

Carcasses increase the probability of predation of ground-nesting birds: a caveat regarding the conservation value of vulture restaurants

A. Cortés-Avizanda, M. Carrete, D. Serrano & J. A. Donazar

Department of Conservation Biology, Estación Biológica de Doñana, CSIC, Sevilla, Spain

Keywords

facultative scavengers; nest predation; opportunistic predators; supplementary feeding; vulture restaurant.

Correspondence

Ainara Cortés-Avizanda, Department of Conservation Biology, Estación Biológica de Doñana, CSIC Avda M^a Luisa s/n 41013 Sevilla, Spain.

Email: ainara@ebd.csic.es

Received 2 October 2008; accepted 27 November 2008

doi:10.1111/j.1469-1795.2008.00231.x

Abstract

Carcasses not only recruit carrion-eaters, but can also attract facultative scavengers which could predate on species living in the surroundings. At supplementary feeding stations ('vulture restaurants') carcasses are available permanently, posing a conservation dilemma: enhancing populations of endangered scavengers might introduce a predation pressure on non-target species. Here, we test if nest predation risk on ground-nesting birds increases near carcasses in Fuerteventura Island (Canary Archipelago). This is an optimal scenario for performing this study because there is a simple community of ground-nesting birds and facultative scavengers; carrion-eaters feed regularly in a unique vulture restaurant but also exploit scattered carcasses of goats. We placed artificial nests along different lines located at variable distances (200 m to 34 km) from the vulture restaurant or from single carcasses. Sixty-seven per cent of lines and up to 90% of nests within lines were predated. Predation risk was higher in lines near carcasses, that is single carcasses or the vulture restaurant. Thus, our study alerts that choosing the location for vulture restaurants may be the key not only for scavengers but also for the conservation of the species living nearby.

Introduction

Animal carcasses appear with a variable spatio-temporal predictability (Rose & Polis, 1998; Ostfeld & Keesing, 2000) and affect ecosystem diversity and functioning (Towne, 2000; DeVault, Rhodes & Shivik, 2003; Roth, 2003; Melis *et al.*, 2004). They provide the primary food resource for guilds of scavengers composed not only of specialist but also of facultative carnivore and avian scavengers (Kristan & Boorman, 2003; Wilmers *et al.*, 2003). These aggregations of facultative scavengers, which are also important predators, can increase predatory pressure in the area surrounding carcasses having profound impacts on prey species (Cortés-Avizanda *et al.*, 2009).

Currently, stock-raising and big-game hunting are ensuring that the availability of vertebrate carcasses, an otherwise spatially random food resource, become predictable at certain sites (Wilmers *et al.*, 2003; Gilbert *et al.*, 2007). A particular case are the so-called 'vulture restaurants' (places with a constant carcass supply) which are increasingly considered key management tools in the worldwide conservation of endangered scavenger populations (Koenig, 2006; Swan *et al.*, 2006). However, this management action can trigger local scale processes associated with the attractiveness of vulture restaurants for facultative scavengers (Piper, 2006). In temperate and warm regions, where vulture restaurants are placed within the range of endangered steppe

birds (Gangoso *et al.*, 2005), they can lead to undesirable predation pressures and therefore to conservation conflicts.

Using as a study model a simple scavenger community in the Canary Islands, we examined whether carcasses (both single and aggregated in a vulture restaurant) increase nest predation risk for steppe birds by attracting facultative scavengers to their vicinity.

Study area and methods

We conducted the study in the spring of 2006 (26 March to 1 April) on the island of Fuerteventura (Canary Archipelago), where both natural and human-provided carcasses are available (Gangoso *et al.*, 2005). Goat herds roam freely on the island and their carcasses become available for scavengers. Moreover, there is a vulture restaurant in the centre of the island (Fig. 1) where goat and pig carcasses (1–4 per week) and slaughterhouse remains (*c.* 200 kg week⁻¹) are left to provide supplementary food for the endemic endangered Egyptian vulture *Neophron percnopterus majorensis*. Thus, our research was carried out within a scenario in which both predictable and unpredictable carcasses are found. Potential nest predators in the island are native facultative avian scavengers (Egyptian vultures, common ravens *Corvus corax* and yellow-legged gulls *Larus michaellis*); wild carnivores are absent and only a few feral cats *Felis catus* and dogs



Figure 1 Study area showing the percentage of nest predated (in black) and the presence of fresh carcasses (black arrows; the thickest one shows the vulture restaurant).

