Short Note

Cannibalism by a Male Grey Seal (*Halichoerus grypus*) in the North Sea

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Intraspecific infanticide can facilitate acquisition of resources, direct energy gains, increased opportunities for mating, or enhanced parental care for own offspring (Hrdy, 1974, 1979; Packer & Pusey, 1983; Ebensperger, 1998; Ben-David et al., 2004). For pinnipeds, intraspecific infanticide is commonly considered to be maladaptive. Pup death is often a byproduct of misdirected sexual aggression from subadult males, harassment from nonmaternal females, or misdirected maternal care (Campagna et al., 1988; Higgins & Tedman, 1990; Rose et al., 1991; Kiyota & Okamura, 2005; Boyle, 2011; Robinson, 2014). However, pinnipeds also engage in intraspecific infanticide which includes predation and consumption-that is, cannibalism. At present, male New Zealand sea lions (Phocarctos hookeri) (Wilkinson et al., 2000), northern elephant seals (Mirounga angustirostris) (see Wilkinson et al., 2000), and grey seals (Halichoerus grypus) (Bédard et al., 1993; Kovacs et al., 1996) are the only pinnipeds with documented cases of cannibalism. In this short note, we report on five observed cases of cannibalism by a male grey seal in the eastern Atlanticthe first confirmed cannibalism for the species in the North Sea, and the first since the observations by Bédard et al. (1993) and Kovacs et al. (1996) in Canada.

On 2 December 2014, on the Isle of May (IoM) breeding colony (56° 11' 07.45" N, 2° 33' 20.87" W; Figure 1), one of the authors (AB) was conducting field observations on a female grey seal as part of a behavioural physiology study. From a distance of approximately 50 m, she observed an adult male moving with a weaned pup grasped in his jaws. The pup appeared to be in good condition, was alive while being carried, and was vocalizing. The male dragged the pup into a nearby shallow freshwater pool and forced

it under the water, holding it there for several minutes, presumably to drown it. Subsequently, the male pulled back his head with the pup's neck still grasped in his jaws and anchored the pup's body with his fore flippers. This motion tore through the skin and blubber. After the initial laceration, the male anchored the pup with his claws while tearing strips of skin and blubber from the carcass with his teeth. He also used his lower jaw to scrape away at the blubber layer while leaving the skin intact. While we observed the male swallowing the torn off strips of skin and blubber, no organs were observed being eaten. When the male left the pool in the afternoon, the carcass was recovered for necropsy pathology.

We found a fresh carcass in the same pool on the morning of 3 December 2014, suggesting an overnight predation event. After removing this carcass from the pool, dedicated observations of the general area where the original sighting occurred (Figure 1) were initiated at 0918 h by AB and JO. The male positioned nearest to the pool was identified via pelage markings and facial scars as the same individual observed the previous day. At 1106 h, after travelling approximately 40 m away from the pool, he grabbed a weaned pup, again in good condition, by the neck with his jaws. There were many other weaned and nursing pups around, but the male did not investigate the targeted pup or others immediately before selection (see Movie S1; video available on the Aquatic Mammals website: www.aquaticmammalsjournal.org/index.php? option=com_content&view=article&id=10&Item id=147). The male's subsequent behaviours in this event were similar to those described from the previous day. The male was sedated on the evening of 3 December, and tagged with a Sea Mammal Research Unit (SMRU) GPS/GSM transmitter to track his movements on the breeding colony and at



Figure 1. The Isle of May (IoM) breeding colony, with main breeding areas shaded in black (Pomeroy et al., 2000). The insert depicts Kirkhaven Harbour, the area where the cannibalism events were observed in 2014. All male positions around Kirkhaven Harbour were mapped on 3 December 2014. The red dot is the focal cannibal male. White dots are other males attempting to maintain access to oestrus females. At least one other male was observed to the south-southeast, not shown in this image. The black dot is the observer position, behind a stone wall. As the aerial photograph was taken during the breeding season, breeding females and pups can be seen around the male positions.

sea after his anticipated departure from the colony. His capture mass was 189.2 kg, his nose-to-tail length was 205 cm, and his axial girth was 149 cm.

Similar behavioural observations were conducted by AB and JO during all daylight hours from 4 December 2014 until the male departed the colony on 8 December 2014. During this time, the cannibalistic male spent most of his time in or near the same pool and in close proximity to three to four breeding females with dependent pups. To ensure the removal of carcasses for necropsies was not instigating further cannibalism events, no carcasses were removed from the pool for necropsy between 3 and 6 December. Even with carcasses left in the pool, the male was not observed scavenging from prior kills, and cannibalism events on freshly selected pups were observed on three more occasions. Two events were video recorded, and the third was photographed (low light levels precluded video recording). Overall, the five observed mortalities due to the focal male's cannibalism represent 0.6% of the pups born on the colony, compared to an average pre-weaning pup mortality of 7%

for the IoM from other natural causes (Pomeroy et al., 2000); however, the cannibalism mortality was spatially localized within a small area of the colony (Figure 1).

