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Using radio-telemetry to assess the risk European starlings pose in pathogen transmission among feedlots

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Abstract: We monitored site-use and movements of 102 radio-tagged European starlings (*Sturnus vulgaris*) during the winter months at 2 concentrated animal feeding operations (feedlots) in central Kansas. Our research investigated the spatial ecology of wintering starlings as part of a broad epidemiological study on the possible role of starlings in pathogen transmission at feedlots. Site fidelity was 0.677 and 0.552 (days at capture-site per total days tagged) for feedlots A and B, respectively. Minimal exchange (9%) occurred between feedlots A and B and was often followed by a roost-site change. Starlings rarely abandoned the feedlot where they were captured, but we observed 41 (40%) birds that temporarily switched allegiance from their capture sites to other feedlots; the farthest bird was detected 68 km from the capture site. We speculate that the limited frequency of time spent at non-capture-site feedlots could lower the potential for risk of starlings spreading pathogens among feedlots. We suggest management strategies within the feedlot that may reduce starling populations and speculate that this would lower the risk of spreading pathogens among feedlots.

***Key words*:** concentrated animal feeding operations, European starling, feedlots, human–wildlife conflicts, Kansas, pathogen transmission, radio telemetry, roosting sites

EUROPEAN STARLINGS (*STURNUS VULGARIS*) are an Old World bird species that was successfully introduced into Central Park, New York, New York, approximately 120 years ago. Their current population in North America is approximately 200 million birds (Feare 1984). European starlings (henceforth starlings) are a peridomestic and highly gregarious species, except during the reproductive season. Starlings aggregate in enormous flocks numbering in the tens- and hundreds-of-thousands during fall and winter. It is during this time that they can become serious agricultural and urban pests, particularly at feedlots with open-feeder systems, such as dairy farms and cattle feedlots (Besser et al. 1967, Pimentel et al. 2000; Figure 1).

Even though the economic impacts of feed losses can be substantial due to daily visits by foraging starlings, the potential of spreading pathogens within and among herds may have a much larger economic importance. For example, starlings are asymptomatic carriers of several zoonotic pathogens, including *Escherichia coli* (henceforth *E. coli*) OH157:H7 and *Salmonella enterica* (Clark and McLean 2003, Colles et al. 2008, LeJeune et al. 2008, Carlson et al. 2011), that can cause serious illness to humans. Cattle, too, are asymptomatic carriers of *E. coli* O157:H7 and have been established as the main source of its infections in humans (Diez-Gonzalez et al. 1998, Fratamico et al. 2002). *E. coli* O157:H7 clinically sickens >73,000 people annually in the United States (Mead et al. 1999).

Because starlings are extremely abundant at feedlots and spend months at a time in close contact with thousands of animals in confined quarters, it is likely that they could play an important epidemiological role in pathogen dissemination. However, to date, no definitive

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Figure 1. Hundreds of starlings hover over a cattle feedlot.

epidemiological evidence has directly linked starlings in the spread of pathogens among feedlots. If starlings were acting as pathogen vectors to cattle, the most likely transmission route would be through livestock ingestion of starling feces from contaminated water and feed (Foster et al. 2006).

During the winters of 2006–2007 and 2007–2008, we tracked 102 radio-tagged starlings that were captured at 2 feedlots in central Kansas. We hypothesized that starlings were likely candidates as biological vectors of pathogens because of their close association with livestock and sheer numerical sizes of populations visiting feedlots daily. Our study examined the broader spatial aspects of the potential for pathogen transmission by starlings rather than the within-site focus of the other studies. In particular, we described the frequency of use both among and within days and exchange of starling populations between and among livestock facilities on a local scale during the wintering period. The evidence that starlings are disease vectors is steadily accumulation but remains only circumstantial. However, our data could be used for implementing management plans to reduce the potential risk of starlings in the spread of infectious zoonotic pathogens.

