African Journal of Ecology

Note and Record

Do black-backed jackals affect numbers of smaller carnivores and prey?

Joanna M. Bagniewska and Jan F. Kamler*
Department of Zoology, Wildlife Conservation Research Unit, The Recanati-Kaplan Centre, University of Oxford, Tubney House, Abingdon Road, Tubney, Abingdon, OX13 5QL, U.K.

Introduction

The important role of mesocarnivores in ecosystems has recently received increased attention (Prugh *et al.*, 2009; Ritchie & Johnson, 2009; Roemer, Gompper & Van Valkenburgh, 2009). Mesocarnivores can function in roles similar to apex predators (Roemer, Gompper & Van Valkenburgh, 2009) and, consequently, can decrease populations of prey and smaller carnivores (Prugh *et al.*, 2009; Ritchie & Johnson, 2009). Mesocarnivores often increase in numbers with reductions in numbers of apex predators, a phenomenon termed 'mesopredator release' (Crooks & Soule, 1999; Prugh *et al.*, 2009).

In Africa, research on the effects of mesocarnivores on prey species and smaller carnivores has been little studied. A dominant mesocarnivore in South Africa may be the black-backed jackal (*Canis mesomelas*), as recent research has shown that jackals have lethal and sublethal effects on cape foxes (*Vulpes chama*) and bat-eared foxes (*Otocyon megalotis*), which resulted in jackals suppressing numbers of cape foxes (Kamler, Stenkewitz & Macdonald, 2013). Similarly, numbers of black-backed jackals were inversely related to numbers of cape foxes, bat-eared foxes and small-spotted genets (*Genetta genetta*) across 22 sites in South Africa, associated with intensity of jackal control (Blaum, Tietjen & Rossmanith, 2009). However, research on the effects of black-backed jackals on the numbers of prey species and other smaller carnivores has not been studied.

This study examined the relative abundance of black-backed jackals, smaller carnivores and small prey species across three sites in South Africa. The research was conducted in a region where apex predators had been extirpated, leaving jackals as the most dominant carnivore in the area. The goal was to determine whether abundance of jackals was inversely related to abundance of important prey species and smaller carnivores.

*Correspondence: E-mail: jan.f.kamler@gmail.com

Material and methods

This article was part of a larger study investigating the ecology of black-backed jackals across three study sites in South Africa (Klare *et al.*, 2010; Kamler, Klare & Macdonald, 2012a; Kamler *et al.*, 2012b). The sites were Benfontein Game Farm (BGF; 110 km^2; 28°53′S, 24°49′E) located 8 km south-east of Kimberley, private ranches (PR; 81 km^2; 28°59′S, 24°48′E) located 5 km south of BGF and Rooipoort Nature Reserve (RNR; 420 km^2; 28°39′S; 24°11′E) located 50 km west of Kimberley. Detailed descriptions of the study sites, habitat and species present are given in previous papers (Klare *et al.*, 2010; Kamler, Klare & Macdonald, 2012a; Kamler *et al.*, 2012b). Numbers of black-backed jackals across sites were related to levels of human persecution and were relatively low on PR, moderate on BGF and relatively high on RNR (Klare *et al.*, 2010; Kamler, Stenkewitz & Macdonald, 2013).

We estimated relative abundance of carnivores and small (0.5–3 kg) prey using scent-station surveys, which have been used to assess relative abundance of carnivores (Roughton & Sweeny, 1982; Sargeant, Johnson & Berg, 1998). Although developed for carnivores, scent stations also show trends in the relative abundance of small prey such as leporids, probably due to the latter's attraction to the novel scent or freshly sifted dirt (Drew, Fagre & Martin, 1988). For scent-station visitations on each site, we established three 5.5-km transects, with >2 km separating each transect. Transects were placed along dirt tracks that were selected randomly within each site. Along each transect, scent stations were placed every 0.5 km, resulting in 12 scent stations per transect. Scent stations consisted of a 1-m circle of sifted soil, baited with a cotton pad soaked in synthetic fermented egg solution (Schmitt Enterprises, Inc., New Ulm, MN, USA). We baited stations and checked them for three consecutive mornings in July 2007 and replicated this process in August 2007. Each morning, tracks were identified to species based on shape and size (Liebenberg, 1990; Stuart & Stuart, 1994) and then the soil was resifted to erase all tracks. For each transect, we calculated a scent-station index (SSI) for each species based on the total number of stations with visits, divided by the total number of operable stations, multiplied by 10 (Roughton & Sweeny, 1982). For PR and RNR, we took the mean SSI based on both replicates, whereas there was only one replicate for BGF. We pooled SSI from all transects in analysis, regardless of site, because although jackal numbers differed among sites, jackal distribution was not uniform within each site due to the spacing of jackal core areas (Kamler *et al.*, 2012b). We used Pearson's correlation to compare the SSI between jackals and smaller carnivores and prey.