Post-hoc analysis of the videos revealed that the sequence and durations of the stages performed were consistent across events (see Appendix, Table S1). To provide a framework for subsequent observations of this type of behaviour, we split each cannibalism sequence into three distinct phases: (1) acquisition and transport (Figure 2a-b; from the moment the male grasped the pup until arrival at the pool), (2) submersion (Figure 2c; the period from arriving at the pool until the male began to tear at the flesh), and (3) consumption (Figure 2d; the period from the onset of pulling at the flesh until he abandoned the carcass). The process of acquisition and transport comprised 30% of the total duration, averaging 12 min after selecting the pup. Submersion was typically brief, averaging 5 min, and was followed by an average of 21 min of consumption (Movie S1 & Table S1).

The behavioural pattern exhibited by the male on the IoM bears both similarities and differences to previous cases of grey seal and pinniped cannibalism. In previous reports of cannibalism from Canada, and in a recent case of interspecific predation of harbor seals by a male grey seal in the North Sea (van Neer et al., 2015), the focal male carried out similar submersion and consumption stages, but it was at sea or in shallow seawater while floating at the surface (Bédard et al., 1993; Twelves & Neill, 1994; Kovacs et al., 1996; Boyle, 2009, 2010, 2011). On the IoM, the focal male *submerged* and *consumed* the weaned pups in a pool; however, the water levels in the pool were shallow enough that the male was never fully submerged. This also allowed him to pin the pup against the substrate, potentially aiding in the tearing and consumption process.

The target selection process has not always been well documented in previous cases of pinniped cannibalism. On Amet Island, Nova Scotia, the cannibalistic male grey seal was observed grabbing pups' hind flippers and dragging them into the water (Kovacs et al., 1996). Other cases often began with a sighting of a male already holding a live or dead pup in the water (Bédard et al., 1993; Wilkinson et al., 2000; Boyle, 2010). On the IoM, the focal male ignored pups in close proximity to the pool and consistently travelled approximately 40 m (more than three times the average hourly distance-moved for a male grey seal at a breeding colony [Twiss, 1991]) away from his general location near the pool (Figure 1), passing many weaned pups along the way (see Movie S1). After selecting a weaned pup, he then grasped the pups' neck in his jaws and travelled back over rugged terrain to the pool (Movie S1 & Table S1). Weaned pups on the IoM weigh 35 to 50 kgs (Kovacs, 1987), and seal locomotion is not efficient on land (Garrett & Fish, 2014). Therefore, the effort involved in dragging a live pup to the freshwater pool is likely energetically costly. Further work is needed to determine what mechanisms underlie the selection of targets; however, the observations from the IoM suggest the process might not be entirely random.

In pinnipeds, cannibalism is often exhibited by nonterritorial, socially immature males (Kovacs et al., 1996; Wilkinson et al., 2000). If cannibalism for these individuals is driven by energy acquisition (Ebensperger, 1998), then their position on the outskirts of the colony would enable them to acquire food without incurring the costs of holding a position among oestrus females and competitor males (Anderson & Fedak, 1985; Twiss, 1991). Alternatively, in other vertebrates, cannibalism can be a sexually selected behaviour if males gain direct fitness benefits such as inducing oestrus in their victim's mothers (Packer & Pusey, 1983; Ebensperger, 1998). Killing a weaned seal pup would not induce female grey seal oestrus (Kovacs, 1987; Pomeroy et al., 1994), but it might provide fitness benefits. Most territorial male grey seals fast during the breeding season, and mating success is positively linked to length of stay (Boness & James, 1979; Anderson & Fedak, 1985; Lidgard et al., 2005). Therefore, as seen in some fish which consume their eggs in order to remain in their territory longer (Manica, 2002), cannibalism might extend a territorial male's stay on the breeding colony and increase his fitness through increased mating opportunities. The IoM male displayed behaviours suggesting social and sexual maturity. He held a terrestrial position among breeding females and other reproductively active males (Figure 1) for at least 9 d, and was observed attempting to copulate with oestrus females. The Amet Island male grey seal was considered nonterritorial but copulated with at least two females each year, suggesting sexual if not social maturity (Kovacs et al., 1996). The average arrival mass for territorial male grey seals is 256 kg (Twiss, 1991); therefore, without confirmation of total tenure duration, we cannot determine if the relatively low mass of the IoM male suggests young age, maturity but poor condition (Lidgard et al., 2005), or prolonged stay on the colony prior to our initial observations (Twiss, 1991). In order to tease apart if cannibalism for male grey seals is driven solely by energy acquisition or by sexual selection, further work is needed (1) to examine the sexual and social maturity of the IoM male and other cannibalistic males, and (2) to quantify the energetics involved with all behavioural stages of cannibalism in water and on land.

