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Note

Torpor may facilitate opportunistic predation of live-trapped small mammals: a cautionary note

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Abstract
Small mammals are often key components in ecological monitoring programs, and live trapping is often used to obtain small mammal density estimates or other metrics. However, an aspect of such trapping that has received little attention is opportunistic predation of captured animals. Here, we report a Common Raven (*Corvus corax*) preying on a deermouse (*Peromyscus* spp.) after it was released from a live trap. The mouse was torpid when removed from the trap. The raven preyed on the deermouse right after it was released, likely because the mouse had not yet fully aroused from torpor and was not able to find adequate shelter or evade the raven. Best practices to avoid similar occurrences include passively warming the animal before releasing it or returning it to the trap to arouse from torpor in safety. Our observation further highlights the need for researchers to be vigilant about opportunistic predation of small mammals captured and released from live traps and to take actions to mitigate the risk, especially if the mammals are exhibiting signs of torpor.

Key words: *Corvus*; *Peromyscus*; small mammal monitoring; small mammal trapping

Small mammals are important in most terrestrial food webs as key consumers, seed dispersers, and prey. Hence, they are often key ecological indicators and important components in ecosystem monitoring programs worldwide (e.g., Solari *et al.* 2002; Avenant 2011; Meserve *et al.* 2011; Boonstra *et al.* 2018; Torre *et al.* 2018). Monitoring small mammal populations often relies on live-trapping campaigns, which permit analyses based on capture–mark–recapture designs (Krebs *et al.* 2011, 2019; Jung *et al.* 2020); however, less-invasive means to monitor small mammal populations are also being explored (e.g., camera trapping; Villette *et al.* 2016; Littlewood *et al.* 2021; Parsons *et al.* 2021). Live trapping small mammals carries with it inherent risks to captured mammals. For instance, captured individuals may die in live traps because of exposure to the elements or stress (Sealander and James 1958; Corke 1967; Ferns 1978; Montgomery 1980; Gurnell 1982; Slade *et al.* 1993; Fletcher and Boonstra 2006; Lemckert *et al.* 2006; Stephens and Anderson 2014; Jung 2016; Torre *et al.* 2016; Read *et al.* 2018). In addition, some small mammals may sustain fatal injuries while trying to escape from wire mesh live traps (Jung and O'Donovan 2005). As such, trapping protocols, best practices, and standards are often available—and continually refined—to ensure the welfare of captured individuals and increase the probability of them surviving capture and handling (Petit and Waudby 2012; Hampton *et al.* 2016; Waudby *et al.* 2019; Machtinger and Williams 2020).

One aspect of live trapping that has received scant attention in the literature is opportunistic predation of captured animals (Ferguson and Forstner 2006; Ferguson *et al.* 2008). One exception is the opportunistic predation of bats captured in mist nets, which has recently been documented and mitigations to reduce the problem have been proposed (e.g., Rocha-Mendes and Bianconi 2009; Jung *et al.* 2011; Serra-Goncalves *et al.* 2017; Gallego *et al.* 2021). Small rodents captured in pitfall traps have been reported to be predated while in traps. For example, Delicate Mouse (*Pseudomys delicatulus*) and Northern Hopping Mouse (*Notomys aquilo*) were observed being predated from pitfall traps by Ghost Bat (*Macroderma gigas*) in

Australia (Diete *et al.* 2016). In Texas, several mammalian and avian predators were observed investigating pitfall traps and preying on captured animals, with Northern Raccoon (*Procyon lotor*) and American Crow (*Corvus brachyrhynchos*) the most detected species (Ferguson *et al.* 2008). Accordingly, modifications to pitfall traps have been suggested to mitigate the risk of predation to captured animals (e.g., Aubry and Stringer 2000; Ferguson and Forstner 2006; Edwards and Jones 2014). Larger animals are also sometimes subject to opportunistic predation when live trapped. For instance, Honey Badger or Ratel (*Mellivora capensis*) have preyed on foxes (Rüppell's Fox [*Vulpes rüppelli*] and Red Fox [*Vulpes Vulpes*]) live trapped by researchers in Saudi Arabia (Lenain and Ostrowski 1998).

Similar observations of opportunistic predation of small mammals during live-trapping campaigns using box-style traps (e.g., Sherman, Longworth, Elliot, or Ugglan traps) are less reported. This may be because predation events have not been well studied or observed, not because they do not occasionally occur. Predators disturbing small mammal traps is a long-standing problem and several mitigations to reduce their access to traps have been developed (e.g., Getz and Batzli 1974; Watson and Watson 1985; Layne 1987; Matlack *et al.* 2006; Roden-Reynolds *et al.* 2018). For instance, small mammal live traps in Yukon must often be protected with a wire cage to prevent disturbance by Red Squirrel (*Tamiasciurus hudsonicus*) and Arctic Ground Squirrel (*Urocitellus parryii*; Boonstra and Krebs 2006). Access to trap contents by predators may be primarily to obtain the bait, but opportunistic predation of captured small mammals is likely. In an exceptional observation, up to 41% of Sherman traps in Kansas were opened by crows (Matlack *et al.* 2006). Direct predation of captured small mammals was not observed, but, based on fresh pellets in the traps, some predation was suspected. Also in Kansas, carnivores, including raccoons, Virginia Opossum (*Didelphis virginiana*), Long-tailed Weasel (*Mustela frenata*), Striped Skunk (*Mephitis mephitis*), and Domestic Cat (*Felis catus*), preyed on small mammals captured in Sherman traps (Slade *et al.* 1993). In the Pacific Northwest, Spotted Skunk (*Spilogale gracilis*) also disturb small mammal traps (Hooven *et al.* 1979). Wild Boar (*Sus scrofa*) disturbed or destroyed small mammal traps in Spain (Torre *et al.* 2022). Fire Ant (*Solenopsis invicta*) introduced to the southern United States, preyed on 12.7% of captured small mammals, with Northern Pygmy Mouse (*Baiomys taylori*) the most affected (Masser and Grant 1986). In agricultural fields in Australia, birds opportunistically preyed on House Mouse (*Mus musculus*) after they were released from live traps, when the mice were at high densities and little cover was available (C.J.K. and A.J.K. pers. obs.). Here, we report a Common Raven (*Corvus corax*) preying on a deermouse (*Peromyscus* spp.) after it was released from a live trap and we provide best practices to avoid similar occurrences.

