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Hunting intensity alters movement behaviour of white-tailed deer

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Abstract

Recreational hunters have largely replaced natural predators of white-tailed deer (*Odocoileus virginianus*) across much of North America; thereby, providing the greatest form of risk (both direct and indirect) to survival. On a 1861-ha property in Oklahoma, USA, we evaluated how controlled hunting influenced movement behaviour (using movement rate [m/h] and relative displacement index [%]) of 37 adult (≥2.5 years) male deer at three risk treatment levels (i.e., control = no risk; low-risk = 1 hunter/101 ha; and high-risk = 1 hunter/30 ha), two temporal periods of risk (i.e., diurnal [06:00–18:00] and nocturnal [18:00–06:00]), and across time (36 days); time was modelled as a continuous variable that covered five risk exposure periods (risk present or absent in brackets; i.e., pre-season [absent], scout [present], pre-hunt [absent], hunt [present], and post-hunt [absent]). Movement rate (m/h) decreased over time for all risk treatment levels and temporal period of risks; however, the magnitude (i.e., slope) of decrease varied across treatments. The magnitude of decrease in movement rate was similar for control and low risk treatments during diurnal and nocturnal periods, but was different between low and high risk, and high risk and control treatments. Relative displacement (%) of deer was greatest at the start of the study, decreasing during the study finally resulting in displacement values being three times less after hunting season. Deer responded to the presence of hunters on the landscape by adapting movement strategies both spatially and temporally to avoid potential contact with hunters. During the study, deer reduced movements and used smaller areas more intensively, as indicated by the relative displacement index. Reducing movement or space use may lead to lower detection of deer by hunters, thus increasing the probability of survival through reduced harvest. Understanding deer behavioural responses to hunters (and at different levels of risk) could be used to facilitate or reduce harvest based on population management objectives.

Zusammenfassung

Freizeitjäger haben die natürlichen Räuber der Weißwedelhirsche (*Odocoileus virginianus*) in weiten Teilen Nordamerikas ersetzt und sind der wichtigste Risikofaktor (sowohl direkt als auch indirekt) für deren Überleben. Auf einem 1861-ha-Anwesen in Oklahoma (USA) untersuchten wir, wie kontrollierte Bejagung das Bewegungsverhalten (Bewegungsrate = m/h) und den

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relativen Ortsveränderungsindex (%) von 37 adulten (Alter ≥2.5 Jahre) Hirschen beeinflusste. Wir betrachteten drei Risikostufen (Kontrolle = kein Risiko, geringes Risiko = 1 Jäger/101 ha und hohes Risiko = 1 Jäger/30 ha), zwei Tageszeiten (tagsüber und nachts) sowie den Zeitverlauf (36 Tage). Die Zeit wurde als eine kontinuierliche Variable modelliert, die fünf Risiko-Perioden abdeckte: Vorsaison (kein Risiko), Erkundungsphase (Risiko), Ruhe vor der Jagd (kein Risiko), Jagdzeit (Risiko) und Nach-Jagd-Phase (kein Risiko). Die Bewegungsrate nahm über die Zeit bei allen Risikostufen ab, aber das Ausmaß der Abnahme variierte zwischen den Behandlungen. Die Abnahme der Bewegungsrate war ähnlich für die Kontrolle und bei geringem Risiko während der Nacht und tagsüber, aber es gab Unterschiede zwischen der Hoch-Risiko-Behandlung und den beiden anderen Behandlungen. Die relative Ortsveränderung der Hirsche war am Anfang der Untersuchung am größten und nahm mit der Zeit bis auf ein Drittel des Ausgangswertes in der Nachsaison ab. Die Hirsche reagierten auf die Anwesenheit von Jägern im Gelände, indem sie ihre Bewegungen räumlich und zeitlich anpassten, um möglichen Kontakt mit Jägern zu vermeiden. Sie reduzierten ihre Bewegungen und nutzten kleinere Gebiete intensiver. Dies könnte dazu führen, dass die Hirsche seltener von Jägern aufgespürt werden, wodurch die Überlebenswahrscheinlichkeit durch geringeren Abschuss steigt. Die Kenntnis der Reaktionen der Hirsche auf Jäger (und bei unterschiedlichen Risikostufen) könnte dafür genutzt werden, entsprechend der Ziele des Populationsmanagements Abschüsse zu erleichtern oder zu reduzieren.

