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A Most Dangerous Game: Death and Injury to Birds from Porcupine Quills

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ABSTRACT.—Predation is dangerous, not only for the prey but sometimes also for the predator. Because these dangers to predators are not well understood, we document evidence of predation or scavenging by a Golden Eagle (*Aquila chrysaetos*) on a North American porcupine (*Erethizon dorsatum*) in Pennsylvania, USA, with potentially lethal consequences to the eagle. We

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also review published literature on incidence of porcupine quills causing injury or death to birds. At least nine species have been documented as having contact with porcupine quills. A minimum of 39% of these interactions resulted in death to the bird, demonstrating the risk birds face when interacting with porcupines. Predation of porcupines should be selected against and irregular, yet it apparently persists and is likely more common than currently recognized. *Received 30 April 2014. Accepted 26 September 2014.*

Key words: *Aquila chrysaetos*, birds, Golden Eagle, porcupine, predation.

Predation is dangerous not only for the prey, but also for the predator. Despite presumably strong selective pressure on predators to evolve mechanisms to either effectively subdue potentially harmful prey or to choose prey that are not dangerous, there are numerous examples of mammalian predators that are injured or killed by their prey (e.g., large ungulates; Mech and Nelson 1990, Smith et al. 2004). However, risk to birds that engage in predation is less well reported and is consequently less well understood.

It is widely assumed that birds can be injured or killed sometimes by their prey. Certainly large birds such as storks, cranes, and swans can present a risk to similarly sized attackers, and most avian predators presumably only attack large prey when they feel they have an advantage (e.g., eagles and falcons hunt flying cranes and bustard from above). Likewise, falconers anecdotally report cases where sciurid prey can bite and injure the feet of hawks and eagles. However, other mammalian and avian prey may present “hidden” defenses, and it may be less clear to a naïve (e.g., young or non-local) predator that even some small prey present risk.

Here we document the outcome for a young Golden Eagle (*Aquila chrysaetos*) of a likely predatory interaction with a North American porcupine (*Erethizon dorsatum*). We also review literature on birds injured or killed by porcupine quills, and we discuss reasons why different bird species may be exposed to porcupine quills.

MATERIALS AND METHODS

We established a network of winter camera trapping sites to document the distribution and abundance of Golden Eagles and other regional predators and scavengers in eastern North America. At each camera trap site, road-killed carcasses (predominantly white-tailed deer, *Odocoileus vir-*

ginianus) were placed as bait in small openings in forests. Adjacent, we placed a motion-sensitive trail camera to photograph animals that came to the bait to scavenge. Cameras were set ~3 m from the bait and 1 m above the ground, although the exact height depended on snow cover and site-specific characteristics. Cameras were programmed to take pictures when triggered by motion, with a maximum time interval between pictures of 1 min.

We also reviewed literature on bird-porcupine interactions by searching four databases of scientific articles (SORA [the searchable ornithological research archive; sora.unm.edu/node], Google Scholar, Web of Science, and BioOne) for the word “porcupine.” We then reviewed articles for records of avian-porcupine interactions and tabulated these results here. We also queried the USGS Bird Banding Lab and the National Eagle Repository for all records involving the word porcupine.

RESULTS AND DISCUSSION

In 2009, we operated ~100 trail camera bait sites. Over the next 5 years this number increased, reaching 236 sites in 2014. During this period, we recorded ~3.2 million pictures and documented presence at bait of at least 34 avian and 23 mammalian species. We recorded Golden Eagles at 112 out of 178 sites at which pictures were sorted and species classified. Other common avian species included American Crows (*Corvus brachyrhynchos*), Common Ravens (*Corvus corax*), Red-tailed Hawks (*Buteo jamaicensis*), Red-shouldered Hawks (*Buteo lineatus*), Turkey Vultures (*Cathartes aura*), Black Vultures (*Coragyps atratus*) and Bald Eagles (*Haliaeetus leucocephalus*).

