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Observations of Giant Petrels (*Macronectes* sp.) Attacking and Killing Antarctic Fur Seal (*Arctocephalus gazella*) Pups

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Antarctic fur seals (*Arctocephalus gazella*) spend a majority of their lives out at sea where they are known to be preyed on by leopard seals (*Hydrurga leptonyx*) and presumably also by killer whales (*Orcinus orca*) and sharks (Boveng et al., 1998; Walker et al., 1998; Reisinger et al., 2016). Anecdotal accounts over the past three decades also suggest that during the breeding season, when large numbers of individuals aggregate ashore, Antarctic fur seals experience land predation by northern and southern giant petrels (*Macronectes halli* and *M. giganteus*). To the best of our knowledge, however, no substantiated account has yet been published. This gap in the literature is problematic given that predation can influence population dynamics, especially terrestrial predation that mainly affects juvenile survival.

Long-term monitoring studies of Antarctic fur seal populations at South Georgia and the South Shetlands have documented ongoing declines attributed respectively to climate change-driven reductions in food availability (Forcada & Hoffman, 2014) and increased aquatic predation by leopard seals (Krause & Hinke, 2021; Krause et al., 2022). Less attention has been given to changes in terrestrial predator–prey dynamics resulting from declines in the densities of animals ashore. For example, smaller aggregations of fur seals may be less vigilant (the Many Eyes hypothesis; Olson et al., 2015) or predators may be able to harvest a larger proportion of prey at low density (the Predator Satiation hypothesis; Kramer et al., 2009). Furthermore, predators may shift facultatively between scavenging and predation, respectively, as the availability of carcasses increases or decreases (Wilson & Wolkovich, 2011). For example, scavengers may take advantage of temporarily vulnerable segments of prey populations, such as newborn young, when densities are low and carrion is scarce (Mattisson et al., 2016).

To facilitate further research addressing the drivers of Antarctic fur seal population dynamics, we provide photographic and video evidence of Antarctic fur seal pups being attacked and killed ashore and in the shallows. Since the 1980s, when the British Antarctic Survey began its long-term monitoring program of Antarctic fur seals on South Georgia, anecdotal observations of terrestrial predation of pups by otherwise scavenging birds, such as giant petrels, brown skuas (*Stercorarius antarcticus*), and snowy sheathbills (*Chionis albus*), have been made. However, aside from one account of sheathbills pecking at open wounds on seals (Doidge et al., 1984), to the best of our knowledge, no direct evidence of similar behaviors by other avian species has yet been published. To substantiate these anecdotal reports of terrestrial predation on Antarctic fur seal pups, we provide detailed verbal accounts and video evidence of two techniques frequently employed by the northern and southern giant petrel species when attacking and killing Antarctic fur seal pups: (1) pecking and (2) drowning. Interactions between giant petrels and Antarctic fur seal pups were recorded opportunistically during the 2021 breeding season at Bird Island and on the mainland of South Georgia, which together with the other islands in the South Georgia island group account for around 95% of the global pup production of Antarctic fur seals (Forcada & Staniland, 2018).

Northern and southern giant petrels are large, scavenging seabirds that breed sympatrically on South Georgia (Poncet et al., 2020). Hatching dates of both petrel species overlap with the Antarctic fur seal, gentoo penguin (*Pygoscelis papua*), and macaroni penguin (*Eudyptes chrysolophus*) breeding seasons, which range roughly from late November until February (Hunter, 1984; Duck, 1990; Barlow & Croxall, 2002). During this time, fur seal placentae and carcasses as well as penguin carcasses make up the vast majority of the petrel's diet (Hunter, 1983). Thus, so far, giant petrel feeding ecology has been described in the scientific literature as "clearing beaches of decaying matter" (Doidge et al., 1984, p. 459), although we did find an anecdotal account of giant petrels attacking macaroni penguin chicks (Horswill et al., 2016).

