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Short Note

Observations from Video Footage of Red Fox (*Vulpes vulpes*) Activity Within a Grey Seal (*Halichoerus grypus*) Breeding Colony on the UK Mainland

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Pinnipeds are highly adapted to the marine environment, yet they are constrained to give birth and raise their pups on land or ice (Bartholomew, 1970). As a result, terrestrial predators present a major threat to breeding pinnipeds; this is particularly true for newborn pups, which are especially vulnerable (Kovacs, 1987). For that reason, it is generally accepted that avoidance of terrestrial predators is one of the main selective pressures that lead pinnipeds to use remote and uninhabited locations, such as offshore islands, as breeding sites (Bartholomew, 1970; Hindell, 2009). There are numerous reports of terrestrial predators regularly scavenging or predating on ice breeding pinnipeds in Arctic regions where the seals do not have access to island sites (Andriashek et al., 1985; Derocher et al., 2002; Roth, 2002). Such predation pressures can have a considerable impact upon breeding success; for example, studies from northern Canada have reported that polar bears (*Ursus maritimus*) take up to 44% of the estimated annual pup production of ringed seals (*Phoca hispida*; Hammill & Smith, 1991). Arctic foxes (*Alopex lagopus*) have also been reported to predate on ringed seals, taking an average of 26.1% of the estimated pup production over a 3-y period (Smith, 1976). Where pinnipeds form mainland breeding colonies, terrestrial predators can also impact pup survival; for example, brown hyenas (*Parahyaena brunnea*) are known to take up to 9.6% of Cape fur seal (*Arctocephalus pusillus pusillus*) pups on mainland breeding colonies in Namibia, Africa (Wiesel, 2010).

Of the two pinniped species in the UK, harbour seals (*Phoca vitulina*) minimise the risk of terrestrial predation by forming breeding colonies on sheltered inter-tidal sites where soon after parturition, the mother and pup will enter the sea (Summers et al., 1980; Cordes et al., 2011). Grey seals (*Halichoerus grypus*) typically breed on offshore islands or inaccessible sea-caves where terrestrial predators do not occur. Unlike harbour seals, grey seal pups remain on land from birth, and mothers typically remain with the pup throughout the period of lactation (Pomeroy et al., 1999). After weaning, the pups can remain on the colony unattended for up to several weeks (Fedak & Anderson, 1982). Historically, potential terrestrial predators of UK grey seals included wolves and bears, but more recently, their major terrestrial predators have been humans, with grey seal culls occurring from 1958 to 1985 (Lambert, 2002). With changes in legislation and public opinion over the last three or four decades, which consequently resulted in the end of the grey seal culls (Lambert, 2002), there appears to have been a corresponding increase in the number of grey seal breeding colonies forming on the UK mainland. As a consequence, grey seals at these sites may have to contend with threats from terrestrial predators. The largest of these mainland breeding colonies is at Donna Nook, Lincolnshire, where pup production increased from 618 in 2000 to 1,417 in 2010. It is from Donna Nook that we present evidence of red fox (*Vulpes vulpes*) activity within a grey seal breeding colony and discuss the implications of these observations.

Donna Nook (53° 28' N, 0° 9' E) is located on the Lincolnshire coast, near North Somercotes, UK, where the Humber Estuary opens to the North Sea. Annually, between November and December, the Donna Nook National Nature Reserve is host to a large breeding colony of grey seals that gathers on the sand flats far inshore close to publicly accessible areas patrolled by Lincolnshire Wildlife Trust (LWT) wardens. The grey seals also use areas adjacent to the Defence Training Estate Donna Nook Air Weapons Range, where public access is

restricted. It was within this area of the colony that this observational study was conducted.

Nighttime video footage was recorded using a custom-made weatherproof camera constructed by Astra Communications Ltd (Bristol, UK). The specifications of the camera were 540TV colour/monochrome, 9-22 mm auto-iris lens with a minimum illumination of 0 Lux. A weatherproof infrared (IR) lamp was used to increase the area of illumination; the lamp had an output of 850 nM IR with a range of up to 40 m and an IR spread of 30°. The footage was recorded to a 32 GB SD flash memory card via a Vista MiniD400. The camera, lamp, and recording equipment were powered using two 12-v car batteries. Video footage was collected continuously between 1600 to 0800 h over three nights—25 November and 7 and 8 December 2010—resulting in a total of 2,880 min of footage. A small area (approximately 10 m × 8 m) at the periphery of the main breeding colony was filmed. The size of the area under observation was limited by the field-of-view of the camera and the IR spread.

