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White-tailed Deer (*Odocoileus virginianus*) Fawn Risk from Gray Wolf (*Canis lupus*) Predation During Summer

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Little is known about how often various prey animals are at risk of predation by Gray Wolves (*Canis lupus*). We used a system to monitor the presence during the day of two radio-collared Gray Wolves within 2 km of a radio-collared White-tailed Deer (*Odocoileus virginianus*) with a fawn or fawns in August 2013 in the Superior National Forest of northeastern Minnesota. We concluded that the fawn or fawns were at risk of predation by at least one wolf at least daily.

Key Words: Gray Wolf; *Canis lupus*; White-tailed Deer; *Odocoileus virginianus*; fawn; predation; hunting behaviour; radio-tracking; Superior National Forest; Minnesota

Introduction

Almost nothing is known about how often any individual prey animal is at risk of contending with predators, yet "predation risk is key to understand prey population dynamics" (Pettorelli *et al.* 2011: 307). No doubt the frequency at which any individual prey is "tested" (Mech 1966) by predators is highly variable depending on predator and prey species, the density of each, and many other factors. Nevertheless, any information on this subject would be revealing and would improve our understanding about how some prey survive for years in the face of wolf predation while others are killed (Mech *et al.* 2015).

Information currently available about how often individual prey get tested by wolves consist of a few scattered reports with various types of data. For White-tailed Deer (*Odocoileus virginianus*) fawns in the Superior National Forest of Minnesota during summer, preliminary evidence indicates that a given doe and fawn could be visited by a Gray Wolf (*Canis lupus*) every 3–5 days (Demma *et al.* 2007) or, according to another study, wolves visit specific doe–fawn groups in their territory an average of about once every 13–20 days (Demma and Mech 2009a). In Yellowstone National Park, wolves came within 1 km of Elk (*Cervus elaphus*) an average of every 9 days, which the authors considered a reasonable proxy for how often Elk were at risk from the wolves (Middleton *et al.* 2013). Based on 1265 concurrent fixes of a Moose (*Alces alces*) and a wolf (five Moose in the territory of two wolves, all wearing a Global Positioning System [GPS] radio collar), only 0.11% of all Moose fixes were within 1 km of a wolf (Eriksen *et al.* 2009).

In our study area, the main prey of wolves during summer is White-tailed Deer fawns (Frenzel 1974; Van Ballenberghe *et al.* 1975; Nelson and Mech 1986; Kunkel and Mech 1994). During the month of our study, fawns usually spend much of their time with their mother or within 100 m of her on average (Ozoga *et al.* 1982). To gain further insight into how often individual fawns might be at risk from wolves in our area, we used a data-logging, radio-receiver system to detect how often either of two radio-collared wolves came reasonably close to fawns accompanying a radio-collared doe in the wolves' territory. We assume that wolves coming close to fawns represent a reasonable measure of wolves hunting fawns as per Eriksen *et al.* (2009) and Middleton *et al.* (2013).

Study Area

We conducted the study in the Superior National Forest, approximately 22 km southeast of Ely, Minnesota (48°N, 92°W) within the much larger area of a long-term wolf and deer investigation (Mech 2009). The area is generally flat and forested, with scattered open lowlands and a few logging roads. Summer temperatures generally range from 20°C to 35°C. During the previous winter, wolf density in the territory encompassing our study area was 38.5/1000 km^2 (see Methods), and an estimate of deer density was 0.4-2.7 adult deer/km^2 (Lenarz and Grund 2011). The wolf pack that includes the two radio-collared wolves apparently included a litter of pups during the study because the pack increased from three members in winter 2012–2013 to six in 2013–2014 (LDM and SBM, unpublished observations). For more details about the study area, see Mech (2009).

Methods

Two female wolves (numbered 7117 and 7205) estimated to be 5 and 3 years old (Gipson *et al.* 2000) from the same pack and collared with very-high-frequency (VHF) radios for other research (Mech 2009) were the subjects of this study, along with VHF radio-collared doe 8330, aged 8 years by incisor sectioning (Gilbert 1966). The composite territory (100% minimum-convex polygon) of the wolves included the home range of doe 8330 (Figure 1). From 2 April to 22 October 2013, the territory of the wolves included 78 km^2 (based on 31 locations detected from the air), and the home range of the doe, toward the northern edge of the wolf territory, occupied approximately 0.93 km^2 (based on nine locations detected from 30 May to 4 June 2012 and six from 8 June to 3 July 2013), some 1.2% of the area of the wolves' territory. The wolf collars transmitted between 0800 and 2000, and the deer collar between 0940 and 2135.

