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The effects of radar on avian behavior: Implications for wildlife management at airports

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ABSTRACT

Airports often contain foraging, breeding, and roosting resources for wildlife. Airports also have different types of radars to assist with air traffic control, monitoring weather, and tracking wildlife that could become a risk for collision with aircraft. The effect of radar electromagnetic radiation on wildlife behavior is not well understood. The goal of this study was to determine whether bird behavior is affected by radar in two contexts: stationary radar (e.g., surveillance radar) and approaching radar (e.g., aircraft weather radar). We used brown-headed cowbirds (*Molothrus ater*) as a model species as they are common at airports. We hypothesized that radar challenges attention mechanisms and thus might distract birds from foraging or avoiding threats (i.e. aircraft). In the stationary radar context, we performed one experiment in the summer and one in the winter. In the summer, we found indication of changes in vigilance and movement behaviors during and after exposure to stationary radar. For example, movement rate increased from before to during radar exposure in the summer ($t_{101} = -3.21$, $P = 0.002$). In the winter, we also found that stationary radar increased movement behaviors. In the approaching radar context, we found that birds exposed to an approaching vehicle with radar showed earlier escape responses ($t_{56.3} = -2.66$, $P = 0.010$) or escape flights that dodged sideways more than with the radar off ($t_{41.5} = -2.67$, $P = 0.011$). Taking these findings together, we suggest that birds might avoid stationary radar units, and moving radar units (e.g., aircraft) might enhance escape responses at low vehicle speeds during taxi, but likely not at higher speeds during take-off, landing, and flight.

1. Introduction

Airports utilize a large number of sources of electromagnetic radiation, specifically in the microwave range (Joseph et al., 2012). Radar is a type of microwave that air traffic control and aircraft use for navigation, surveillance, communication, and detection of weather patterns and bird flocks (Huansheng et al., 2010; Joseph et al., 2012; Stimson, 1998). These sources of electromagnetic radiation may make airports areas with high levels of microwaves (Joseph et al., 2012), and have the potential to affect habitat use by birds and/or cause negative consequences at the individual or population levels (Kelly and Allan, 2006). However, little is known about how these microwaves might affect animals. Some studies indicate that even low doses of electromagnetic radiation can have significant effects on many aspects of an organism's ecology (reviewed in Balmori, 2009; Cucurachi et al., 2013; Fernie and Reynolds, 2005) and behavior (Tanner, 1966; Tanner et al., 1967).

Radar is associated with electric and magnetic fields that pulse on multiple time scales simultaneously (Stimson, 1998; Fig. 1a). Microwaves are only emitted for a small percentage, or duty cycle, of the total interpulse period (Fig. 1b). Airports use many X-band radars (Fig. 1a) with microwaves of a frequency that can penetrate skin and muscle tissues to a depth of ~4 mm (National Council on Radiation Protection and Measurements, 1981). This tissue penetration may allow an animal to detect these microwaves through one of two mechanisms: thermoreception (Byman et al., 1986) and auditory detection (Lin, 1978).

Microwaves have been shown to raise body temperature (Byman et al., 1986) and through thermoreception increase the incidence of thermoregulatory behaviors (e.g., gaping, wing spreading, and panting) in birds (Wasserman et al., 1985). Thermoreception of microwaves has also been hypothesized to cause changes in avoidance and dominance behaviors (Wasserman et al., 1984a,b). Pulses of microwaves generate a thermoelastic pressure