Results and discussion

There were sufficient data to calculate SSI for five carnivore species, including black-backed jackal, aardwolf (*Proteles cristatus*), cape fox, bat-eared fox and mongoose (primarily yellow mongoose [*Cynictis penicillata*]), as well as three species of potential prey, including hares (*Lepus capensis* and *L. saxatilis*), South African ground squirrel (*Xerus inauris*) and Cape porcupine (*Hystrix africaeaustralis*). The SSI of jackals was negatively related to the SSI for ground squirrel ($P = 0.020$) and hare ($P = 0.027$), and marginally negatively significant for mongoose ($P = 0.063$; Fig. 1). There tended to be negative relationship between the SSI of jackals and all other species, although it was not significant for cape fox ($P = 0.118$), bat-eared fox ($P = 0.160$), aardwolf ($P = 0.282$) and porcupine ($P = 0.543$).

Our data are the first to show negative relationships between the abundance of black-backed jackals and hares, ground squirrels and mongooses. Perhaps this relationship is not surprising, considering the seasonal diets of jackals on BGF comprised 19–36% (frequency of occurrence) ground squirrels, 7–27% hares and 0–12% small carnivores, primarily yellow mongooses (Klare *et al.*, 2010). The effects of black-backed jackals on smaller species may be similar to that shown in North America for coyotes

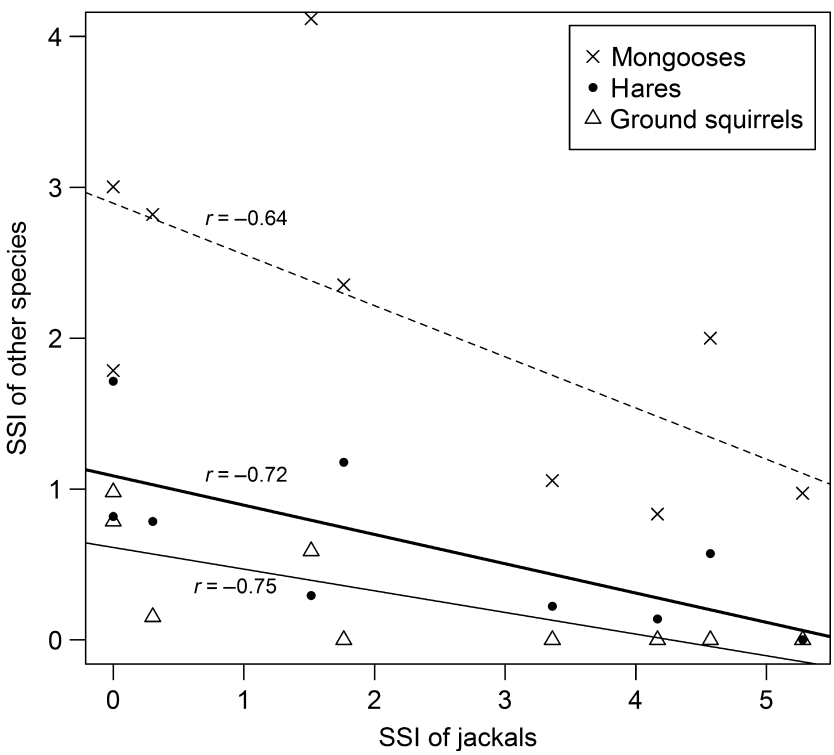

Fig 1 Regression analyses showing the significant negative relationship between the scent-station index (SSI) of black-backed jackals and mongooses (mostly yellow mongoose), hares and South African ground squirrels from nine transects across three sites in South Africa, 2007

(*Canis latrans*), whose numbers have been inversely related to numbers of a wide variety of smaller carnivores and small prey (Crooks & Soule, 1999; Kamler *et al.*, 2003; Ripple *et al.*, 2013). In fact, our review of previous studies showed that black-backed jackals consume or kill at least 17 species of smaller carnivores from six families (Table 1). Although consumption of small carnivores often was low (<5% of diets) in the reviewed studies, and some consumption might have been from carrion, our review nevertheless indicates that jackals have the potential to affect a wide diversity of smaller species. We recommend future research that investigates the effects of black-backed jackals on numbers of smaller species, as this will lead to a better understanding of the ecological role of jackals in ecosystems, especially in areas where this species is the dominant carnivore. Future research also is needed regarding the effects of apex predators on black-backed jackals, as this may affect the relationships between jackals and smaller carnivores and prey.