A stationary radio-tracking system (R4500S receiver/data logger; Advanced Telemetry Systems, North Isanti, Minnesota, USA) with an omnidirectional antenna recorded the presence of radio-collared wolves and deer within a 1.0-km radius of the detection site from 29 July through 29 August 2013 (although on only part of the first and last days). The system was deployed so that its programmed detection area covered the entire estimated summer range of the doe (Figure 1). About half the home range of another radio-collared doe also fell within the detection area, and other non-collared deer could also have lived in the detection area along with their fawns. Our objective was to detect the radio-collared wolves only while they were within the detection area while their transmitters were active.

The receiving and data-logging units were protected in a hardened plastic box; cables were threaded through a hole in the side rim of the plastic lid of the box and sealed with silicon. The omnidirectional antenna was mounted on a wooden platform about 2 m off the ground against a tree. The entire unit was powered by a heavy-duty marine battery, also housed inside the box. The box was padlocked shut and cable-locked to a tree, and a warning/information label was affixed to the top of the box. We programmed the frequencies of the wolves and deer into the receiver and set the search function to check them every 5 minutes.

To calibrate the detection radius of the receiver and data logger, we carried a test collar of the same type used on both the wolves and the deer, at wolf height to simulate deployed collars, to different areas along concentric circles at various distances from the system to the edges of the desired detection area (3.14 km^2), a radius of 1.0 km. We manually recorded test times and locations and compared them with the system-recorded times. We adjusted the receiver gain and repeated the tests until the system approximately monitored the desired study area but not beyond the 1.0-km radius.

The radio-collared doe whose range was within the radio-tracking system was included in the monitoring sequence to test the system's reliability. If the system's detection range was constantly covering the prescribed range, the system should always detect the deer while its transmitter was active.

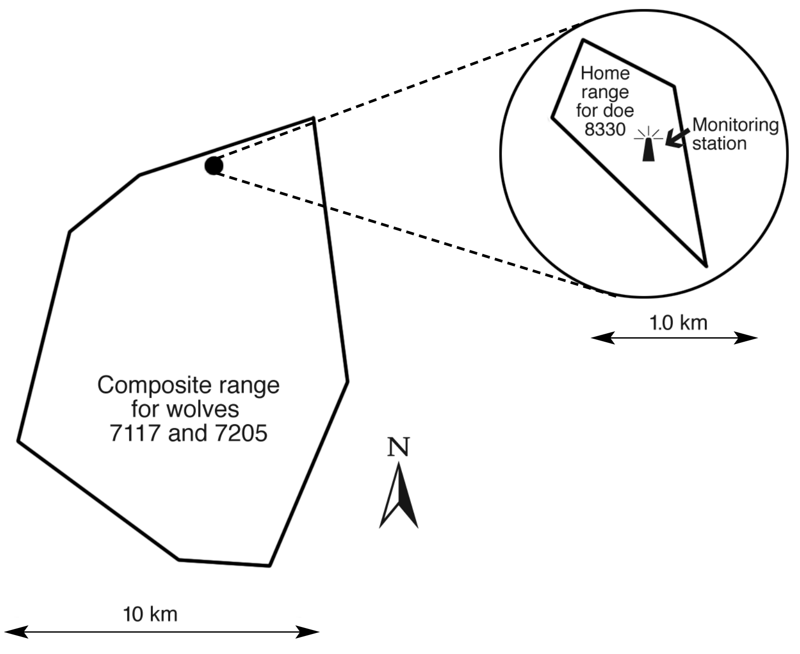

FIGURE 1. Diagram of the monitoring system for detecting radio-collared Gray Wolves (*Canis lupus*) and White-tailed Deer (*Odocoileus virginianus*) in the Superior National Forest study area, Minnesota, 29 July to 29 August 2013.

We downloaded the stored data about once a week, and exchanged the battery for a freshly charged one at the same time.

Because our objective was to determine how often our radio-collared wolves approached the vicinity of fawns, we searched weekly for fawn tracks within the home range of our collared doe in selected areas of adequate tracking substrate.