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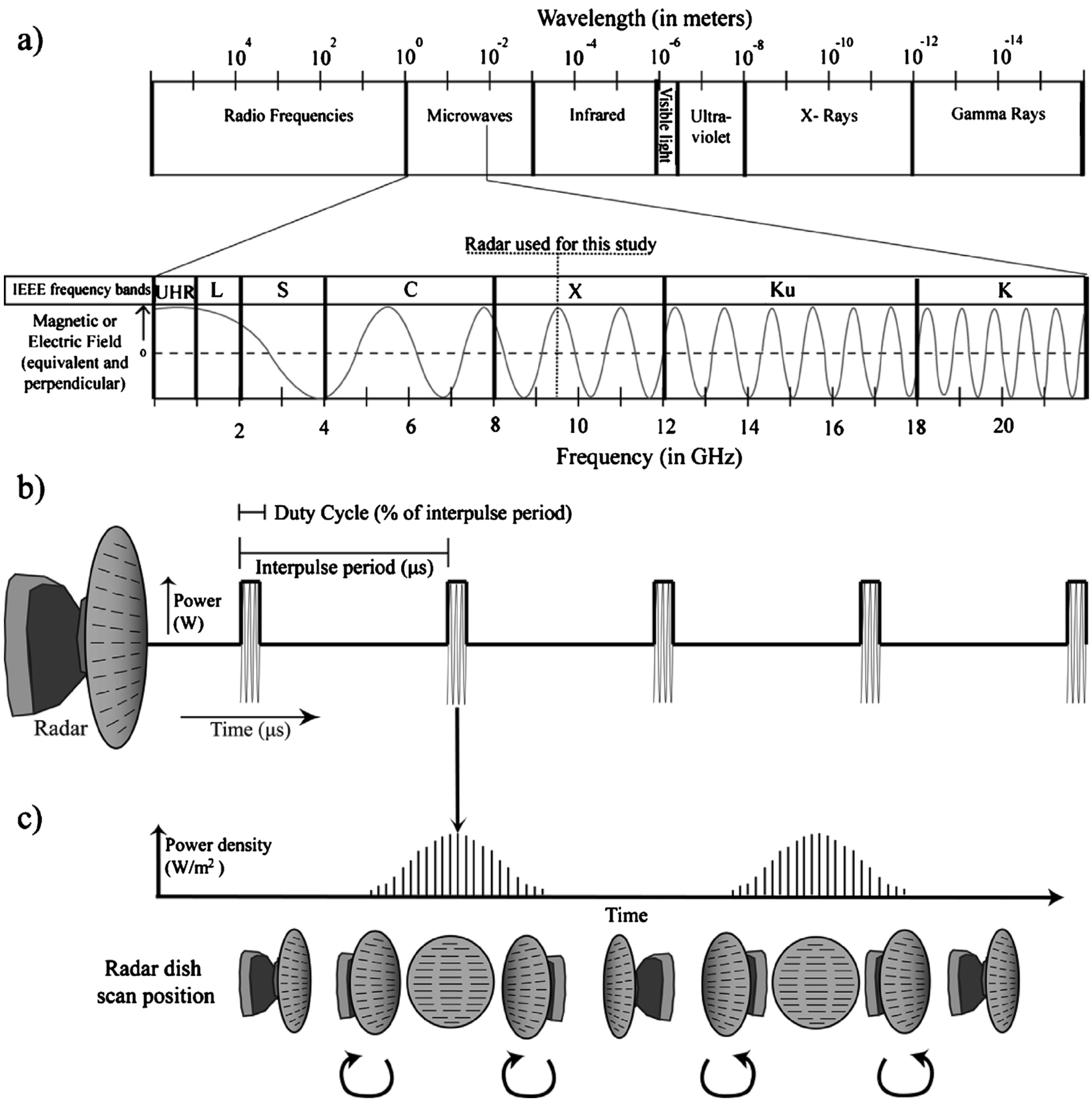

Fig. 1. Properties of radar. (a) The electromagnetic spectrum, with microwaves inset. The frequency of radar used in this study (9.3 GHz) is marked with the dotted line. Also displayed in (a) is the nature of electromagnetic waves, with equivalent and perpendicular magnetic fields, the intensity of which follow the wave pattern of the electromagnetic radiation wavelength. Adapted from Sorrentino and Bianchi (2010). Radar pulses: (b) the peak power emitted per pulse at the antenna, and (c) power density at some distance as transmitted by the antenna. Power density is modulated by the dish or antenna, which rotates to scan up to 180° around it. A single pulse from (b) is displayed as one of the vertical lines in (c). Adapted from Stimson (1998).

wave that is heard as an auditory sound (Lin, 1977), which has been shown in mammals but not in birds (Lin, 1978). In both mechanisms, the intensity of the response is dependent on the power density of the incident microwaves (Lin, 1978; Wasserman et al., 1985).

We investigated how radar affects bird behavior using brown-headed cowbirds (*Molothrus ater*) by simulating two situations in which animals are exposed to radar at airports: stationary (e.g., surveillance radar) and approaching (e.g., aircraft weather radar). Under semi-natural conditions, we investigated the foraging and vigilance behaviors of cowbirds in response to stationary radar in two experiments. In a third experiment, we assessed cowbird escape behavior in response to an approaching threat (vehicle) fitted with radar.

Assuming that birds can detect and process radar microwaves with their sensory systems, we hypothesized that radar increases sensory load and challenges attention mechanisms. Attention is limited (Dukas, 2004), and birds with difficult foraging tasks are less likely or take longer to detect other stimuli (Dukas and Kamil, 2000; Kaby and Lind, 2003). Based on this attention hypothesis, we made a general prediction: radar microwaves would reduce the ability of birds to attend to other sensory tasks. In the stationary radar context (hereafter experiment 1A and 1B), we predicted that birds would forage less during exposure to radar microwaves, as they would attend to radar to the detriment of foraging. In approaching radar context (hereafter experiment 2), we predicted that birds would alert later to and escape later from the approaching threat with radar on. Additionally, we predicted that the direction of the escape flights would be more irregular with the radar on than off, because the intermittent microwaves may cause distraction while in mid-flight. However, we also considered an alternative hypothesis for experiment 2: if radar microwaves attract more attention and/or increase alertness to the threat, then radar may enhance the detection and perception of the approaching stimulus. Hence, we alternatively predicted that birds would respond earlier to the approaching threat with radar on than one with radar off.

In experiment 2 we were able to use two different radar units with different power densities. Therefore, we hypothesized that