Predator personalities alter ecosystem services

Biologists, guides, animal care specialists, and those who otherwise live and work closely with wildlife have detailed stories about animal personalities (Stamps and Groothuis 2010). The domestication of animals was driven in part by human preferences for personality traits selected over millennia. But do individual animal personalities affect the health of ecosystems and species conservation? Hunter *et al.* (2022) argue so. They developed the notion that animal personalities modulate ecosystem services, focusing on how those personalities affect pollination, seed dispersal, pest regulation, ecotourism, and soil processes. However, predation was not a focus.

We show that this concept applies to predators, whereby intraspecific variation in personality can have cascading effects on ecosystems. Understanding the mechanisms by which predation affects ecosystems is fundamental to ecology and a long-standing rationale for species conservation. How predation as an ecological force results in either density- and/or trait-mediated effects is well developed (Ohgushi *et al.* 2012). The ecological importance of predator personalities is largely overlooked, but recent research demonstrates that predator personalities can explain variation in diet breadth and diversity (Scheel *et al.* 2017; Arbilly 2018) and that human disturbance affects personality development in wild carnivores (Greenberg and Holekamp 2017). Predators with certain personality traits may therefore disproportionately impact lower trophic levels (Toscano *et al.* 2016), which may ultimately have important cascading effects on ecosystems.

A recent analysis of gray wolf (*Canis lupus*) predation on American beavers (*Castor canadensis*) identified a distinct mechanism by which predators have an "outsized effect" on ecosystems when they kill ecosystem engineers (Gable *et al.* 2020). If a species plays a critical role in ecosystem functioning (eg an ecosystem engineer), then predators of that species can have outsized ecological impacts. Wolf predation of individual beavers, which are consummate ecosystem engineers, can therefore lead to strong ecosystem-scale effects. Predation influences where and when beavers engineer ecosystems, modifying the spatial and temporal distribution of wetlands and associated ecosystem services without necessarily altering beaver density or beaver behaviors via nonlethal effects (Gable *et al.* 2020).

To assess how predator personalities can alter ecosystem services, we examined wolf kill rates of beavers (beavers killed per day) and wolf ambushing rates (ambushing attempts per day) for wolves in the same social group and same age class operating under the same or similar ecological conditions (methods described in Gable *et al.* [2020, 2021]) within Minnesota's Greater Voyageurs Ecosystem. This approach reduced the effect of certain confounding parameters (eg prey density, environmental conditions) that may influence variation in hunting success and behavior, and thus allowed a comparative assessment of the role of personality. We found substantial variation in pack member kill rates and ambushing rates; within the same pack, the kill and ambushing rates of some wolves were 229% and 263% higher than those of other wolves, respectively (Figure 1). This within-pack variation of hunting behavior suggests personality-driven differences in wolf predation. A successful ambushing personality requires waiting at ponds or along beaver feeding trails, and certain individual wolves wait much more often and much longer than others (Gable *et al.* 2021). One can say some wolves are more patient or persistent than others when it comes to hunting and killing beavers.

This wolf–beaver–wetland dynamic illustrates how predator personalities, manifested through differences in kill rates of ecosystem engineers, can alter ecosystem services. Logically, wolves with higher kill rates of beavers will likely influence wetland creation and recolonization (Figure 3 in Gable *et al.* [2020]). Consequently, in a wolf population, a fraction of individuals with strong "beaver-hunting" personalities can be disproportionately responsible for the outsized ecological effects that result from preying on beavers.

Wolves are unlikely alone in this capacity. Cougars (*Puma concolor*) and American badgers (*Taxidea taxus*) exhibit substantial individual variation in predation on ecosystem engineers (beavers and prairie dogs [*Cynomys* spp], respectively) that is not explained by prey availability or other ecological factors, suggesting personality-driven differences (Lowrey *et al.* 2016; Kagel *et al.* 2020). Only five killer whales (*Orcinus orca*) need to specialize in preying on sea otters (*Enhydra lutris*) to suppress local otter numbers and initiate effects on marine kelp forests via otter–urchin–kelp trophic cascades (Williams *et al.* 2004). We expect that predator personalities modulate ecosystems more substantially when predators kill ecosystem engineers and/or keystone species. Longitudinal, individual-based studies of predators that prey on keystone species or ecosystem engineers will be crucial in future research (O'Dea *et al.* 2022).