Results and Discussion

We found fawn tracks during five of the six surveys from 29 July through 26 August 2013. Although we found no tracks on 29 August, that survey was preceded by a heavy rainstorm that would have washed out any tracks. Thus at least one fawn, and probably more because mature does often produce twins (Verme and Ullrey 1984; DelGiudice *et al.* 2007) and because at least two does occupied a portion of the detection range, were present in the study area throughout most or all of the study.

The monitoring system detected the radio-collared doe every day, an average of 81% of the time during each day. We have no way of knowing whether lack of detection meant the deer was out of range or in a position where the system could not detect her. If she was outside the detection range, it probably was not for long because she was detected every day, at least 40% of the time (except for the partial first day). If lack of detection was because she was in a poor position (e.g., shielded from the antenna by the tree the antenna was mounted against) and, if the same problem pertained to wolf detection, that would make our conclusions about how often the fawns were at risk of wolf predation less than actual.

The monitoring system detected wolf 7117 on 24 of the 32 12-h days (Figure 2) and wolf 7205 on 22 days (Figure 3). However, on several days, only one-to-a-few detections were made. To better relate wolf detections to possible interactions with fawns, we arbitrarily chose to omit all the four or fewer consecutive detections (representing 20 minutes). We chose that value because at an assumed travel rate of 6.0 km/h, a wolf could cross the widest expanse of a 1.0-km-radius reception circle in that time. Wolves travel at about 8 km/h while crossing frozen waterways and open tundra (Mech 1994), but we assumed that wolves would travel more slowly through the forested underbrush of our study area, especially when searching for prey. Given these assumptions, wolf 7117 recorded four or more consecutive detections on 6 days (Figure 2). Wolf 7205 met that criterion on 11 days (Figure 3). Because the wolf transmitters were active only half the time (12 h/day)

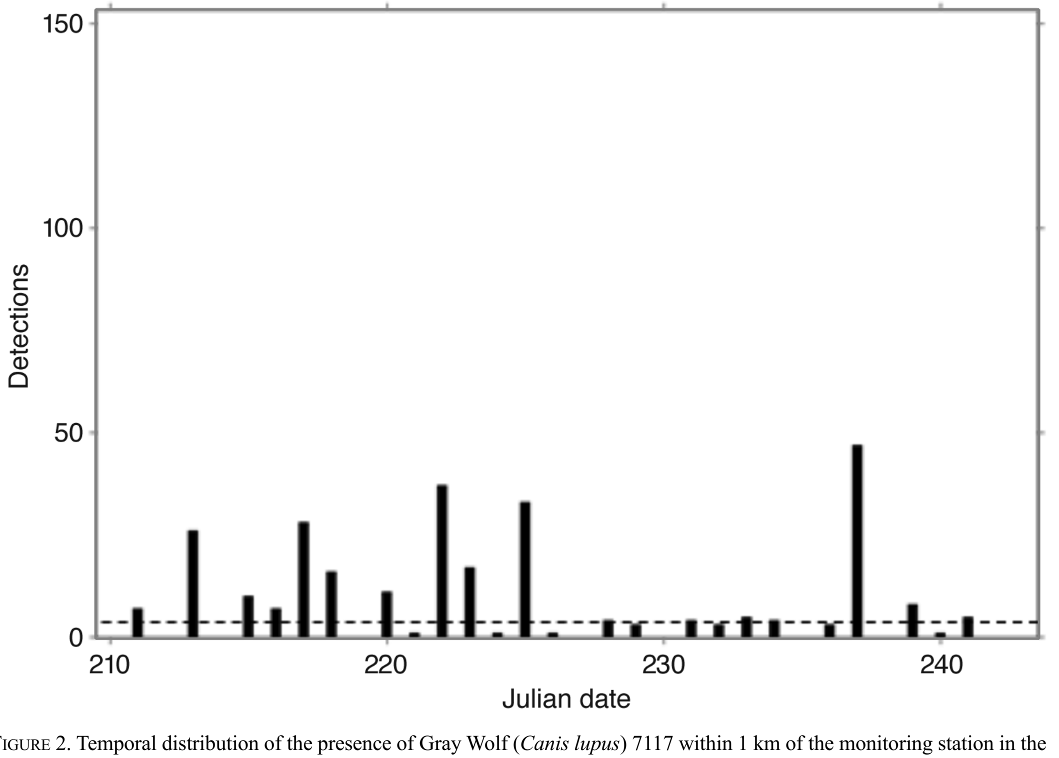

FIGURE 2. Temporal distribution of the presence of Gray Wolf (*Canis lupus*) 7117 within 1 km of the monitoring station in the Superior National Forest study area, Minnesota, 29 July to 29 August 2013 (Julian dates 210–241). Number of detections possible per day = 144. Dashed line indicates 4 consecutive detections.