At one site in Tuscarora State Forest, Perry County, Pennsylvania, we recorded presence of a porcupine in multiple photographs on 20 March 2014 (Fig. 1a). In some of these images, Common Ravens and a young Golden Eagle are watching the porcupine. One week later, on 28 March 2014, we recorded a young Golden Eagle with porcupine quills in its face and head (Fig. 1b). Based on lack of molt and feather replacement patterns (Bloom and Clark 2001), we aged this bird as a second year (hatched in summer 2013, ~10 months previous to being photographed). We recorded >36 pictures of this eagle, the first at 1705 EST on 28 March and the last at 1423 on 9 April 2014. On each occasion, the eagle was feeding on the bait of roadkill white-tailed deer. A bird with similar molt pattern (rectrices L4 and



FIG. 1. Images of (a) a North American porcupine (*Erethizon dorsatum*) recorded on 20 April 2014 at a scavenger bait site, as recorded by a remote-trigger trail camera; and (b) a Golden Eagle with at least four porcupine quills in its face (location of quills indicated by arrows).

TABLE 1. Bird-porcupine interactions as recorded in scientific literature. We searched SORA, GoogleScholar, Web of Science and BioOne for the word “porcupine” to populate this database. Bird species are presented in taxonomic order. See Figure 2 for a map of interactions.

Avian Species					
Common name	Latin name	Result to bird	Outcome	Region	Citation
Ruffed Grouse	<i>Bonasa umbellus</i>	8 quills in breast	Healed	Wisconsin, USA	Schorger 1961
Bald Eagle	<i>Haliaeetus leucocephalus</i>	quill in throat	Death	Montana, USA	McClelland et al. 2006
Sharp-shinned Hawk	<i>Accipiter striatus</i>	migrant, 3 quills in left foot	Removed	Michigan, USA	Kelley and Kelley 1969
Rough-legged Hawk	<i>Buteo lagopus</i>	foot injuries	Death	Wisconsin, USA	Hamerstrom 1969
Golden Eagle	<i>Aquila chrysaetos</i>	in pellet/prey remains “covered underneath in quills”	Unknown	North America	Olendorff 1976
		immature female, quills in feet	Near death	Minnesota, USA	Lano 1922
		in pellet/prey remains eaglelet in nest with quill in foot	Removed	Maine, USA	Nikula 1995
		eagle with quills in throat & intestine	Unknown	Montana, USA	McGahan 1968
		HY eagle with =>4 quills in head & face	Unknown	New Mexico, USA	Stahlecker et al. 2009
			Death	Pennsylvania, USA	Everett 1989
			Unknown	Pennsylvania, USA	this study
Great Horned Owl	<i>Bubo virginianus</i>	112 quills	Near death	Montana, USA	Wiley 1969
		1 quill in anterior neck	Removed	New York, USA	Parkes 1950
		=>66 quills in body, especially right foot	Shot	Quebec, Canada	Eifrig 1909
Peregrine Falcon	<i>Falco peregrinus</i>	quill in pellet	Unknown	Alaska, USA	Ritchie 1982
Steller’s Jay	<i>Cyanocitta stelleri</i>	quill in head, starved to death	Death	Colorado, USA	Griffin 1952
Common Raven	<i>Corvus corax</i>	failed predation attempt on porcupine	Unknown	Wisconsin, USA	Gehring 1993
		1 quill in gizzard, 1 quill in heart	Death	Wisconsin USA	Wing 1936

L5 were growing; all other tail feathers were juvenile) was repeatedly photographed without porcupine quills during 20–27 March 2014. The last known quill-free image of this bird was taken at 1007 on 27 March 2014.

We were able to identify 4 porcupine quills on the bird (Fig. 1b). At least one quill was positioned above the right eye, one ventrally between the two lower mandibles, and two on the left side of the bird’s face, one above and one below its mouth (see arrows in Fig. 1b). We observed no evidence of quills on the bird’s feet or on any other part of its body. Our evidence does not speak to whether the presence of quills on the eagle was a result of a direct predation attempt or of scavenging.

We did not record evidence of avian-porcupine interactions at any of the other 236 trail camera sites in our study. The USGS Bird Banding

Laboratory reviewed all their records (they have only saved notes since 2006) and found no records of the word “porcupine” aside from place names (e.g., “the Porcupine River, AK”). The National Eagle Repository does not keep records of this type, and the biologist there recalled only “a few occasions” where porcupine quills were present in eagle carcasses he received (D. Wiist, pers. comm.).