Including our observations from the IoM, cannibalism and interspecific infanticide are only confirmed for a few individuals at present around the UK and in the North Sea (Boyle, 2010; van Neer et al., 2015). However, there is very little evidence addressing how rare behaviours like cannibalism arise or if and how they are maintained in a population. Cultural transmission of new behaviours often occurs in foraging and social contexts (Baird et al., 1992; Krützen et al., 2005; Riesch et al., 2012). Some grey seals exhibit specialized foraging strategies such as predation on salmon from fish farms (Quick et al., 2004), and the species has exhibited geographically isolated breeding behaviours (Hewer, 1957; Lawson, 1993; Bishop et al., 2014). Photo-identification catalogs, individualbased behavioural observations, and diet analyses that adopt techniques such as stable isotope quantification (Kelly, 2000) could be used to identify cannibalistic males, transmission of the behaviour, and the spatial extent of foraging at higherthan-expected trophic levels.



Figure 2. The three stages of the cannibalism events: (A & B) Acquisition and transport, involving the male selecting the weaned pup (A), grasping it by the neck, and carrying it back to the freshwater pool (B). *Note the female in Panel B is not the predated pup's mother. Panels depict two different cannibalism events: Panel A was photographed on 3 December 2014, and Panel B was photographed on 4 December 2014. (C) *Submersion*, where the male pushes down on the pup with its torso and holds it submerged under water. The pup's neck is still grasped in the male's jaws. (D) *Consumption*, where the male proceeds to tear strips of blubber and flesh from the pup. During the consumption period, the male typically swallowed two times/min; *swallowing* was defined as tipping the head back to consume a piece of tissue or visible throat undulations (e.g., at 00:32:30; Movie S1). We were unable to account for the size of the pieces being consumed.

It is unknown how long cannibalism has persisted in the North Sea. From observations of the cannibalized carcasses on the IoM, the inflicted wounds appeared to be in a spiral pattern (see Thompson et al., 2015, for full necropsy description). Observations of pinniped carcasses bearing similar lesions, sometimes called corkscrew lacerations, have been reported around the UK since 1985 and around Sable Island, Canada, since 1980 (Lucas & Natanson, 2000; Bexton et al., 2012; van Neer et al., 2015). Intensive behavioural observations have been conducted on selected grey seal breeding colonies throughout their range for over 40 y (Cameron, 1967; Anderson et al., 1975). However, barring the Amet Island reports (Bédard et al., 1993; Kovacs et al., 1996), no previous sightings of this behavior have been formally reported. Many incomplete, incidental, or anecdotal observations of grey seal cannibalism; predation of harbour seals (Phoca vitulina); and predation, scavenging, and consumption of

harbour porpoises (*Phocoena phocoena*) have been reported more recently (Twelves & Neill, 1994; Boyle, 2010, 2011; Haelters et al., 2012; R. Besant, pers comm., 9 December 2014; Bouveroux et al., 2014; Stringell et al., 2015; van Neer et al., 2015). Similarly, recent DNA analyses have provided evidence for grey seals consuming (predation and scavenging) harbour porpoises in the North Sea (Jauniaux et al., 2014; van Bleijswijk et al., 2014; Leopold et al., 2015a, 2015b).

Whether these recent reports, including the IoM case presented herein, represent an increase in a rare behaviour or merely a heightened awareness of a few individuals is unknown. However, rare behaviours like cannibalism have been noted as important indicators of individual, social, or ecosystem changes in other species, such as polar bears (*Ursus maritimus*), which are exposed to rapidly changing environments (Derocher & Wiig, 1999; Stirling & Derocher, 2012). We, therefore, suggest the need for a greater emphasis to

be put on rigorous reporting, long-term collaborative record-keeping, and continued publication of the occurrences of these rare behaviours. This will enable better assessments of their prevalence through time and an understanding of their emerging importance in ecology.

Author Contributions

AB first witnessed the behaviour. AB, SM, and JO completed the subsequent fieldwork. AB, ST, and PP led the writing, with contributions from all authors.

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Appendix

Table S1. Time and date of videoed cannibalism events (n = 4) during December 2014 on the IoM grey seal breeding colony. The duration of each stage and the distance the male travelled to select a pup^{α} during the cannibalism events are noted from the video records.

Date and observer (2014)	First sighting with pup	Duration acquisition/ transport	Duration submersion	Duration consumption	Total duration	Distance (m)
2 Dec, AB	11:07:04	00:11:00†	00:02:22	00:20:05	00:33:27	20β
3 Dec, AB	11:06:42	00:09:27	00:03:21	00:15:14	00:28:02	40
4 Dec, JO	08:48:12	00:25:27	00:03:37	00:36:07	01:05:11	43
5 Dec, JO	11:21:59	00:02:17†	00:12:58	00:14:45	00:30:00	14β

† Observation/video records of this stage are incomplete.

 α The direct line distance from the first sighting of the male with a pup to the freshwater pool, estimated from Google Earth^o.

 β Distance measure is incomplete due to not observing the initial selection of the pup.