Table 1 Review of carnivore species found in scats (SC) or stomachs (ST) of black-backed jackals, or reported to have been killed (KI) by black-backed jackals

Species	Data type	Study
Hyaenidae		
Aardwolf (*Proteles cristatus*)	SC	1
Canidae		
Bat-eared fox (*Otocyon megalotis*)	SC, KI	2, 3, 4, 5, 6
Cape fox (*Vulpes chama*)	KI	3, 7
Domestic dog (*Canis lupus familiaris*)	ST	8, 9
Felidae		
Caracal (*Caracal caracal*)	SC, ST	10, 11
African wild cat (*Felis silvestris*)	ST	8
Black-footed cat (*Felis nigripes*)	KI	12
Domestic cat (*Felis silvestris catus*)	ST	9
Mustelidae		
Striped polecat (*Ictonyx striatus*)	SC, ST	2, 8, 10, 11, 13
African striped weasel (*Poecilogale albinucha*)	SC	2, 10
African clawless otter (*Aonyx capensis*)	SC	10
Herpestidae		
Yellow mongoose (*Cynictis penicillata*)	SC, ST	2, 11, 14
Cape grey mongoose (*Galerella pulverulenta*)	SC, ST	8, 10
Meerkat (*Suricata suricatta*)	ST	11
Dwarf mongoose (*Helogale parvula*)	KI	15
White-tailed mongoose (*Ichneumia albicauda*)	SC	13
Viverridae		
Small-spotted genet (*Genetta genetta*)	SC	2, 10, 16

(1) Brassine & Parker (2012); (2) Klare *et al.* (2010); (3) Kamler, Klare & Macdonald (2012a); (4) Schaller (1972); (5) Nel & Maas (2004); (6) Smithers (1971); (7) Stuart & Stuart (2004); (8) Bothma (1971); (9) Grafton (1965); (10) Do Linh San *et al.* (2009); (11) Kok (1996); (12) J. F. Kamler & A. Sliwa, pers. obs.; (13) Rowe-Rowe (1983); (14) Kamler *et al.* (2012b); (15) Lamprecht (1978); (16) Kaunda & Skinner (2003).

Acknowledgements

We thank the landowners for cooperating with this study and McGregor Museum and De Beers Consolidated Mines for providing logistical support. Funding was provided by a small grant to JMB from the Zoological Society of London, John Ray Trust and St. Anne's College (Oxford University); a Research Fellowship to JFK from the Wildlife Conservation Society; and a Marie Curie Fellowship to JFK from the European Commission.

References

Blaum N., Tietjen B. & Rossmanith E. (2009) Impact of livestock husbandry on small- and medium-sized carnivores in Kalahari Savannah Rangelands. *J. Wildl. Manage.* **73**, 60–67.

Bothma J.P. (1971) Food of *Canis mesomelas* in South Africa. *Zool. Afr.* **6**, 195–203.

Brassine M.C. & Parker D.M. (2012) Does the presence of large predators affect the diet of a mesopredator? *Afr. J. Ecol.* **50**, 243–246.

Crooks K.R. & Soule M.E. (1999) Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* **400**, 563–566.

Do Linh San, E., Malongwe, N.B., Fike, B., Somers, M.J. & Walters, M. (2009) Autumn diet of black-backed jackals (*Canis mesomelas*) in the thicket biome of South Africa. *Wildl. Biol. Pract.* **5**, 96–103.

Drew G.S., Fagre D.B. & Martin D.J. (1988) Scent-station surveys for cottontail rabbit populations. *Wildl. Soc. Bull.* **16**, 396–398.

Grafton R.N. (1965) Food of the black-backed jackal: A preliminary report. *Zool. Afr.* **1**, 41–53.