Study area

Our study area included feedlots, farms, towns, and wildlife refuges located in Barton and Stafford counties in central Kansas. The topography of the study area was mainly flat with some rolling hills. Temperatures ranged from -21 to 17°C and -18 to 20°C; precipitation ranged from 0 to 2.7 cm and 0 to 0.1 cm during the winter months in 2006–2007 and 2007–2008, respectively (National and Local Weather Forecast 2008).

Agriculture was the primary land use in the study area, with major crops such as wheat, corn, sorghum, soybeans, and cotton (National Agricultural Station Service [NASS] 2008). In both 2006 and 2007, Kansas produced >2.5 million head of cattle, making it the second largest producer in the United States (NASS 2008). Barton County, which comprised the major portion of our study area, produced approximately 70,000 head of cattle annually (NASS 2008). Within the study area, there were >15 commercial feedlots ranging in size from 5,000 to 30,000 head (Kansas Livestock Association 2011).

Quivira National Wildlife Refuge (QNWR) is a large block of undeveloped public land used for recreation and hunting; it is located in northern Stafford County, Kansas. Quivira National Wildlife Refuge was used as a roost site by large numbers of great-tail grackles (*Quiscalus mexicanus*), red-winged blackbirds (*Agelaius phoeniceus*), and starlings. The refuge was 8,957 ha and provided food, water, and habitat to >300 species of migrating birds (U.S. Fish and Wildlife Service [USFWS] 2003). The refuge included grasslands, farmlands, and marshes, with approximately 30 water bodies ranging from 4 to 607 ha (USFWS 2002).

Methods

Radiotelemetry

We used modified Australian (JBW Marketing, West Columbia, South Carolina) drop-in decoy traps to capture starlings at 2 feedlots, A and B (Figures 2 and 3). We determined sex based upon the presence or absence of an amber colored eye ring that is typical of females. This characteristic has been shown to be 97% accurate to determine sex (Smith et al. 2005). If the eye ring was unclearly identifiable, we examined throat feathers and bill-base color; males' throat feathers are longer, with a pointed end, and tend to be more colorful and iridescent than those of females (Smith et al. 2005). From December 27, 2006, to January 24,

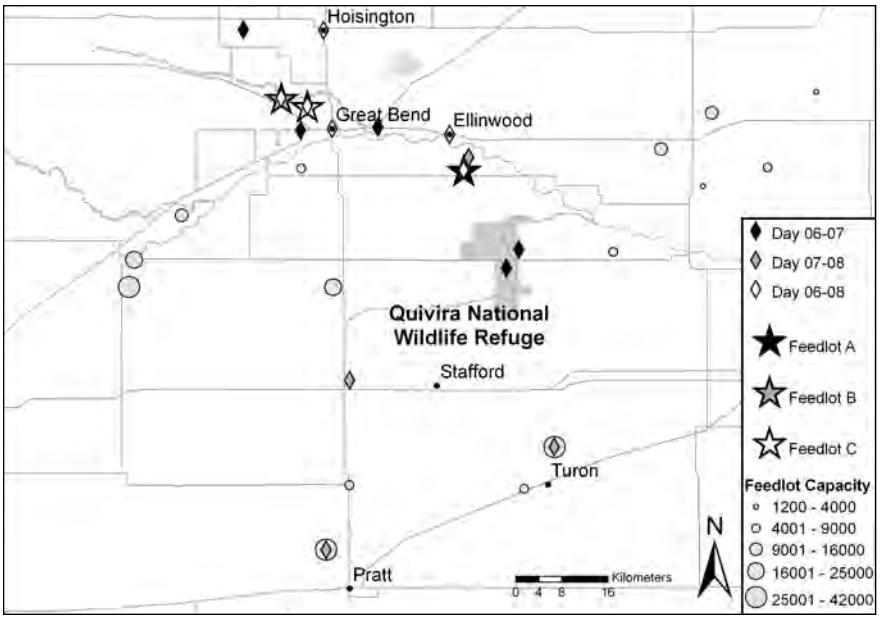

Figure 2. Day locations (*n* = 14) used by 153 radio-tagged European starlings captured in central Kansas during the winter months of 2006–2008. The detection of an individual radio-tagged starling at multiple sites accounts for the number of starlings detected to be greater than the 102 were radio-tagged.