In the observations in this study, giant petrels mainly attacked small, unattended Antarctic fur seal pups in beach areas with a low density of adult animals. Either individually or in groups, giant petrels most frequently approached the pups from the ground and pecked under the shoulder joint, where the fore-flipper connects to the body, or at the anus. While healthy pups or pups in close proximity to their mothers could successfully fend off such attacks, weaker or unattended pups were often dragged to less dense beach areas or towards the water (Figure 1). Pecking usually created a hole in the body cavity from which the petrels tore off pieces of flesh or pulled out the pup's entrails. Pups would invariably cry out during the attack but were often too weak to crawl away (see supplementary video file, timestamp for video 1; the supplementary video file for this paper is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147). Occasionally, two or more petrels were observed attacking a single pup, which was subsequently pulled apart by the two individuals.

The natal coat of Antarctic fur seal pups lacks the water-repellent properties of adults (Irving et al., 1962). Thus, while pups do venture into the water prior to molting at around 60 days of age, they do not yet demonstrate efficient swimming and diving behavior. In the shallow waters adjacent to the breeding beaches, we observed giant petrels exploiting this opportunity by blocking swimming pups from returning to the shore until they became exhausted and drowned. During this time, the giant petrels invariably pecked under the shoulder of the pup to pull off pieces of flesh (see supplementary video file, timestamps for videos 2, 3 & 4). We observed petrels sitting on the water surface between a pup and the shore and pecking or snapping at the pup if it approached the shoreline, thereby blocking its return to the beach (see supplementary video file, timestamp for video 5). Finally, petrels were also observed actively pulling a pup towards the water or holding a pup underwater to drown it (see supplementary video file, timestamps for videos 6 & 7).

These observations (Table 1) raise a number of questions and possible directions for future work. First, northern and southern giant petrel populations on South Georgia and Bird Island have increased by 27 and 74%, respectively, from the 1980s until 2007 (Poncet et al., 2020). Over the same period, the number of Antarctic fur seals breeding on Bird Island has declined by 24%, and the average birth weight of female pups has declined by 7.8% (Forcada & Hoffman, 2014). Consequently, there are not only more giant petrels now than several decades ago, but shrinking seal

Figure 1. Giant petrel (*Macronectes* sp.) attacking an Antarctic fur seal (*Arctocephalus gazella*) pup near the water's edge

Table 1. Details of the videos accompanying our verbal descriptions of giant petrel (*Macronectes* sp.) predatory behaviors. A short textual description of each video is provided. The files have been collated, and the timestamps denote when each observation begins in the supplementary video file. Except for video 5 (date: 24 January 2022; location: Grytviken, South Georgia), all observations were filmed on 25 December 2021 at King Edward Point Beach, South Georgia. Please note the graphic context of some of the videos.

Video file	Timestamp	Textual description of video
Video 1	6 s	Giant petrel pecking under the flipper of a live pup on land, tearing off large bits of flesh and entrails.
Video 2	34 s	Giant petrel pecking under the flipper of a live pup in the water, tearing off large bits of flesh and entrails.
Video 3	52 s	Two giant petrels initially fighting over access to a pup in the water; one petrel then chases the pup and begins to peck it under the flipper.
Video 4	1 min 15 s	Giant petrel pecking under the flipper of a live pup in the water.
Video 5	1 min 27 s	Giant petrel initially preventing a pup from returning to the shore by holding its head underwater and pecking it under the flipper and anus; the attack is interrupted by a second giant petrel, at which point the pup successfully swims to shore.
Video 6	2 min 21 s	Giant petrel pecking under the flipper of a live pup, tearing off large bits of flesh and entrails; the pup was initially on land, but the petrel grabbed it by the head and attempted to drag it into the water.
Video 7	2 min 56 s	Giant petrel pecking under the flipper of a live pup in very shallow water—possibly by the force of the pecking, the pup is dragged into deeper water.

populations and lighter pups may provide the birds easier opportunistic access to weak, undefended pups. A declining fur seal population also likely corresponds with a decrease in the amount of carrion available for the giant petrels to scavenge. As this preferred food source becomes scarce, giant petrels may increasingly revert to facultative predation. A recent study conducted during two breeding seasons did find that pup mortality due to predation was higher at a low density compared to a high density breeding colony, and that predation contributed to a majority of pup deaths (Nagel et al., 2021a). Still, long-term observations are necessary to substantiate any possible relationship between fur seal population density and terrestrial pup predation by giant petrels.