Kamler J.F., Ballard W.B., Gilliland R.L., Lemons P.R. & Mote K. (2003) Impacts of coyotes on swift foxes in northwestern Texas. *J. Wildl. Manage.* **67**, 317–323.

Kamler J.F., Klare U. & Macdonald D.W. (2012a) Seasonal diet and prey selection of black-backed jackals on a small-livestock farm in South Africa. *Afr. J. Ecol.* **50**, 299–307.

Kamler J.F., Stenkewitz U., Klare U., Jacobsen N.F. & Macdonald D.W. (2012b) Resource partitioning among cape foxes, bat-eared foxes, and black-backed jackals in South Africa. *J. Wildl. Manage.* **76**, 1241–1253.

Kamler J.F., Stenkewitz U. & Macdonald D.W. (2013) Lethal and sublethal effects of black-backed jackals on cape foxes and bat-eared foxes. *J. Mammal.* **94**, 295–306.

Kaunda S.K.K. & Skinner J.D. (2003) Black-backed jackal diet at Mokolodi nature reserve, Botswana. *Afr. J. Ecol.* **41**, 39–46.

Klare U., Kamler J.F., Stenkewitz U. & Macdonald D.W. (2010) Diet, prey selection, and predation impact of black-backed jackals in South Africa. *J. Wildl. Manage.* **74**, 1030–1042.

Kok O.B. (1996) Dieetsamstelling van enkele karnivoor-soorte in die Vrystaat, Suid-Afrika. *S. Afr. J. Wildl. Sci.* **92**, 393–398.

Lamprecht J. (1978) On diet, foraging behaviour and interspecific food competition of jackals in the serengeti national park, East Africa. *Z. Saugetierkunde* **43**, 210–223.

Liebenberg L. (1990) *A Field Guide to the Animal Tracks of Southern Africa*. David Philip Publishers, Claremont, South Africa.

Nel J.A.J. & Maas B. (2004) Bat-eared fox (*Otocyon megalotis*). In: *Canids: Foxes, Wolves, Jackals and Dogs* (Eds C. Sillero-Zubiri, M. Hoffman and D.W. Macdonald). IUCN/SSC Canid Specialist Group, Cambridge, UK.

Prugh L.R., Stoner C.J., Epps C.W., Bean W.T., Ripple W.J., Laliberte A.S. & Brashares J.S. (2009) The rise of the mesopredator. *Bioscience* **59**, 779–791.

Ripple W.J., Wirsing A.J., Wilmers C.C. & Letnic M. (2013) Widespread mesopredator effects after wolf extirpation. *Biol. Cons.* **160**, 70–79.

Ritchie E.G. & Johnson C.N. (2009) Predator interactions, mesopredator release and biodiversity conservation. *Ecol. Lett.* **12**, 982–998.

Roemer G.W., Gompper M.E. & Van Valkenburgh B. (2009) The ecological role of the mammalian mesocarnivore. *Bioscience* **59**, 165–173.

Roughton R.D. & Sweeny M.W. (1982) Refinements in scent-station methodology for assessing trends in carnivore populations. *J. Wildl. Manage.* **46**, 217–229.

Rowe-Rowe D.T. (1983) Black-backed jackal diet in relation to food availability in the Natal Drakensberg. *S. Afr. J. Wildl. Res.* **13**, 17–23.

Sargeant G.A., Johnson D.H. & Berg W.E. (1998) Interpreting carnivore scent-station surveys. *J. Wildl. Manage.* **62**, 1235–1245.

Schaller G.B. (1972) *The Serengeti Lion: A Study of Predator-prey Relations*. University of Chicago Press, Chicago.

Smithers, R.H.N. (1971) *The Mammals of Botswana. Museum Memoir 4*. The Trustees of the National Museum of Rhodesia, Harare, Zimbabwe.

Stuart C. & Stuart T. (1994) *A Field Guide to the Tracks and Signs of Southern and East African Wildlife*. Southern Book Publishers, Johannesburg.

Stuart C. & Stuart T. (2004) Cape fox (*Vulpes chama*). In: *Canids: Foxes, Wolves, Jackals and Dogs* (Eds C. Sillero-Zubiri, M. Hoffman and D.W. Macdonald). IUCN/SSC Canid Specialist Group, Cambridge, UK.

(*Manuscript accepted 04 September 2013*)

doi: 10.1111/aje.12125