Keywords: Animal behaviour; Global positioning systems; Hunting; Relative displacement; Oklahoma; *Odocoileus virginianus*

Introduction

Presently, recreational hunters are a prominent force at shaping population dynamics of large ungulates across much of North America, and for many cervids, hunters may be the greatest form of risk (both direct and indirect) to survival. Because of the direct harvest of game animals by hunters, as well as disturbance from humans, Frid and Dill (2002) suggested that prey approached by humans likely respond similarly to those approached by other predators, thus there are perceived predation risk effects associated with humans. Animal response to human predation risk varies greatly depending on the type of risk, environment and temporal scale (Dasmann & Taber 1956; Van Etten, Switzenberg, & Eberhardt 1956; Kammermeyer & Marchinton 1975; Kilgo, Labisky, & Fritzen 1998; Karns, Lancia, DePerno, & Conner 2012). Hunting probably has the greatest potential to create risk effects, which can cause game animals to alter spatial distributions and behaviour to reduce the potential threat of harvest or disturbance (Cromsigt et al. 2013). Not only can humans directly take wildlife (i.e., harvest), but the risk effects potentially can have fitness consequences whereby survival and reproduction suffer when animals make trade-offs between risk avoidance and energy acquisition (Gill & Sutherland 2000). Today, overabundant populations of game animals such as white-tailed deer (*Odocoileus virginianus*) can cause human–wildlife conflicts that cannot be overcome by harvest alone. Because of the potential direct and indirect effects of human predation risk, managing game animals by altering their spatial distribution and behaviour may be an alternative to reducing population numbers (Cromsigt et al. 2013).

Human predation risk is likely to elicit greater responses from animals as perceived risk of predation increases (Frid & Dill 2002). Animal response to predation risk is commonly evaluated by examining movement behaviour (Miller, Garner, & Mench 2006; Stankowich 2008). For example, movement rate of elk (*Cervus elaphus*), when exposed to human predation risk, increased during intensive hunting seasons in Montana (Cleveland, Hebblewhite, Thompson, & Henderson 2012). Similarly, in white-tailed deer, human hunting activity may influence movement or space use patterns (Autry 1967; Sparrowe & Springer 1970; Pilcher & Wampler 1981; Root, Fritzell, & Giessman 1988). However, it is unknown how the redistribution of animals after disturbance will affect other fitness producing activities (Gill, Sutherland, & Watkinson 1996). Changing behaviour or distribution patterns, most often through changes in movement, can either impede the risk of predation, or increase the vulnerability of the animal to predation when the predation event is dependent on the change in behaviour (Little et al. 2014). For white-tailed deer, understanding hunt-related movements by deer is important because they can directly influence harvest recommendations and management success (Rhoads, Bowman, & Eyler 2013). For example, deer are more vulnerable to harvest as they move more as a result of hunter presence and associated risk depending on the timing of the hunting season in relation to breeding season (Little et al. 2014), thereby facilitating harvest through increased vulnerability of the prey when exposed to risky situations. Conversely, if deer move less in the presence of human predation risk, then harvest requirements may not be met because too few deer are observed and harvested (Little et al. 2014).

To address the effects of hunters on wildlife behaviour, we focused our study on white-tailed deer, one of the most widely hunted big-game animals in North America (Halls 1973). Hunters are filling the predatory role once held by natural predators for the purposes of managing white-tailed deer in much of North America. However, a paucity of information

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