Second, it is yet unclear how increased predation by giant petrels might affect fur seal population dynamics. It is possible, for instance, that by targeting small, weak pups that might otherwise have died of starvation, the overall impact of predation on population growth may not be strong. Furthermore, pups born at low density and thus under higher predation pressure may adjust their phenotype to match their environment (i.e., niche conformance; Trappes et al., 2022). This was recently suggested by Nagel et al. (2021b) who found that pups born at low density were more active and spent a greater amount of time in sheltered habitats compared with pups born at high density, which may be an adaptive behavioral response to increased predation risk.

In conclusion, declining Antarctic fur seal densities may be linked to an increase in pup mortality attributable to facultatively predatory giant petrels. Although terrestrial predation has been anecdotally observed by the long-term monitoring program carried out by the British Antarctic Survey at South Georgia, we provide the first detailed account of such behavior by giant petrels. More thorough investigations of this system through a combination of detailed, long-term field observations and demographic modeling could provide valuable information on top-down effects and ecosystem performance in the face of ongoing environmental change.

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Literature Cited

Barlow, K. E., & Croxall, J. P. (2002). Provisioning behaviour of macaroni penguins *Eudyptes chrysolophus*. *Ibis*, *144*(2), 248-258. https://doi.org/10.1046/j.1474-919X.2002.00046.x

Boveng, P. L., Hiruki, L. M., Schwartz, M. K., & Bengtson, J. L. (1998). Population growth of Antarctic fur seals: Limitation by a top predator, the leopard seal? *Ecology*, *79*(8), 2863-2877. https://doi.org/10.2307/176522

Doidge, D. W., Croxall, J. P., & Baker, J. R. (1984). Density-dependent pup mortality in the Antarctic fur seal *Arctocephalus gazella* at South Georgia. *Journal of Zoology*, *202*, 449-460. https://doi.org/10.1111/j.1469-7998.1984.tb05095.x

Duck, C. D. (1990). Annual variation in the timing of reproduction in Antarctic fur seals, *Arctocephalus gazella*, at Bird Island, South Georgia. *Journal of Zoology*, *222*, 103-116. https://doi.org/10.1111/j.1469-7998.1990.tb04032.x

Forcada, J., & Hoffman, J. I. (2014). Climate change selects for heterozygosity in a declining fur seal population. *Nature*, *511*(7510), 462-465. https://doi.org/10.1038/nature13542

Forcada, J., & Staniland, I. J. (2018). Antarctic fur seal. In B. Würsig, J. G. M. Thewissen, & K. M. Kovacs (Eds.), *Encyclopedia of marine mammals* (3rd ed., pp. 25-27). Academic Press. https://doi.org/10.1016/B978-0-12-804327-1.00046-7

Horswill, C., Ratcliffe, N., Green, J. A., Phillips, R. A., Trathan, P. N., & Matthiopoulos, J. (2016). Unravelling the relative roles of top-down and bottom-up forces driving population change in an oceanic predator. *Ecology*, *97*(8), 1919-1928. https://doi.org/10.1002/ecy.1452

Hunter, S. (1983). The food and feeding ecology of the giant petrels *Macronectes halli* and *M. giganteus* at South Georgia. *Journal of Zoology*, *200*(4), 521-538. https://doi.org/10.1111/j.1469-7998.1983.tb02813.x

Hunter, S. (1984). Breeding biology and population dynamics of giant petrels *Macronectes* at South Georgia (Aves: Procellariiformes). *Journal of Zoology*, *203*(4), 441-460. https://doi.org/10.1111/j.1469-7998.1984.tb02343.x

Irving, L., Peyton, L. J., Bahn, C. H., & Peterson, R. S. (1962). Regulation of temperature in fur seals. *Physiological Zoology*, *35*(4), 275-284. https://doi.org/10.1086/physzool.35.4.30155424