Canis familiaris are occasionally encountered in the vicinity of towns. Ground-nesting species are mainly steppe birds such as lesser short-toed larks *Calandrella rufescens*, Berthelot's pipits *Anthus berthelotti* and, locally, cream-coloured coursers *Cursorius cursor*, stone curlews *Burhinus oediconemus*, black-bellied sandgrouses *Pterocles orientalis* and houbara bustards *Chlamidotys undulata*. Thus, this area constitutes an optimal scenario for testing the hypothesis that aggregations of facultative scavengers around carcasses can increase predation pressure on surrounding passerine nests.

Inferences drawn from data generated by well-designed artificial nest studies can be useful in addressing a number of ecological questions (Moore & Robinson, 2004). Thus, we constructed 312 artificial nests imitating those of two steppe species with different nest-building patterns: the lesser short-toed lark which builds a typical passerine nest in a shallow scrape under a small shrub, and the cream-coloured coursier which lays its eggs in a shallow scrape on bare ground without any nesting material. We placed 25–30 artificial nests separated by *c.* 30 m along 12 lines (312 nests in total) grouped in five different zones at different distances from the vulture restaurant (200–33 500 m; Fig. 1) and far from any human settlement. Within each zone the distance between paired lines varied between around 700 and 1500 m. Lark nests were simulated by using natural straw, while coursier nests were built by just creating a shallow scrape. Within each nest, we put two fresh Japanese quail eggs to

imitate natural clutches. Nest positions were recorded with a GPS to avoid visible signs to mark nests. Artificial nests were placed and examined at dawn and dusk to avoid attracting predators. Lines were checked at least once a day over 5–6 days (total exposure time ranged from 53 to 71 daylight hours; mean \pm SD: 61.5 ± 6.3). A nest was considered predated when at least one egg disappeared or showed evident signs of damage. During each control we noted the presence and number of facultative scavengers observed near lines (<100 m), either perched or flying, as well as carcasses in the surroundings (<200 m). Besides those of the vulture restaurant, two fresh carcasses (one goat carcass and one yellow-legged gull) were found near different lines (Fig. 1).

We used generalized linear mixed models (GLMM) (Littel *et al.*, 1996) to relate the abundance of facultative scavengers (link function: logarithmic, error distribution: Poisson, dependent variable: number of Egyptian vultures, ravens or yellow-legged gulls per visit) and nest predation (link function: logit, error distribution: binomial, dependent variable: predated and non-predated nest) to the presence of fresh carcasses (single carcasses or aggregated in the vulture restaurant), and distance to the vulture restaurant, while controlling for nest and line characteristics (Table 1). Models were fitted by using a forward stepwise procedure (Donázar, Hiraldo & Bustamante, 1993), where significant effects ($P < 0.05$) were retained. To avoid non-independence of the data, all models included 'line' nested in 'zone' as a random term.

Table 1 Explanatory variables used in the GLMMs aimed at determining factors influencing (a) predator–scavenger abundance, (b) the probability of nest predation

Carcass availability	
(1) Presence (1/0) of fresh carcasses close (<200 m) to the line of nests. (a) (b)	
(2) Distance (m) to the vulture restaurant (a) (b)	
Abundance of predator–scavengers	
(3) Number of common ravens observed during each line control (b)	
(4) Number of Egyptian vultures observed during each line control (b)	
(5) Number of yellow-legged gulls observed during each line control (b)	
Nest site characteristics	
(6) Type of nest: 'short-toed lark'/'cream-coloured courser' (b)	
(7) Scrub identity (<i>Salsola/Sueda</i>) (only for 'short-toed lark' nests) (b)	
(8) Height (cm) of the scrub (only for 'short-toed lark' nests) (b)	
Line habitat characteristics ^a	
(9) Percentage of grass, camephyte and total vegetation coverage considering 4% categories (0–25; 25–50; 50–75; 75–100) (b)	
(10) Vegetation height (cm), measured as the mean height of the five nearest plants to the observer (b)	
(11) Percentage of ground covered by stones (b)	

^aEstimated visually following Carrete *et al.* (in press).

GLMM, generalized linear mixed model.

Results

Numbers of common ravens and Egyptian vultures were positively related to distance to the vulture restaurant ($F_{1,57} = 4.31$, $P = 0.042$; and $F_{1,58} = 4.32$, $P = 0.042$, respectively), with maximum numbers (15 common ravens and nine Egyptian vultures) in the closest line. Abundance of yellow-legged gulls was not correlated to the explanatory variables considered.