2007, we radio-tagged 47 birds (22 males, 25 females), including 31 birds at feedlot A and 16 birds at feedlot B. We radio-tagged 55 birds (30 males, 25 females) from December 17, 2007, to January 11, 2008, including 44 birds at feedlot A and 11 birds at feedlot B. Radio transmitters weighed approximately 2.5 g, and radio-tagged starlings were >80.0 g, with an average mass for males of 84.6 g (SE = 0.7) and 83.1 g (SE = 0.6) for females.

Radio transmitter frequencies ranged from 164.0 to 167.0 megahertz; transmitters were purchased from Advanced Telemetry Systems (ATS Inc., Isanti, Minn. [Model A2440]). A figure-8 elastic harness was attached to the radio tags. The harness loops fit snugly on the thighs, with the radio transmitter body resting on the dorsal surface of the bird's synsacrum (Rappole and Tipton 1991). The radio antenna extended beyond the tail approximately 5 cm. Detection range for the transmitters was generally 1 to 2 km.

We placed fixed datalogger receiving systems (R4500S Receiver [Datalogger], Advanced Telemetry Systems Inc., Isanti, Minn.) at feedlots A and B. During the winter of 2007–2008, many (>25%) of the radio-tagged starlings captured at feedlot B interchanged with a nearby feedlot (C), located 4 km from feedlot B, and, thus, the datalogger was rotated between these 2 feedlots. Logged data included transmitter frequency, signal pulse rate and strength, date,

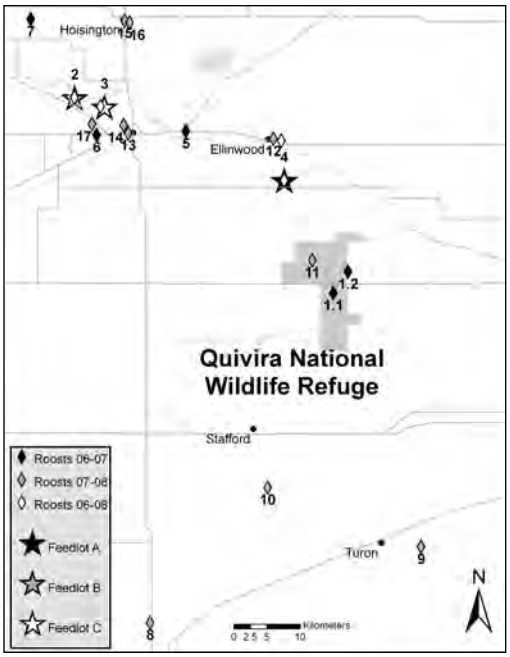

Figure 3. Roost-site locations (*n* = 19) used by 134 radio-tagged European starlings captured in central Kansas during the winter months of 2006 to 2008. The detection of an individual radio-tagged starling at multiple sites accounts for the number of starlings detected to be greater than the 102 that were radio-tagged.

and time. At the fixed sites, data were recorded continuously by the dataloggers, with the strongest signal stored hourly. We used pole-mounted 3- or 6-element Yagi antennas. The fixed-site receiving systems were powered by a deep-cycle 12-volt battery and were run from December 31, 2006, to February 19, 2007, and from December 18, 2007, to February 14, 2008. The mobile receiver was a 4-wheel-drive pickup truck with a roof-mounted, dual, 6-element Yagi antenna, and a global positioning system (GPS). We searched for missing radio-tagged starlings with the mobile unit every other day and covered feedlots, farms, towns, and wildlife refuges within a 50-km radius of our trapping sites. If radio-tagged starlings were found at distances >30 km, we revisited those particular sites on a weekly rotation. For both years combined, the stationary system provided 93% of the total locations (n = 20,777), while the mobile system contributed 7% (n = 1,564).