On 27 May 2021, we live trapped small mammals (mice and voles; <60 g) near the border of Kluane National Park, in southwestern Yukon, Canada, as part of a long-term monitoring program of food webs in the boreal forest (e.g., Krebs *et al.* 2011, 2019; Boonstra *et al.* 2018). Briefly, we used a 10 × 10 array of Longworth live traps (Longworth Scientific Instruments Co., Oxford, United Kingdom), baited with whole oats and apple and supplied with a wooden cover and cotton bedding, to capture small rodents (see Krebs *et al.* 2011, 2019 for details). At ~0730 local time, T.S.J. caught an adult male deermouse (21 g) that was lethargic and appeared to be arousing from torpor. After processing the animal (i.e., determining its weight and sex and reading the ear tag), we held it for 3–4 min to warm it passively. On release, it was moving slowly, so we recaptured it by hand and held it for another 2–3 min before releasing it beside a log within 2 m of the trap and moving to the next trapping station. After leaving, we heard the call of a raven from near the trap. Working on the adjacent grid line about 15–20 m away, A.J.K. saw a raven rise from the vicinity of where the deermouse was trapped, and she noticed it had a small mammal with a long tail in its beak. She communicated this information to T.S.J. and C.J.K., and T.S.J. immediately saw two ravens fly toward him. The lead raven landed in the top of a tall, dead White Spruce (*Picea glauca* (Moench) Voss) tree, where we could clearly see a small mammal with a long tail in its beak, as it was silhouetted against the sky. Unfortunately, it perched too briefly to photograph, as it quickly flew off to avoid the approach of the other raven. The ravens were not seen again. Temperature at the time of capture was about 5°C and it was slightly overcast.

We believe that the raven successfully preyed on the deermouse because the mouse had not yet fully aroused from torpor and was not able to find adequate shelter or evade the raven. Deermice may use daily torpor as an energy conservation measure in response to inclement weather or food shortages (Lynch *et al.* 1978; Vogt and Lynch 1982; Tannenbaum and Pivorun 1988, 1989; Nestler 1990). Use of torpor may occur any time of the year but is most likely when the ambient temperature is <5°C (Lynch *et al.* 1978; Tannenbaum and Pivorun 1988). Arousal from torpor occurs via nonshivering thermogenesis (Tannenbaum and Pivorun 1989) and takes about 12 min (Nestler 1990), during which time the animal is likely to be listless and slow or unable to respond to stimulus or potential threats. Had the deermouse not been in torpor, it would likely have had a better chance of escaping predation by the raven.

Several best practices to prevent similar incidents of opportunistic predation of live-trapped small mammals that are torpid are apparent. Perhaps most important is that those live capturing small mammals be cognizant of the possibility of animals in traps being in torpor, especially when trapping at cooler temperatures. Detecting animals in torpor is straightforward if trapping crews are aware that it is possible. Researchers should consider trapped animals that are noticeably listless or lethargic as torpid. Passively warming the animal in the researchers' hands can be effective if done long enough. In our case, the time we held the animal to warm it was likely insufficient. Nestler (1990) indicated that it takes deermice about 12 min to arouse from daily torpor. More important than the elapsed time, for passive warming to be effective to mitigate predation risks, it should continue until the animal is notably active, which can be subjectively measured by how vigorously it struggles and tries to escape. Another solution is to return the torpid animal to a locked-open live trap so that it can arouse from torpor in relative safety. This approach may be enhanced by placing a warming device in the trap for at least 12 min before releasing the animal. This would not protect it from terrestrial predators, such as weasels (*Mustela* spp.) or snakes, but it would provide protection from aerial predators. Alternatively, the trap could be closed to protect the animal; however, a researcher would have to return to release the animal once it aroused from torpor.

Researchers must be constantly aware and mindful of potential predators when processing small mammals, regardless of whether they are torpid. Prior identification of species of predators where trapping occurs is essential. Some species of corvids and mustelids may be attracted to small mammal traps and researchers processing captured animals. In our case, we were unaware of the ravens watching the deermouse being processed. Captured animals must always be released only when they appear fully able to respond to threats and where they can immediately seek cover, such as under a log or shrub, down a hole, or in a thicket of grass. Our observation further highlights the need for researchers to be vigilant for potential opportunistic predation of small mammals captured in live traps and to take actions to mitigate the risk.

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