Kramer, A. M., Dennis, B., Liebhold, A. M., & Drake, J. M. (2009). The evidence for Allee effects. *Population Ecology*, *51*(3), 341-354. https://doi.org/10.1007/s10144-009-0152-6

Krause, D. J., & Hinke, J. T. (2021). Finally within reach: A drone census of an important, but practically inaccessible, Antarctic fur seal colony. *Aquatic Mammals*, *47*(4), 349-354. https://doi.org/10.1578/AM.47.4.2021.349

Krause, D. J., Bonin, C. A., Goebel, M. E., Reiss, C. S., & Watters, G. M. (2022). The rapid population collapse of a key marine predator in the northern Antarctic Peninsula endangers genetic diversity and resilience to climate change. *Frontiers in Marine Science*, *8*, 796488. https://doi.org/10.3389/fmars.2021.796488

Mattisson, J., Rauset, G. R., Odden, J., Andrén, H., Linnell, J. D. C., & Persson, J. (2016). Predation or scavenging? Prey body condition influences decision-making in a facultative predator, the wolverine. *Ecosphere*, *7*(8), e01407. https://doi.org/10.1002/ecs2.1407

Nagel, R., Stainfield, C., Fox-Clarke, C., Toscani, C., Forcada, J., & Hoffman, J. (2021a). Evidence for an Allee effect in a declining fur seal population. *Proceedings of the Royal Society B: Biological Sciences*, *288*, 2882. https://doi.org/10.1098/rspb.2020.2882

Nagel, R., Mews, S., Adam, T., Stainfield, C., Fox-Clarke, C., Toscani, C., Langrock, R., Forcada, J., & Hoffman, J. I. (2021b). Movement patterns and activity levels are shaped by the neonatal environment in Antarctic fur seal pups. *Scientific Reports*, *11*, 14323. https://doi.org/10.1038/s41598-021-93253-1

Olson, R. S., Haley, P. B., Dyer, F. C., & Adami, C. (2015). Exploring the evolution of a trade-off between vigilance and foraging in group-living organisms. *Royal Society Open Science*, *2*, 150135. https://doi.org/10.1098/rsos.150135

Poncet, S., Wolfaardt, A. C., Barbraud, C., Reyes-Arriagada, R., Black, A., Powell, R. B., & Phillips, R. A. (2020). The distribution, abundance, status and global importance of giant petrels (*Macronectes giganteus* and *M. halli*) breeding at South Georgia. *Polar Biology*, *43*(1), 17-34. https://doi.org/10.1007/s00300-019-02608-y

Reisinger, R. R., Gröcke, D. R., Lübcker, N., McClymont, E. L., Hoelzel, A. R., & de Bruyn, P. J. N. (2016). Variation in the diet of killer whales *Orcinus orca* at Marion Island, Southern Ocean. *Marine Ecology Progress Series*, *549*, 263-274. https://doi.org/10.3354/meps11676

Trappes, R., Nematipour, B., Kaiser, M. I., Krohs, U., van Benthem, K. J., Ernst, U. R., Gadau, J., Korsten, P., Kurtz, J., Schielzeth, H., Schmoll, T., & Takola, E. (2022). How individualized niches arise: Defining mechanisms of niche construction, niche choice and niche conformance. *BioScience*, biac023. https://doi.org/10.1093/biosci/biac023

Walker, T. R., Boyd, I. L., McCafferty, D. J., Huin, N., Taylor, R. I., & Reid, K. (1998). Seasonal occurrence and diet of leopard seals (*Hydrurga leptonyx*) at Bird Island, South Georgia. *Antarctic Science*, *10*(1), 75-81. https://doi.org/10.1017/S0954102098000108

Wilson, E. E., & Wolkovich, E. M. (2011). Scavenging: How carnivores and carrion structure communities. *Trends in Ecology and Evolution*, *26*(3), 129-135. https://doi.org/10.1016/j.tree.2010.12.011