Variation in animal personalities with respect to the ecological impact of predation has important practical applications because in some cases modifying animal personalities in a population may be possible. For example, by modifying personalities in a proportion of predators that coexist with humans (eg urban carnivores [Breck *et al.* 2019]; depredation management [Swan *et al.* 2017; Hunter *et al.* 2022]), resource managers may maximize ecological services to humans (eg public health benefits [Braczkowski *et al.* 2018]) and minimize human–wildlife conflicts (eg beneficial predation of animals considered as agricultural "pests" [Jhala *et al.* 2019]). Widespread lethal control and recreational hunting may also affect facets of predator personalities differently (eg boldness/aggressiveness [Hunter *et al.* 2022]; dispersal propensity), given that such actions have altered behavioral traits in other species (Ciuti *et al.* 2012). Studying the variation of personality traits among individuals
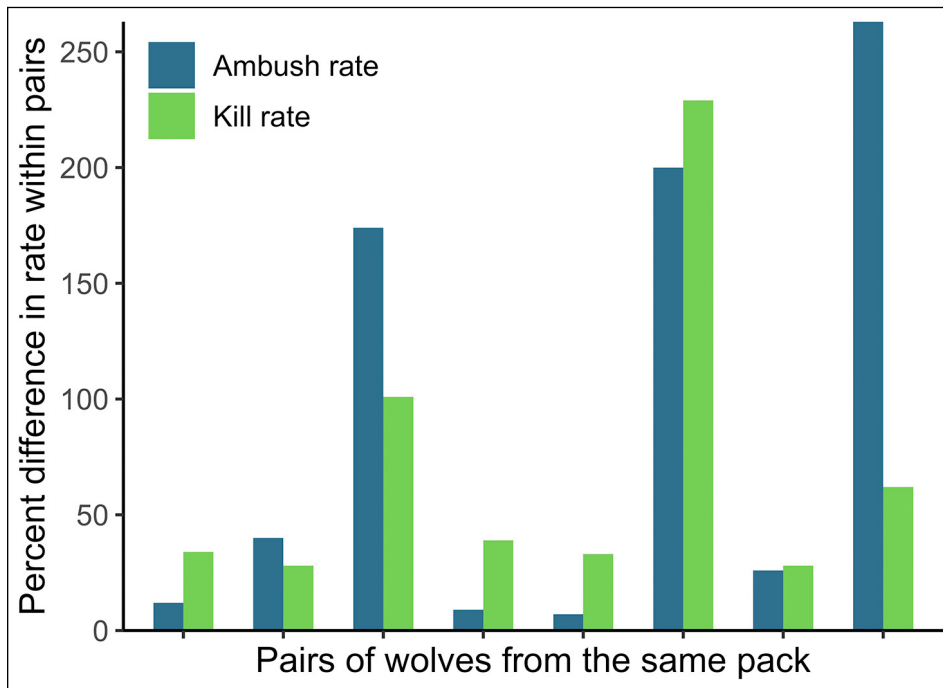
Figure 1. Percent difference in wolf ambushing rates (attempts per day) and kill rates (kills per day) of beavers for pairs of wolves from the same pack operating in identical (pair studied during the same period in the same year, *n* = 6) or very similar (pair studied during same period 1 year apart, *n* = 2) ecological conditions. Data from eight pairs of wolves across six packs in the Greater Voyageurs Ecosystem, Minnesota, from 2019 to 2020.

in predator populations is important to sustaining ecosystem services and our coexistence with carnivores.

◼ Data Availability Statement

Data are sensitive and cannot be provided publicly due to the current status of wolves in Minnesota under the US Endangered Species Act. Please query Joseph Bump (bump@umn.edu) to obtain data.

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Note regarding changes at *Frontiers*

This issue of *Frontiers in Ecology and the Environment* will be the last to feature our dispatches section. This monthly news column has been a staple of *Frontiers*' pages since our first issue in February 2003. We have had the privilege of showcasing the extraordinary writing of many journalists in the intervening two decades, some of whom have been with us since that first year. We will miss featuring their work!

Frontiers continues to evolve, as always, with new sections and series appearing and older ones ending from time to time. With this in mind, it is our pleasure to announce that *Frontiers*' next issue will introduce a new commentary column. As compared with our traditional – and ongoing – editorials, commentaries are expanded opinion pieces, grounded in science, that offer greater length and flexibility to prospective authors. We are delighted that our inaugural commentary will be authored by current ESA President Dennis Ojima and colleagues, celebrating the 50th anniversary of LANDSAT. Commentaries will not appear in every issue, but several more are in the pipeline, and we welcome proposals. For author guidelines and other details, or to propose a commentary, please contact Editor-in-Chief Rich Wallace (richwallace@esa.org).

A note of thanks to *Frontiers*' long-serving International Advisory Board, which was disbanded earlier this year. The members of that board served an important supporting role in *Frontiers*' early years and helped to establish the journal and secure its place in the landscape of scholarly publications in ecology and environmental science. We are indebted to them for their service.

Finally, we wish to acknowledge the passing in April of *Frontiers*' founding Editor-in-Chief, Dr. Sue Silver. *Frontiers*' first 18 years of success were due to Sue's deft leadership and the remarkable staff and editorial board she built. It is an honor to have followed in her footsteps.

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Erratum

In the EcoPic by Cárdenas *et al*. (2022; **20**: 139, doi.org/10.1002/fee.2489) entitled "Swallow-tailed gull predation on a marine eel: personality traits implied?", the focal bird species was misidentified. A corrected version of the text appears below:

The photograph of the original EcoPic pictured a lava gull (*Leucophaeus fuliginosus*), not a swallow-tailed gull (*Creagrus furcatus*) as previously described. Unlike *C furcatus*, *L fuliginosus* is listed as Vulnerable by the IUCN, very rare in terms of abundance, endemic to the Galápagos Islands, and diurnal. The lava gull feeds primarily on seabird eggs and chicks, fishes (clupeids and exocoetids), and marine invertebrates such as squids. It is however best known as a scavenger, with a substantial portion of its diet consisting of fish scraps and food items regurgitated by mammals and other birds (doi.org/10.2173/bow.lavgul1.01) (*Cotinga* 2015; https://tinyurl.com/4mjrep7e). This unusual observation of a lava gull trying to swallow a tiger snake eel (*Myrichthys* cf *maculosus*, an ophichthid) is, to the best of our knowledge, the first documented record of predation between these species. Aside from the gull species misidentification, the core message remains intact: the "behavioral syndrome" concept, which considers the importance of "personality traits" to answer ecological and evolutionary questions, may help to explain this type of extraordinary event.