Nest predation was detected in 67% of the lines, with a maximum frequency within lines of 92% (mean \pm SD: 20.0 ± 33.8 ; $n = 12$; Fig. 1). In all cases the eggs were extracted, broken and eaten in the immediate vicinity of the nest and, when available, the structure of the nests was completely destroyed. On two occasions we discovered common ravens predating on nests in this fashion. Lines with carcass presence showed higher predation rates (8–92%) than their respective paired lines where carcasses were absent (0–12%, see Fig. 1). The probability of nest predation increased with carcass availability ($F_{1,302} = 100.3$, $P < 0.0001$) and raven abundance ($F_{1,57} = 4.3$, $P = 0.0424$) but decreased with vegetation cover ($F_{1,302} = 78.0$, $P < 0.0001$). Once carcass presence was included in the model, no other variable significantly improved it significantly. This last result indicates that nest predation risk increases when a carcass appears.

Discussion

Carcasses can play an important role in ecosystem diversity and community structure (DeVault *et al.*, 2003). Indeed, we show how fresh carrion, both scattered and concentrated at

predictable sites such as vulture restaurants, can increase nest predation risk in their immediate surroundings (*c.* 500 m) due to the aggregation of scavengers which are also facultative predators (or vice versa). This result, obtained on an island with a relatively simple vertebrate community, should be taken into account when considering other regions where much more complex assemblages of carrion-eaters with broad trophic niches are present (Hiraldo, Blanco & Bustamante, 1991; Travaini *et al.*, 1998; Selva & Fortuna, 2007). Experiments with artificial nests may not replicate predation rates on natural populations (Weidinger, 2001), thus we encourage future research designed to evaluate the effects of carcasses on non-target species breeding near vulture restaurants.

The vulture restaurant is a special case of a carcass site where facultative scavengers concentrate permanently because of a constant food supply. There, the probability of predation risk could be persistent over time, having a stronger effect on the population dynamics of prey species. Although our study was not designed to detect differences between single, scattered carcasses and vulture restaurants, previous studies support this possibility (Kristan & Boorman, 2003; Cortés-Avizanda *et al.*, 2009). Thus, information regarding populations of sympatric endangered prey species should be taken into account during the design of vulture restaurants to avoid conflicts between conservation strategies. In particular, species of conservation concern such as most of those living in open habitats can be seriously affected by secondary predation (Yanes & Suárez, 1996), and their distribution should be considered during planning.

Vulture restaurants are a widespread tool for scavenger conservation, and current legislation often promotes their establishment as the only alternative to extensive ranching. However, they are not a *panacea* and different studies are showing negative consequences for target populations (e.g. Carrete, Donázar & Margalida, 2006; Blanco *et al.*, 2007; Lemus *et al.*, 2008) as well as for non-target species (Cortés-Avizanda *et al.*, 2009; present results). In the latter sense, whole ecosystem management should be favoured instead of single-species approaches, which can trigger undesirable effects on species of conservation concern.

Acknowledgements

M. de la Riva helped with GIS, and L. Gangoso, A. Trujillano and R. Agudo helped during field work. J.L. Tella and R. Jovani reviewed earlier drafts of the paper. The Cabildo Insular de Fuerteventura gave logistic support. The LIFE04 NAT/ES/000067 and the project CGL2004-00270/BOS funded this research.

References

- Blanco, G., Lemus, J.A., Grande, J., Gangoso, L., Grande, J.M., Donázar, J.A., Arroyo, B., Frias, O. & Hiraldo, F. (2007). Geographical variation in cloacal microflora and bacterial antibiotic resistance in a threatened avian