Data analysis

We obtained a large number of data points for each radio-tagged starling. To display and interpret these data points in ArcGIS, numerous duplicated points were eliminated from the data set. Because most of the radio-telemetry data came from stationary data loggers, we used only the strongest signal point for each hour in our analysis. Based on the time of the day the signal was collected, we assigned activity, such as departing to and from roost, roosting, and daily activity. Once these manipulations were complete, we then imported these data into ArcGIS for map displaying purposes. We used ArcInfo 9.3 to display and view the data and to measure distances among sites used by radio-tagged birds. Site fidelity was determined by days at a capture site per total days tagged.

Results

Day activity

Throughout most of the winter, most radio-tagged starlings used the same feedlot in which they were initially trapped. The average site fidelity for both field seasons was 67.7% and 55.2% (days at a capture site per total days tagged) for feedlots A and B, respectively. We excluded starlings from this analysis if they were detected ≤3 days at the site of capture. The greater site fidelity (0.677) shown by the feedlot A cohort was probably the result of fewer feedlots and other areas for day activity within close proximity of the feedlot. Less time spent at feedlot B (0.552) was attributable to use of 22,000 head of livestock, feedlot C, within 4 km of feedlot B.

Over both field seasons, 9 of 101 radio-tagged starlings used both feedlots A and B, 4 birds used both feedlots B and C, and 5 birds used all 3 feedlots. Of the 9 starlings that used both feedlots A and B, 55% (n = 5) continually switched between both sites, whereas the remaining 45% (n = 4) remained at the site of switch after the switch was made. Of the 4 starlings that used both feedlots B and C, 75% (n = 3) continually switched between both sites, whereas, the remaining 25% (n = 1) stayed at the feedlot of switch. Of the 5 starlings that used all 3 feedlots, 60% (n = 3) continually switched among feedlots, 20% (n = 1) were not observed at a previous feedlot once the switch was made, and 20% (n = 1) were captured at A then continually visited between feedlots B and C but were not observed at feedlot A again.

Although most birds stayed near their feedlots of capture for most of the study period, 23 birds were located away from their capture sites, including one that was located 68 km from the initial trap site. Only four of these 23 radio-tagged starlings were found at 2 additional, large (30,000 and 34,500 head) commercial feedlots located approximately 50 and 70 km, respectively, from the initial trap site. Other off-site locations of radio-tagged starlings included residential areas (n = 7), a grain elevator (n = 1), a cemetery (n = 4), a shelter belt (n = 1), a vacant swine operation (n = 1), and small farms (n = 5; Figure 2).

Roost activity

We found 19 roosts during the 2 field seasons. QNWR served as the largest communal roost, providing habitat for 58 (56%) radio-tagged starlings. During the winter of 2006–2007, 36% of the starlings using the large communal roost also used a satellite roost. The large communal roost changed locations 3 times (roost sites 1.1, 1.2, and 1.3; Figure 3) in 2006–2007. In total, 33 birds used roost 1.1, 7 birds also used roost 1.2, 9 birds used 1.3, and 4 birds used all 3 communal roost sites. Most (88%) of the radio-tagged starlings roosting at QNWR were trapped and

radio-tagged at feedlot A. During the winter of 2007–2008, 25 radio-tagged starlings used the large communal roost within QNWR (roost site 11; Figure 3). The communal roost did not change locations; however, 24% of the radio-tagged starlings that used QNWR as a roost site also used satellite roost sites.

Although QNWR served as the largest communal roost-site location, 16 satellite roost sites containing <250 individuals were detected. Satellite roosts were found at the 3 feedlot study sites (roost sites 2, 3, and 4; Figure 3), which provided roosting habitat for 42 (41%) radio-tagged starlings. Most of the radio-tagged birds that used feedlot B for day activity also roosted at the feedlot. Other satellite roost locations were detected at a firehouse, a small cattle operation, and several residential areas. These residential roost sites were typically individual birds either within trees or within structures of homes. The starlings that used roost sites 8, 9, and 10 were within 1 km, 8 km, and 30 km, respectively, of the feedlot that each used during the day (Figure 3).

