Topic: Beaver (*Castor fiber, Castor canadensis*) predator avoidance behavior in foraging and territory defense.

Topic Summary

Beavers forage for non-woody plants and deciduous trees (Salandre et al., 2017). While foraging, they are predated mainly by wolves and coyotes (Engelhart & Muller-Schwarze, 1995). Predation levels vary by region and season, with beavers sometimes being a significant food source for wolves (Engelhart & Muller-Schwarze, 1995). Direct and indirect observations suggest beaver predator avoidance behaviour involves adaptive activity patterns (McClintic et al., 2014; Swinnen et al., 2015), safe habitat selection (Smith et al., 1994), and inhibition of foraging (Severud et al., 2011; Smith et al., 1994) and territory defense, (Rosell & Sanda, 2006) both mediated by olfactory risk assessment. Fitness models, non-adaptive behaviours, and population comparisons suggest predator avoidance is shaped by evolution, genetics, and learning (Basey & Jenkins, 1995; Engelhart & Muller-Schwarze, 1995; McClintic et al., 2014; Rosell & Sanda, 2006; Smith et al., 1994; Swinnen et al., 2015).

Direct observations of beavers suggest predator avoidance involves safe habitat selection, and inhibition of optimal territory defense and foraging (Basey & Jenkins, 1995; Rosell & Sanda, 2006). Ground surveys of beaver habitats suggest beavers prefer greater water depths when avoiding predators (Smith et al., 1994). Binocular observations of decreased aggression and overmarking on scent mounds with predator odors suggests reduced territoriality to avoid predators (Rosell & Sanda, 2006). Naked eye observations of foraging have been used to develop models that suggest beavers forage less profitable foods when predation risk is high (Basey & Jenkins, 1995).

Indirect observations suggest beavers modify foraging and activity patterns to avoid predators (Engelhart & Muller-Schwarze, 1995; Swinnen et al., 2015). Reduction in camera trap

activation on predator odor treated trails and overnight counting of odor treated aspen sticks suggest beavers avoid using forage trails and foods with predator odors (Engelhart & Muller-Schwarze, 1995; Severud et al., 2011). Transect surveys around beaver ponds suggests reduction in foraging range and foraging easier foods to avoid fatal run-ins with predators (Smith et al., 1994). Radio tags used to measure movement patterns suggest beavers move faster in wetlands to avoid aquatic predators (McClintic et al., 2014). Camera traps over 24-hour periods have suggested beavers use nocturnal activity to avoid diurnal predators (Swinnen et al., 2015).

Genetic and learning influences were studied by comparing populations with different predator types and abundances (Engelhart & Muller-Schwarze, 1995; Smith et al., 1994). For example, in Lake Superior, bear predation occurs on Stockton but not Outer (Smith et al., 1994). Approximately 20 years of bear predation led to differences in habitat selection, foraging range and choice between Stockton and Outer beavers which suggests genetic differences and learning are involved (Smith et al., 1994). Similarly, Engelhart & Muller-Schwarze (1995) found small differences in the degree of avoidance to different predators between two beaver populations subjected to different predator types and abundances. Beavers settling decades before suggests differences are due to genetic variation and learning (Engelhart & Muller-Schwarze, 1995).

Evolutionary influences were studied by observing behaviours that are no longer adaptive (Rosell & Sanda, 2006; Swinnen et al., 2015) and by testing models predicting fitness maximizing behaviours (Basey & Jenkins, 1995; McClintic et al., 2014). For example, Swinnen et al. (2015) investigated beaver activity patterns in the absence of predation and found that despite higher energy costs, beavers remained nocturnal. Rosell & Sanda (2006) found beavers avoiding wolf odors despite wolves being absent for 100 years. These findings suggest behaviours shaped by natural selection in the past are expressed even when pressures are

alleviated. Basey & Jenkins (1995) tested a foraging model based on weighing predation risk against profitability. Beavers foraged as predicted which suggests predator avoidance has been shaped by evolution to be employed when risks outweigh benefits (Basey & Jenkins, 1995). McClintic et al. (2014) tested a movement model that predicted beavers should increase movement speed away from the lodge to minimize predation risk. Beavers moved as predicted, suggesting evolution of adaptive movement patterns (McClintic et al., 2014).

Neuronal and hormonal mechanisms of beaver predator avoidance are not studied. Therefore, future studies should focus on the internal physiological changes that occur when beavers encounter predator cues. Also, beaver behavior responses to different sources of predator odors and continued exposure to risk should be investigated for comparative studies between species (Hegab et al., 2015).

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