.0	56.2	64.7
Min	700	660	870	865	930	650	830	770
Max	1022	945	1140	1080	1160	1120	1300	1200
Body length								
n	34	18	25	22	33	53	123	90
$\bar{X}$ A-T	619[a]	580[1]	713[b]	689[2]	742[b]	709[2]	762[c]	730[3]
s.e.	8.4	12.2	12.2	12.7	8.1	7.2	4.0	5.4
SD	49.0	51.7	60.9	59.7	46.7	52.2	44.8	51.3
Min	530	480	620	520	640	550	650	600
Max	735	700	880	800	830	790	950	860
Tail length								
n	34	18	25	22	33	53	123	92
$\bar{X}$ T-Z	268[a]	252[1]	307[b]	306[2]	316[b]	297[2]	310[b]	301[2]
s.e.	3.8	10.4	5.4	6.0	5.9	6.4	3.0	2.9
SD	22.1	44.3	27.2	27.9	34.2	46.6	33.0	27.6
Min	220	130	260	260	219	100	160	230
Max	320	320	380	390	410	370	400	370

*A-Z - total body length (including tail length T-Z)

One of the main effects (Sex) differed ($P \leq 0.05$) for all body measurements (AZ, AT and TZ) for each of the age groups.

[a,b,c]Values in rows for males with the same superscript do not differ ($P \leq 0.05$).

[1,2,3]Values in rows for females with the same superscript do not differ ($P \leq 0.05$).

Minnie *et al*. (2015; 2016a,b; 2017) stated that black-backed jackals on farms in South Africa compensated for increased mortality when hunted by increasing the pregnancy rate of young individuals and increasing the litter size at younger ages, thereby increasing reproductive output.

At the local level, growth and development of predators may have marked consequences regarding the onset of reproduction. According to Knowlton (1972) the percentage of female coyotes that are sexually mature and successfully whelp is perhaps one of the more important variables in the reproductive capacity of local populations; field observations in Texas suggest that 1-year-old females do not make an appreciable contribution to the general productivity, but under some circumstances they may. These observations are supported by Gier (1968), less than 10% of this age group becomes sexually active on Kansas but when rodents are abundant, as high as 70% of the yearlings may breed. Minnie *et al*. (2015; 2016a,b; 2017) concurred regarding the effect of nutrition on reproduction but stated it differently, namely: "reproductively active females tended to be in better condition than inactive females."

The body measurements (Table 4) of males were consistently larger for all three variables than for females; again showing the sexual dimorphism of black-backed jackals. Gier (1968) reported that sex differences in weight and measurement of coyotes first became evident from the age of 100 to 125 days and by the age of 250 days young coyote males were mostly heavier and larger than young females.

Total body length (A-Z) and body length (A-T) differed (Table 4) for both sexes between the youngest age group (<0.5 years [pups]) and the other 3 age groups, namely 0.5-1 years (juveniles), between 1-2 years (yearlings) and ≥2 years (adults). The middle 2 age groups, namely 0.5-1 years (juveniles) and 1-2 years (yearlings) also differed for the sexes for both variables from the oldest age group. The tail length (T-Z) of the youngest age group differed from the other 3 age groups. Tail length did not differ between the older 3 age groups in this study. According to Gier (1968) tail length of coyotes varied considerably more than, and semi-independently, from their body length. Hence, tail length of coyotes reaches a fairly high degree of maturity in early life (up to about 6 months) and thereafter increases only gradually with age.

The extent of the data in this study and its contribution to the existing paucity of knowledge on black-backed jackals must be viewed in perspective. Gier (1968) collected information from 2 074 coyote carcasses received during the months October to May for a 15-year period (1947 to 1962). The coyote carcasses were received from a relatively small area, namely 53 of the 102 counties in the state of Kansas, USA. The bulk of the coyote carcasses (Gier 1968; n = 1 946) were received during 4 months, namely December (232), January (647), February (825) and March (222). The land area of Kansas (211 749.6 km^2) is only about 17.34% the size of South Africa (1 221 037 km^2) and 25.72% of the land area of Namibia (823 290 km^2); Kansas is only 10.36% of the combined land area of South Africa and Namibia.

Herein it is reported on 918 black-backed jackals that were hunted over a much larger area in South Africa and Namibia and a relatively short period of about 21 months. It suggests the variation in the data for this study may have been less affected by time but more by geographical factors than in the study by Gier (1968). This may be further investigated.

Conclusions

The method used to collate information on body size and body measurements of black-backed jackals suggests that it is feasible to capitalise on this important source of available scientific data. A necessary first step in meaningful predation management, specifically for the black-backed jackal in South Africa and Namibia, requires good knowledge of the interface between its biology and management (Knowlton *et al*., 1999). Although not

reported here, collaborators also provided elementary information on foetuses carried by gravid female black-backed jackals. Therefore, by aligning hunting operations of the network of specialist hunters according to the reproductive phases of the monoestrus black-backed jackal, it seems feasible to also obtain appropriate and valid scientific data on much needed important aspects of their reproduction with this approach. Such information is urgently needed to inform current approaches in managing predation to mitigate the impact on livestock farms and wildlife ranches.

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