Discussion

Starlings in our study were more likely to visit multiple day activity sites when multiple sites, such as feedlots or residential areas, were within close proximity to their initial trap sites. We detected a 12.5% difference in site fidelity between feedlots A and B. Lesser site fidelity (0.552) was observed in starlings that were initially trapped at site B; this is attributable to close proximity to feedlot C. Greater site fidelity (0.677) was observed at site A; this was most likely due to fewer alternate food sites within close range of the feedlot. These data suggest that feedlots lacking additional nearby locations that are attractive to starlings have fewer interchanges of individuals and, thus, reduce the potential risk of pathogen transmission among feedlots; however, within-herd transmission may be increased. Likewise, feedlots that have nearby locations that are attractive to starlings have a greater interchange of individuals, and, thus, increase the risk of pathogen transmission among feedlots. However, pathogen transmission may be decreased within herds. Starlings interchanging between feedlots, such as those between feedlots B and C, could lead to clustering of genetically identical pathogens, such as those described by Wetzel and LeJune (2006).

Many starlings trapped at site B also roosted there. This behavior was most likely due to the smaller population of birds at site B, and, thus, these starlings had sufficient structures and available space to accommodate them. Other satellite roost sites were detected within close proximity (8 km) to site B; many of these were located in residential areas. Roosting in residential areas near daily activity areas is common and has been reported in other studies (Caccamise and Morrison 1986). These areas are potential nesting sites to the individuals that are yearlong residents. One study showed that starlings started roosting in their nesting sites as early as mid-December (Kessel 1957).

Starlings in our study traveled an average of 17 km from their roost to daily activity sites. Previous studies have shown that starlings will travel >30 km to foraging areas and other daily activity areas (Hamilton and Gilbert 1969, Heisterberg et al. 1984). Morrison and Caccamise (1985) found that starlings were more faithful to their daily activity sites, whereas, we found site fidelity to be 0.677 and 0.552 for sites A and B, respectively. Seasonal differences may account for the differences between studies. Morrison and Caccamise (1985) studied starlings during summer months (June to November), when starlings were more likely to be resident birds, while our study was during the winter months (December to February) when migratory restlessness may be more common.

Dense congregations of birds, such as those detected in our study, potentially facilitate a greater rate of pathogen transmission (Daszak et al. 2000, Reed et al. 2002). Migratory avian wildlife are more susceptible to infectious pathogens during the winter months because of compromised immune systems caused by the stress of cold temperatures (Daoust et al. 2000, Reed et al. 2002). However, summertime temperatures are more favorable to the survival of pathogens in the environment (Barkocy-Gallagher et al. 2003). Gaukler et al. (2009) found a significant increase in the detection of *E. coli* isolates from starlings during summer months when compared with winter months. These data suggest that even though there are dense congregations of starlings in feedlots during winter months, the levels of pathogens present

will be at their seasonal low, thus, reducing the risk of starlings spreading zoonotic pathogens.

We speculate that the limited frequency of occurrence at noncapture-site feedlots probably lessened the potential for risk of starlings spreading pathogens among area feedlots, although the potential of spreading pathogens within herds could be high. Risks associated with pathogen transmission among feedlots may be much higher during migration because of *en masse* movements to new feedlots. However, these large congregations occur at times of the year when pathogen levels are at the seasonal low.

Management implications

Management strategies within the feedlot may be successful at reducing starling populations. Starlings in this study did not arrive to the feedlot until approximately 1.5 hours after sunrise, and they departed approximately 1.5 hours before sunset. Adjusting the feeding schedules of the cattle to be greatest near sunrise and sunset, when the starlings are not present, could decrease the number of birds using the feedlot. Other strategies to reduce starling numbers are to create restrictions in and around the feed bunks to discourage foraging or to increase the size of the cattle feed to make it difficult for starlings to eat. These management techniques may help reduce starling populations using feedlots, reduce the incidences of interchange between feedlots, and reduce the potential risk of the spread of zoonotic pathogens by starlings.

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