There were a total of 10 occurrences of red fox activity recorded (which may or may not have been the same individual) on two of the three nights (25 November and 8 December 2010; Table 1). An occurrence was defined as a fox entering and leaving the frame for longer than 60 s. If the fox re-entered the frame within this time, it was assumed to be the same fox, and it was regarded as the same occurrence.

There was no direct interaction between the red fox and grey seal(s) in any of the 10 occurrences; however, on three occurrences, as a fox passed through the breeding colony, adult seals clearly displayed a head-up "alert" behaviour (Twiss et al., 2000). This behaviour was only observed on 25 November 2010 (Table 1; Figure 1a). On the same date, there were two occurrences in which a fox stopped at the same location and took an interest in something on the ground. The fox appeared to have its muzzle near to, if not on, the ground during both occurrences (Table 1; Figure 1b). On the morning of 26 November, several carrion crows (*Corvus corone*) were filmed (using the same camera) as they gathered at the same location that the fox stopped at the night before. The crows can be seen pecking and lifting at what looks to be carrion, perhaps placenta (Figure 1c), although the footage is not clear enough to state this with any confidence. Because the video was analysed after the field season ended, it was not possible to investigate the site to determine what might have been of interest to the fox and crows.

The red fox has a renowned generalist diet and is known to forage opportunistically (Leckie et al., 1998; Webbon et al., 2006). Although we acknowledge that we do not present clear evidence of scavenging or predation by red foxes, it is likely that the foxes were foraging within the breeding colony and could have been scavenging on seal placentae (approximately 3 kg each) or on dead or starving pups. The LWT wardens have found evidence of placentae that had been dragged from the sand flats to the sand dunes, and they have also found the remains of dead pups that had been fed upon—all of these findings were assumed to be the result of foxes (Lidstone-Scott, pers. obs.; most recently recorded on 24 November 2010).

It is well-documented that red fox populations suffer higher mortality rates during the winter, which occurs immediately prior to the onset of their breeding period (Heydon et al., 2000; Webbon et al., 2006). Consequently, food availability at this time of year is likely to have an important influence on pre-breeding numbers. Although the diet of red foxes in the UK over the winter period is diverse, there is no evidence that red foxes feed on grey seals (Leckie et al., 1998;

Table 1. Summary of video footage of red fox activity within the grey seal breeding colony at Donna Nook; seal disturbance is defined as a head-up "alert" behaviour by one or more seals, occurring either within 10 s prior to the fox entering the area under observation, during the time the fox is present within the area under observation, or up to 10 s after the fox left the area under observation.

Date	Seal disturbance	Time entered frame	Occurrence number
25 Nov 2010	Yes	2114 h	1
25 Nov 2010	No	2134 h	2
25 Nov 2010	Yes	2140 h	3^
25 Nov 2010	No	2145 h	4
25 Nov 2010	Yes*	2219 h	5^
25 Nov 2010	Yes*	2253 h	6
25 Nov 2010	No	2255 h	7
26 Nov 2010	No	0420 h	8
9 Dec 2010	No	0134 h	9
9 Dec 2010	No	0445 h	10

*A female with a pup in frame performs an "alert" behaviour in the direction of her pup

^The fox has its muzzle close to, if not on, the ground

Figure 1. Screen shots of the video footage showing (a) a fox passing through the colony with a pup and its mother in the centre of the frame and a mother at the lower right of the frame; both mothers are performing an "alert" behaviour; (b) a fox with its muzzle near to, if not on, the ground; the eyes of the fox assist in identifying the position of the muzzle; and (c) a carrion crow pecking at what is assumed to be carrion (perhaps placenta) in the same area that the red fox was the night before. The time date stamp (YYYY-MM-DD, HH:MM:SS) is shown in the top left corner of each screen shot. Contact the corresponding author for access to the video footage.

Webbon et al., 2006). However, the most comprehensive of these studies collected scat samples (which were used to identify hard tissue) between February and March 1999 and 2000 (Webbon et al., 2006), which is shortly after the grey seal breeding season at Donna Nook. Therefore, it is unsurprising that the authors found no evidence of red foxes feeding on grey seals. We suggest that in addition to extracting hard tissues from scat samples, PCR amplification of mitochondrial DNA segments from DNA extracted from the fox scat also should be used in order to identify suspected prey species in the absence of hard tissues (Deagle et al., 2005; Hofreiter et al., 2010). This could be done for fox scat samples collected at Donna Nook during the grey seal breeding season to ascertain if red foxes are feeding on placentae or seal pups, and if so, to what extent.