We reviewed literature on bird-porcupine interactions and found 17 reports of at least 9 species known to have interacted with porcupines (Table 1; Fig. 2), including one other Golden Eagle from Pennsylvania. Approximately 39% of the reported birds that were quilled by porcupines were dead or near death. Of the species reported with quills, all but one (Ruffed Grouse, *Bonasa umbellus*) are either predatory or scavenging in nature, suggesting a reasonable mechanism for

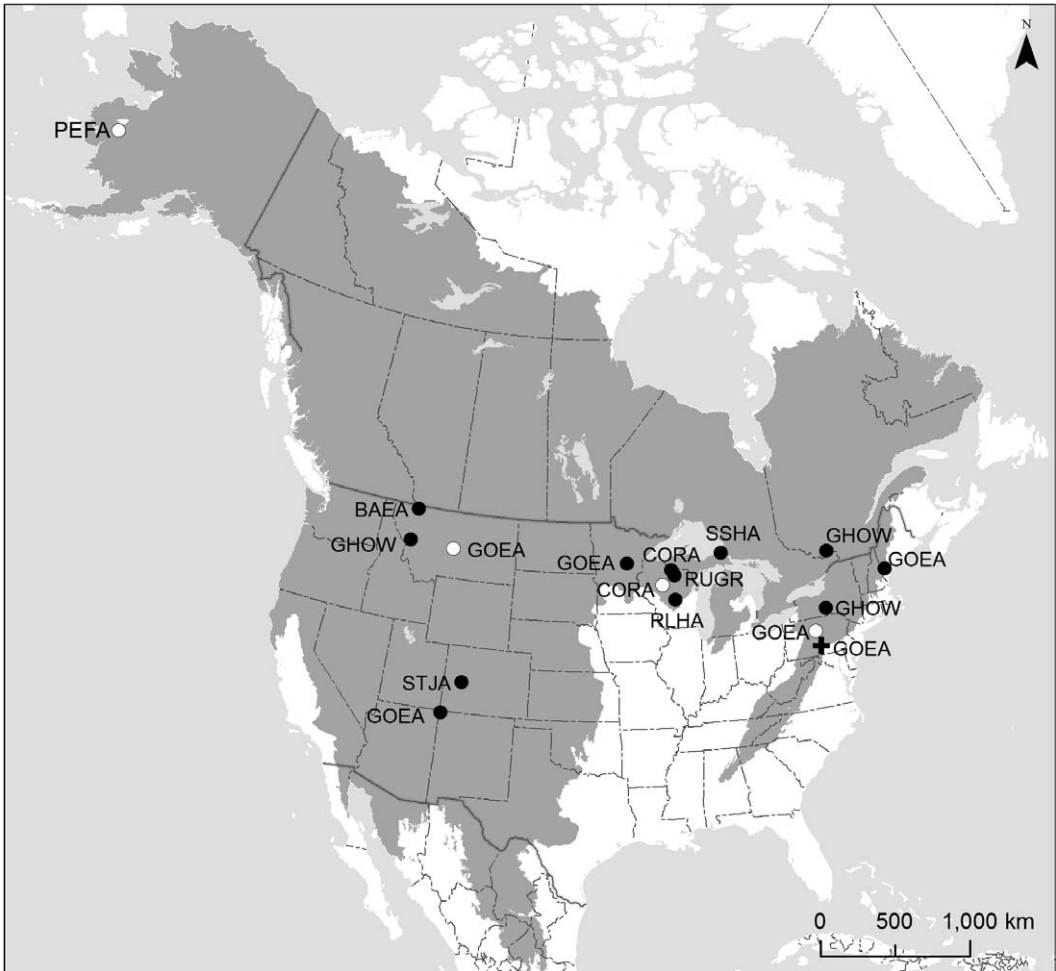


FIG. 2. Map showing locations of bird-porcupine interactions as recorded in scientific literature and overlaid on a range map for North American porcupines (*Erethizon dorsatum*). We searched SORA, GoogleScholar, Web of Science and BioOne for the word “porcupine” to populate this database. Bird species are shown with Bird Banding Lab codes, as follows: Common Raven (CORA), Bald Eagle (BAEA), Golden Eagle (GOEA), Great Horned Owl (GHOW), Peregrine Falcon (PEFA), Rough-legged Hawk (RLHA), Ruffed Grouse (RUGR), Sharp-shinned Hawk (SSHA) and Steller’s Jay (STJA). Black circles are those for which a precise location was provided, white circles are approximate locations in cases where an exact location was not provided. The black cross is the location of the bird observed in this study. See Table 1 for details associated with each interaction.