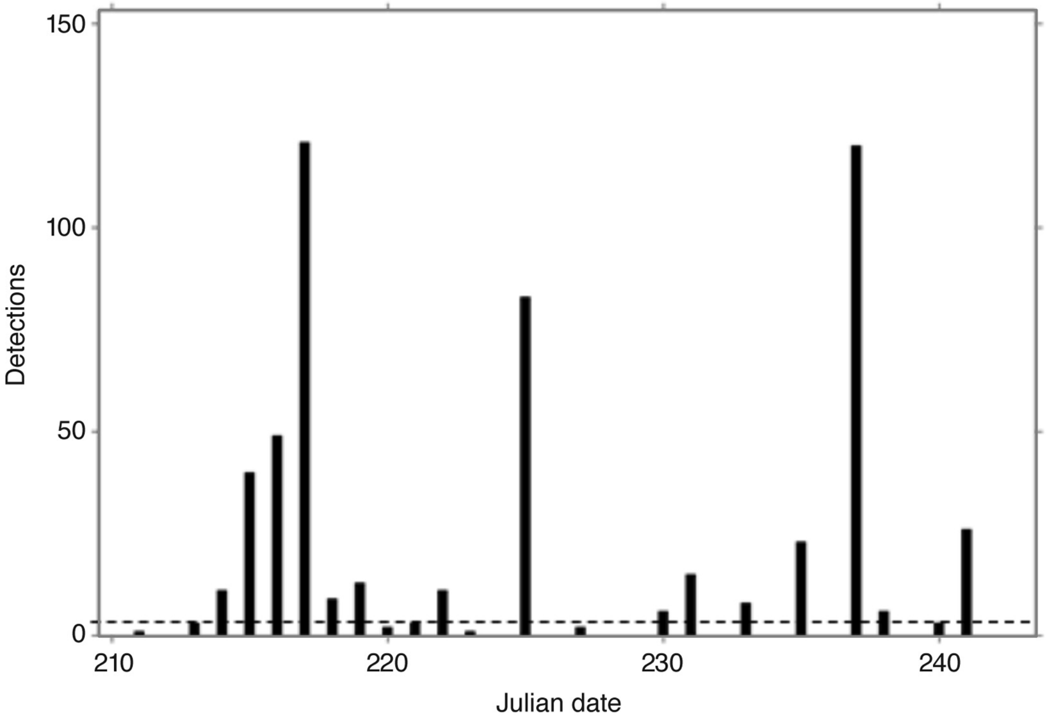

FIGURE 3. Temporal distribution of the presence of Gray Wolf (*Canis lupus*) 7205 within 1 km of the monitoring station in the Superior National Forest study area, Minnesota, 29 July to 29 August 2013 (Julian dates 210–241). Number of detections possible per day = 144. Dashed line indicates 4 consecutive detections.

and because wolves are generally more active at night than during the day, these figures should be considered minimal. The two wolves were separate all four times they were found by aerial tracking during the study and all five times they were found before the study, so their proximities to fawns should be considered additive (see below).

Using the conservative criterion of four or more consecutive detections, and accounting for 3 days when both wolves were detected, at least one radio-collared wolf spent at least 20 minutes within 2 km of the fawn or fawns of the radio-collared doe during the day on at least 14 of the 32 days of the study.

In addition, we observed wolf 7117 with two other wolves during the preceding winter, one of which could have been wolf 7205. During summer in this region, members of wolf packs tend to hunt separately (Demma *et al.* 2007; Demma and Mech 2009b; Palacios and Mech 2010; Barber-Meyer and Mech 2015). Therefore, there is a strong probability that the fawn or fawns in our study were approached by non-radio-collared wolves as well as by our tracked wolves and, thus, more often than our findings indicate.