The largest contributing factors to pup mortality rates on island breeding colonies in the UK are starvation and infection, often as a consequence of the mother-pup bond not forming or being broken (Anderson et al., 1979; Redman et al., 2001). This bond is established immediately after parturition, but disturbances during this period can hinder bond formation. Although disturbance to grey seals was not recorded during every occurrence of red fox activity (Table 1), it is important to note that of the few mothers that were recorded, all had pups that were approaching weaning age (approximately 12 to 16 d old). Therefore, it was not possible to assess whether or not the activity of foxes in any way affected the mother-pup bond formation.

Previous studies have shown that interspecific disturbance to mothers and pups by lesser and greater black back gulls (*Larus fuscus* and *L. marinus*, respectively) is common on island breeding colonies where the gulls often scavenge for the placenta immediately after parturition (Twiss et al., 2003). It has been suggested that females that give birth on the periphery of a colony are possibly more susceptible to disturbance by gulls because of lower densities of seals in these colony regions (Redman et al., 2001; Twiss et al., 2003). The video evidence of red fox activity discussed in this paper was collected at the periphery of a colony; therefore, the same also may be true in regards to scavenging by foxes as it is for gulls.

A further consideration is that the distribution patterns of adult grey seals may also influence the foraging opportunities for red foxes. Previous studies show that fine-scale topography has a major influence on seal distribution on breeding colonies (Twiss et al., 2001), with heterogeneous topography at island sites leading to aggregated distributions of females (Twiss et al., 2000, 2001). Conversely, the topography of Donna Nook is more homogenous, comprising large expanses of relatively flat sand, which appears to promote a less clumped, more uniform spatial distribution of seals. A lower density of seals may allow foxes to move more easily within the colony at Donna Nook, again providing opportunities for scavenging; however, the

Table 2. Summary of the range and average pup mortality figures from three well-established island grey seal breeding colonies and Donna Nook

Location	Year(s)	Range of pup mortality	Average pup mortality	Reference
Farne Islands	1956-1962	10.5-17.9%	14.9%	Coulson & Hickling, 1964
Isle of May	1986	--	12.5%	Baker & Baker, 1988
North Rona	1959-1968	14.5-25.0%	19.2%	Boyd & Campbell, 1971
North Rona	1972	--	30.0%*^	Summers et al., 1975
North Rona	1997-1998	14.4-14.6%	14.5%*	Twiss et al., 2003
Donna Nook	2001-2010	5.2-11.5%	9.0%	Lidstone-Scott, unpub. data

*Data not from the entire breeding colony
^Pup mortality rate is an estimate

average pup mortality for the entire Donna Nook breeding colony between 2001 and 2010 was 9%, which is comparatively lower than island breeding colonies which have ranged between 12.5 and 30% (Table 2). This raises the question of how female seals respond to foxes. If mothers are more attentive of their pups or maintain closer proximity to their pups compared to island sites that are free from potential terrestrial predators, then their behaviour may help account for the lower mortality rates in pups at Donna Nook. Disentangling this explanation from the potential effects of lower seal density would require a detailed study, although Twiss et al. (2003) showed no direct link between local adult density and likelihood of pup death.

The extent to which red fox activity impacts upon grey seals during the breeding season is not clear from the observations presented herein; however, we do consider it to be highly improbable that the occurrence of foxes in this area was by random chance alone. Given that red foxes often occur in high densities (Heydon et al., 2000; Webbon et al., 2004) coupled with the small size of the area under observation, it is more than likely that fox activity is a regular occurrence throughout the breeding colony. Consequently, we suggest that the interactions between red foxes and grey seals at Donna Nook should be investigated further in order to gain a greater understanding of whether or not the presence of red foxes is affecting mother-pup behaviour, colonisation patterns, and pup mortality rates.

A final intriguing implication of the video footage discussed herein relates to the possible origin of disease outbreaks in pinnipeds. Grey seals and harbour seals have experienced several outbreaks of phocine distemper virus (PDV) since it was recognised in 1988 (Cornwell et al., 1992; Hall et al., 1992). PDV is a morbillivirus closely related to the canine distemper virus. There is much debate over (1) where PDV originated and (2) how the outbreaks began. We do not suggest that the red foxes at Donna Nook were responsible for past PDV epidemics (especially as these occurred prior to the major expansion of the Donna Nook seal colony, with 709 pups produced during the 2002 epidemic, which is approximately half of the current pup production rate; Lidstone-Scott, unpub. data). Still, the observations presented herein illustrate the potential for close proximity of canids and pinnipeds at mainland breeding sites and, therefore, the potential for cross-species zoonoses, including rabies.

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