- scavenger in relation to diet and livestock farming practices. *Environ. Microbiol.* **9**, 1738–1749.
- Carrete, M., Donazar, J.A. & Margalida, A. (2006). Density-dependent productivity depression in Pyrenean bearded vultures: implications for conservation. *Ecol. Appl.* **16**, 1674–1682.
- Carrete, M., Serrano, D., Illera, J.C., López, G., Vögeli, M., Delgado, A. & Tella, J.L. (in press) Goats, birds and emergent diseases: apparent and hidden effects of exotic species on an island environment. *Ecol. Appl.*
- Cortés-Avizanda, A., Selva, N., Carrete, M. & Donazar, J.A. (2009) Effects of carrion resources on herbivore spatial distribution are mediated by facultative scavengers. *Basic Appl. Ecol.* (Online DOI: 10.1016/j.baae.2008.03.009).
- DeVault, T.L., Rhodes, O.E. & Shivik, J.A. (2003). Scavenging by vertebrates: behavioural, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems. *Oikos* **102**, 225–234.
- Donazar, J.A., Hiraldo, F. & Bustamante, J. (1993). Factors influencing nest site selection, breeding density and breeding success in the bearded vulture (*Gypaetus barbatus*). *J. Appl. Ecol.* **30**, 500–514.
- Gangoso, L., Donazar, J.A., Palacios, C.J., Hiraldo, F. & Scholz, S. (2005). Contradiction in conservation of island ecosystems: plants, introduced herbivores and avian scavengers in the Canary islands. *Biodivers. Conserv.* **15**, 2231–2248.
- Gilbert, M., Watson, R.T., Ahmed, S., Asim, M. & Johnson, J.A. (2007). Vulture restaurants and their role in reducing diclofenac exposure in Asian vultures. *Bird Conserv. Int.* **17**, 63–77.
- Hiraldo, F., Blanco, J.C. & Bustamante, J. (1991). Unspecialized exploitation of small carcasses by birds. *Bird Study* **38**, 200–207.
- Koenig, R. (2006). Vulture research soars as the scavengers' numbers decline. *Science* **312**, 1591–1592.
- Kristan, W.B. & Boarman, W. (2003). Spatial pattern of risk of common raven predation on desert tortoises. *Ecology* **84**, 2432–2443.
- Lemus, J.A., Blanco, G., Grande, J.M., Arroyo, B., García-Montijano, M. & Martínez, F. (2008). Antibiotics threaten wildlife: circulating quinolone residues and disease in avian scavengers. *Plos One* **3**, e1444.
- Littel, R.C., Milliken, G.A., Stroup, W.W. & Wolfinger, R.S. (1996). *SAS system for mixed models*. Cary, USA: SAS Institute Inc.
- Melis, C., Teurlings, J., Linnell, J.D., Andersen, R. & Bordoni, A. (2004). Influence of a deer carcass on Coleopteran diversity in a Scandinavian forest: a preliminary study. *Eur. J. Wildl. Res.* **50**, 146–149.
- Moore, R.P. & Robinson, W.D. (2004). Artificial bird nests, external validity, and bias in ecological field studies. *Ecology* **85**, 1562–1567.
- Ostfeld, R.S. & Keesing, F. (2000). Pulsed resources and community dynamics of consumers in terrestrial ecosystems. *Trends Ecol. Evol.* **15**, 232–237.
- Piper, S.E. (2006). Supplementary feeding programmes: how necessary are they for the maintenance of numerous and healthy vulture populations? *Proceedings of the international conference on conservation and management of vulture populations*: 41–50 Houston, D.C. & Piper, S.E. (Eds). Greece: Natural History Museum of Crete WWF.
- Rose, M.D. & Polis, G.A. (1998). The distribution and abundance of coyotes: the effect of allochthonous food subsidies from the sea. *Ecology* **79**, 998–1007.
- Roth, J.D. (2003). Variability in marine resources affects arctic fox population dynamics. *J. Anim. Ecol.* **72**, 668–676.
- Selva, N. & Fortuna, M.A. (2007). The nested structure of a scavenger community. *Proc. Roy. Soc. Lond. Ser. B* **274**, 1101–1108.
- Swan, G.E., Cuthbert, R., Quevedo, M., Green, R.E., Pain, D.J., Bartels, P., Cunningham, A.A., Duncan, N., Meharg, A.A., Oaks, J.L., Parry-Jones, J., Shultz, S., Taggart, M.A., Verdoorn, G. & Wolte, K. (2006). Toxicity of diclofenac to Gyps vultures. *Biol. Lett.* **2**, 279–282.
- Towne, E.G. (2000). Prairie vegetation and soil nutrient responses to ungulate carcasses. *Oecologia* **122**, 232–239.
- Travaini, A., Donazar, J.A., Rodríguez, A., Ceballos, O., Funes, M., Delibes, M. & Hiraldo, F. (1998). Use of European hare (*Lepus europaeus*) carcasses by an avian scavenging assemblage in Patagonia. *J. Zool. (Lond.)* **246**, 175–181.
- Weidinger, K. (2001). How well do predation rates on artificial nests estimate predation on natural passerine nests? *Ibis* **143**, 632–641.
- Wilmers, C.C., Stahler, D.R., Crabtree, R.L., Smith, D. & Getz, W.M. (2003). Resource dispersion and consumer dominance: scavenging at wolf and hunter-killed carcasses in Greater Yellowstone, USA. *Ecol. Lett.* **6**, 996–1003.
- Yanes, M. & Suárez, F. (1996). Incidental nest predation and lark conservation in an Iberian semiarid shrubsteppe. *Conserv. Biol.* **10**, 881–887.