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Behavioural reactions of desert bighorn sheep to avian scavengers

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I report previously undocumented encounters between avian scavengers and desert bighorn sheep (*Ovis canadensis nelsoni*). These encounters are of interest because they occurred only during the nursery season when lamb mortality was high. Desert bighorn sheep responded to the presence of avian scavengers with typical anti-predator behaviours, which may indicate that avian scavengers are potential predators *or* that desert bighorn sheep are unable to distinguish between avian scavengers and avian predators.

In the south-western deserts of North America, a facultative scavenger, the common raven (*Corvus corax*) and an obligate scavenger, the turkey vulture (*Cathartes aura*) are sympatric with desert bighorn sheep. Here I report encounters between the sheep and these avian scavengers, which occurred only during the nursery season (March–July), when the sheep responded with anti-predator behaviours.

Data were collected at Grand Canyon National Park (GCNP) between October 1985 and July 1986 (Stockwell, Bateman & Berger, 1991). On 18 March 1986 the first lamb was observed and, by 1 May 1986, 91% of the ewes were accompanied by lambs. I defined the nursery season as from 18 March to 30 July 1986 when the study terminated. Lamb mortality (estimated from lamb to ewe ratios) was relatively high during the nursery season (18 March–30 July 1986) when approximately 35% of the lambs disappeared and were presumed dead (Stockwell, 1989).

During the nursery season, avian scavengers were observed within approximately 100 m of bighorn on 13 occasions (five raven, eight turkey vulture) (Table I). Because turkey vultures migrated into the study site after the beginning of the nursery season, an analysis of seasonal encounter rates would be limited to ravens, but small sample sizes ($n=5$) precluded such a comparison. However, no encounters were observed prior to the onset of the nursery season.

Ewes appeared to regard avian scavengers as potential predators. In 11 of 13 encounters, ewes reacted with typical anti-predator behaviours (Geist, 1971; Berger, 1978*b*) including: (a) alarm (vigilance and/or foot stomping) ($n=10$); (b) fleeing ($n=3$); and (c) aggression (charging toward the bird) ($n=3$).

Vigilance was the only reaction in four of the encounters in which bighorn ewes reacted to the presence of avian scavengers. To distinguish between alarm vigilance and vigilance displayed during foraging, I used foraging efficiency data of undisturbed bighorn ewes to estimate an expected level of vigilance (see Stockwell *et al.*, 1991). These data were compared to the rate of vigilance in the presence of avian scavengers. During the nursery season, undisturbed bighorn exhibited vigilance at 16% ($n=120$) (Stockwell *et al.*, 1991), however, bighorn responded with vigilance in 76·9% of the scavenger encounters ($n=13$). Using the former figure as an expected level of vigilance, bighorn were more vigilant than expected when scavengers were present ($\chi^2=35{\cdot}9$, $P<0{\cdot}001$).

TABLE I

Interactions between ravens or vultures with desert bighorn sheep

Date	Scavenger	Bighorn band size (number of lambs)	Number of animals responding	Reaction of bighorn[1]
03/18	3 ravens	2 (1)	2 (1)	VG, FS
03/19	3 ravens	2 (1)	2 (1)	VG
03/19	1 raven	2 (1)	2 (1)	VG, FL[a]
04/09	1 vulture	4 (2)	4 (2)	VG, FS, FL[b]
05/09	1 vulture	11 (3)	1 (0)	VG
05/10	1 raven	11 (5)	5 (3)	VG
05/26	3 vultures	4 (2)	4 (2)	VG, FL[c]
06/17	1 vulture	1 (0)	1 (0)	CH
06/17	vultures	1 (0)	0 (0)	NR
06/18	ravens	3 (1)	3 (1)	VG
06/19	1 vulture	1 (0)	1 (0)	VG, CH
06/19	1 vulture	1 (0)	1 (0)	VG, CH
06/20	4 vultures	3 (1)	0 (0)	NR

[1] The response of bighorn included: (1) assessment which includes vigilance (VG) and foot stomping (FS); (2) aggression or charging (CH); or (3) fleeing (FL). On two occasions a lone ewe did not respond (NR).

[a] Ewe and lamb ran approximately 150 m.

[b] One ewe and lamb ran approximately 400 m; other ewe and lamb were vigilant.

[c] One lamb fell and rolled downhill twice as it ran less than 50 m.

Ewes with lambs were sensitive to the presence of avian scavengers. In eight of the nine encounters when lambs were present, bighorn ewes responded with vigilance and/or footstomping, and on three occasions certain band members responded by fleeing ($n = 3$). In one encounter a ewe and her lamb ran approximately 150 m in response to a raven. On another occasion, as a turkey vulture circled over a band of two ewes and two lambs, one ewe and her lamb ran approximately 400 m, whereas the other two animals responded only with vigilance. In the third encounter observed, a lamb fell and rolled downhill as it ran in response to three turkey vultures circling overhead; the lamb did not suffer any apparent injury.

Because band size influences bighorn anti-predator behaviour (Berger, 1978*a*), I predicted that smaller bands would be more susceptible to disturbance by avian scavengers. Although sample sizes were small, the trend in the data appears to support this prediction. In six of the seven encounters when nursery bands were small (≤ 4), every band member responded to the presence of avian scavengers. However, in one encounter with a nursery band with eight ewes and three lambs, only one ewe responded. On another occasion, in a band of six ewes and five lambs, only two ewes and three lambs responded to the presence of an avian scavenger.

In contrast, the reactions of a solitary ewe to avian scavengers were qualitatively different. In this case the ewe was observed in the same location over a period of three days. During this period, four encounters were recorded. In one encounter the ewe did not respond, but in the other three encounters the ewe responded with aggression by charging uphill in the direction of the bird ($n = 3$). In two of the encounters where the ewe charged she also responded with vigilance. The reduction in movement and the aggressive behaviour indicate the ewe may have been staying close

to a sick or dead lamb (Geist, 1971). Elenowitz (1983) reported that bighorn ewes may do this for up to seven days after the lamb's death.

Anti-predator behaviours have potential costs such as injury to escaping lambs. Although I did not observe any apparent injuries to lambs that ran in response to avian scavengers, lambs are vulnerable to fatal injury from falling (Brundige, 1987).

In light of such potential costs, why did desert bighorn respond to avian scavengers? First, these behaviours may be selectively beneficial if large avian scavengers threaten the safety of lambs. Although actual attacks by avian scavengers on bighorn lambs were not observed at GCNP, other authors have reported avian scavengers killing the young of various ungulate species (Gilbert, 1919; Larsen & Deitrich, 1970; Schaller, 1972; for more citations of ravens as predators see Heinrich, 1989). The fact that such attacks have not been reported more frequently does not necessarily diminish their significance; as Mundy (1982) suggests, perhaps we have not witnessed predation among scavengers because it is not expected.

Alternatively, if desert bighorn sheep are unable to discriminate between avian scavengers and avian predators, these behaviours may be a maladaptive by-product of a generalized anti-predator response to large avian predators. Although golden eagles (*Aquila chrysaetos*) are potential predators of bighorn lambs (Kennedy, 1948; Kelly, 1980; Nette, Burles & Hoefs, 1984), they are uncommon at GCNP (Brown, Carothers & Johnson, 1987) and were not observed to encounter desert bighorn sheep during this study. Therefore, desert bighorn sheep at GCNP may not have learned to discriminate between avian predators and avian scavengers.

Determining if avian scavengers are actual threats to ungulate neonates or if female ungulates simply cannot distinguish avian scavengers from avian predators will require additional data on the predatory behaviour of avian scavengers and the anti-predator behaviour of ungulate nursery groups.

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