The wolves spent more time in the relatively small monitored area (4% of the wolves' territory) than the full area of their territory: wolf 7117 spent 6% of its time (556 of 4608 possible detections) there and wolf 7205 spent 12% (282 detections). On 25 August, wolf 7205 spent 10 h in the monitored area (Figure 3). These findings are in accord with the assumption that the wolves were hunting the fawns. Although we cannot directly relate wolf detections by the monitoring system to attempts by the wolves to search for and attempt to capture fawns, it is reasonable to assume that most of the wolves' time spent within the monitoring area was related to such attempts. Because the home range of the radio-collared doe comprised such a high percentage of the detection area, even if the wolves used the space within the detection area randomly, they would be within that home range a high percentage of the time. In addition, fawns form the main prey of wolves during summer in this area as indicated above, so wolves must spend much of their time trying to capture fawns. Because of the amount of time the wolves spent in the monitored area, they were likely aware of the fawns' presence. Even if the wolves entered from the opposite side of the monitored area from the fawns' location, they would likely have been able to smell them or at least know where to travel to search for them and would have been able to reach them within a few minutes.

Similar to Middleton *et al.* (2013) and Eriksen *et al.* (2009), we assumed that wolves anywhere within the monitoring distance of our system were probably a threat to fawns, although in extreme cases, a detected wolf could have been as far as 2 km from a fawn.

Nothing is known about how difficult and time-consuming it is for a wolf to find, catch, and kill fawns the age of those during our monitoring, but some information suggests that, in the same general area as ours, wolves spend 20–22 h and travel 1.5–3.0 km around the site of a killed fawn (Demma *et al.* 2007). It would not take much time to consume a fawn; thus, presumably much of this time and travel is spent searching for, chasing, and trying to catch and kill it.

Our findings support those of Demma *et al.* (2007) and Demma and Mech (2009a) that wolves in the Mech (2009) study area spend considerable time near deer fawns and that most fawns are apparently tested by wolves frequently. Our findings suggest that fawns in our study area are probably tested daily by at least one wolf. However, earlier studies in the same region have concluded that in the territory of a pack of five wolves, 1 year old or older, hunting individually, some would visit each doe/fawn about every 3–5 days on average (Demma *et al.* 2007) or about once every 13–20 days (Demma and Mech 2009a). Any number of explanations are possible for the differences between the earlier studies and ours, including the following: (1) our study detected wolves only during the day, whereas the other studies were based on collars recording locations day and night; (2) the ranges of the deer in the earlier studies were generally about a third larger than those in our study; and, probably most important, (3) the wolf pack territory in the earlier studies was about four times the size of the wolf territory in our study and the wolf density about 60% of that of our study (SBM and LDM, unpublished observations).

In the region in and around our study area, 49% of fawns survived from May through October during two earlier summers, with wolves causing half the deaths (Kunkel and Mech 1994). Considering all of the above, it appears that, even though deer fawns are small, inhabit local areas where they can easily be found, and do not possess the strength, power, or other defensive characteristics of adult deer (Mech *et al.* 2015), their ability to survive in the face of frequent attempts by wolves to hunt them is remarkable, at least in our study area, even though they are well defended by their doe (Mech 1984).

Although our findings regarding deer fawn risk of predation by wolves are indirect and imprecise, they help strengthen earlier findings and add more information to the little-studied question of individual prey risk and, thus, to the larger subject of prey population dynamics (Pettorelli *et al.* 2011) from the perspective of the prey.

Additional research on this subject is warranted based on new questions that arose during this study. Does the rate of wolf visits to a doe's home range increase on parturition? Does it decline following fawn mortality? Does it vary across seasons, irrespective of fawn presence?

For subsequent investigations about these and related questions, we recommend several improvements in study design. To better document wolf presence, we suggest: (1) mounting the antenna freestanding rather than attaching it to a tree, (2) using 24-h radio-collars on wolves, and (3) using GPS collars to provide a finer level of wolf data (Demma *et al.* 2007). We suggest supplementing track surveys with the use of trail cameras to better detect fawn presence and minimum abundance. We also suggest expanding the duration of future studies to include the first 5 months of the life of fawns, the entire period when wolves in this area concentrate on hunting fawns (Nelson and Mech 1986), and extending them throughout the fall when fawns transition to near adult size and become more difficult to kill. Radio-collaring more deer in the study area is also recommended.

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