interaction between birds and porcupines. In the case of the Ruffed Grouse, the author suggests that perhaps the bird was a female guarding its nest from porcupine predation, as the quills were all in the front of its breast (Schorger 1961). This is plausible since porcupines are a known predator of ground nesting birds (Maier and DeGraff 2000), and other non-predators have been found dead, embedded with porcupine quills (Pulling 1945).

Porcupine quills are a natural “foam-filled” tube, consisting of a dense outer cortex and a

foam-filled interior core, both made entirely of α -keratin (Wang and McKittrick 2013). The quills of new world porcupines are barbed, causing them to migrate into the body of the injured animal, often with severe consequences. Quills of Old World porcupines (Hystricidae) are longer than those of the New World porcupines (Erethizontidae) and are designed to break at the tip, making them especially effective for defense (Vincent and Owers 1986). Individuals of the hedgehog family (Erinaceidae) also possess quills, although their

different structure suggests that the quills may have evolved as a natural shock absorber that incidentally also have a defensive function (Vincent and Owers 1986). Hedgehog quills are less effective at defense from avian predators, and these species are a frequent component of diet of eagles in central Asia (Katzner 2003).

It is not surprising that the vast majority of the bird-porcupine interactions in the literature involve predatory or scavenging birds. In fact, contact between porcupines and predatory birds may occur because raptors exhibit strong nest defense and will respond to porcupines (Holthuijzen and Oosterhuis 2004). However, the two species with the most recorded porcupine interactions - Golden Eagle and Great Horned Owl (*Bubo virginianus*) - are among the largest of the American raptors and the most likely to attempt to take prey as large as a porcupine. That many of these birds were dead or suffering from fatal injuries speaks to the effectiveness of porcupine quills as a defense strategy. Furthermore, of the two birds accurately aged, both were young, likely indicating that porcupine-induced lessons need not be repeated.

The act of predation can be dangerous and porcupine quills are an effective defense mechanism against many avian and mammalian predators. However, these defenses appear more effective against some species than against others. Although mammals may be killed by porcupine quills (reported in Africa, for example, Mori 2013), New World porcupines are regular prey of mustellids (Zelinski and Duncan 2004, Lofroth et al. 2007), canids (Prugh 2005), felids (McLean et al. 2005, Thompson et al. 2009), and even snakes (Duarte 2003). While these species appear with quills embedded, evidence suggests fisher (*Pekania pennati*) and cougar (*Puma concolor*) regularly include porcupine in their diets and utilize foraging mechanisms that allow them to reduce the number of quills they receive (i.e., they flip the porcupine to kill and feed via the belly, which is not as protected by quills; Sweitzer 1996). There are no bird species that are known to have similar mechanisms to allow predation on porcupines. However, it is known by falconers that certain species of desert-associated hawks will pull cactus spines from their feet (especially Harris's Hawk *Parabuteo unicinctus*; B. Millsap, pers. comm.), something that the porcupine-quilled raptors we reviewed apparently do not do.

We have no data on the survival of the quill-infested eagle that we photographed feeding on deer. However, given the effectiveness of quills as a defense mechanism against birds that we have documented and the likelihood of infection from this injury, it is unlikely to have survived long. Animal defenses against predation are often targeted at a specific taxa. The effectiveness of quills as a predation defense may provide insight into the original evolutionary pressures that supported development of quills as a defense mechanism (quills may have been targeted at avian, not mammalian predators). Furthermore, porcupine populations and distributions are increasing (Fig. 2; Payette 1987, Ilse and Hellgren 2001), making interactions between birds and porcupines more likely. Fatality rates as a result of these interactions therefore may increase, especially for immature birds, including raptors.

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