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Although property damage and losses can be inflicted by wild birds throughout the entire year, avian-vectored diseases of livestock are primarily a winter phenomenon in the Great Plains states. Reasons for this include the following:

(1) During the winter season the birds congregate in flocks of sufficient size to be of epidemiologic significance.

(2) There is a high degree of interaction between birds and livestock only when limited food induces the birds to forage among confined animals and when adverse weather forces the birds to seek shelter in housing units for livestock.

(3) Colder temperatures increase the time of survival of pathogens transmissible by the avian species.

Of the birds which overwinter in this area, starlings (Sturnus vulgaris), English sparrows (Passer domesticus) and pigeons (Columba livia) are found most frequently in close proximity to livestock. Starlings present the most serious threat to animal health in that they move among herds to a greater degree than do the other two species. In studies carried out at Iowa State University over a period of two years, pigeons and English sparrows were observed generally to both roost and forage at the same farm. Starlings, however, sought food primarily at sites other than that at which they roosted and moved an average minimal distance of three to four miles per day during foraging and staging. On one morning, a starling to which a radio-transmitter had been attached was followed during a flight of approximately 22 miles from the roost to the first foraging site; this was a circuitous route to the foraging site that in reality was only 6.4 linear miles from the roost. Depending upon weather conditions, human and livestock activities and individual characteristics of specific birds, starlings did not remain at a single location but rather moved back and forth among farms and among different areas on the same farm. Also, they frequently rested at farms where they did not forage. Disturbed pigeons and English sparrows generally did not leave the premises although they did move quite frequently within the limited area.

In our studies of 22 starlings to which radio-transmitters were attached, starlings foraged at an average of three farms each day although individuals were observed at as many as 14 (Table 1). Two birds regularly moved among seven farms and one among eight during daily foraging routines. Hog lots were especially attractive to starlings and all except two of the birds foraged at least part of the time at such locations. Starlings visited an average of two different hog farms each day during foraging and individuals were observed at as many as eight different farms with swine (Table 2). Only nine of 22 starlings were identified as ever feeding at farms with cattle only.

At farms supporting both swine and cattle, the birds generally were found intermingling with the pigs. On hog farms, starlings were found foraging directly among the swine and in their feeders. However, on beef farms most

Table 1. Maximum number of livestock farms at which 22 individual starlings foraged during a single day.

Maximum Number of Livestock Farms Visited/Day		Number of Starlings
0		1
1		1
2		1
3		4
4		1
5		2
6		1
7		2
8		1
9		1
10		4
11		2
14		1
	TOTAL	22

Table 2. Type of farms serving as foraging sites for individual starlings with radio-transmitters.

	Number of Farms Visited			
Starling	Hogs Only	Cattle Only	Hogs + Cattle	No Hogs or Cattle
1	2	0	1	1
2	0	1	0	1
3	2	0	3	1
4	0	0	1	0
5	1	0	1	6
6	0	0	1	1
7	1	0	4	1
8	2	3	3	2
9	2	1	2	7
10	3	3	3	3
11	2	0	3	6
12	4	0	3	3
13	0	1	2	4
14	1	2	2	4
15	1	1	1	1
16	3	0	1	0
17	3	0	0	0
18	4	3	4	3
19	1	3	2	3
20	3	0	2	2
21	0	0	0	0
22	0	0	3	2

birds sought food in stored silage or in silage bunks but did not forage in the immediate vicinity of the livestock. Pork producers, in general, have been concerned about transmission of disease by birds while beef producers have been concerned with fecal contaminants making feed unpalatable to cattle.

There were 42 swine farms in the area of the study and starlings with radio-transmitters were observed at 27 (64%) of these (Table 3). The birds were found at only 15% of the non-livestock (grain only) farm sites in the same area. During the period of the study, 40% of the observations of starlings with radio-transmitters were at hog lots while only 16% of the observations were at cattle lots and 17% were in fields (Table 4); the latter were the two most preferred sites after hog lots. Fields were preferred early in the winter when farmers were tilling the soil.

Although there was variability among the starlings as to the specific farms which they visited, most birds showed definite preferences for sites where they foraged, loafed and roosted (barns were the preferred roosts, Table 5). Consequently it was possible to calculate the probability of starlings visiting any given farm as well as the probability of a bird moving to any defined type of location (Table 6). An analysis of characteristics of favored farms as compared with unfavored farms may give clues to livestock producers as how to alter management practices to avoid problems with birds. We have not yet done this.

Numbered streamers were attached to an additional 139 starlings in order that more data could be otained regarding interaction between birds and livestock. Eighty to 100% (depending upon the site and time of tagging) of the starlings were observed later at locations other than that where they had originally been captured (Table 7). These birds were also observed at an average of three different farms (range one to eight) and an average of 2.5 hog farms (range zero to six).

Early in the study period starlings visited 80% of the hog farms in the area but the birds narrowed their range to 30% of the farms in the second half of the period. This may indicate selection for farms at which foraging is carried out most efficiently and, again, analysis of the differences in management practices on the two groups of farms may provide clues for reduction of bird problems.

Birds frequently were observed bathing and preening as they rested after feeding. When run-off water or melting snow in gutters on the roofs of buildings is used for this purpose it perhaps serves effectively to eliminate pathogens that might be carried externally by the birds. However, when livestock waterers are the sites of such activity, as they frequently were during the study, agents of disease may contaminate the drinking water supply.

Another observation related to the role of birds as vectors of livestock diseases was, on the basis of returns of banding information, that the population of starlings wintering in the study area was composed of co-existing migratory and sedentary birds. Migration can serve effectively to introduce new pathogens into an area while the resident birds may constitute a susceptible group to which disease may be transmitted.

Investigations carried out at Iowa State University thus indicated that habits of birds, especially starlings, give them the potential to serve as

Table 3. Summary of contact between starlings with radio-transmitters and livestock farms in the study area.

	No. in Study Area	No. Visited	Percent
Livestock Farms	58	34	59
Hog Farms+	42	27	64
Cattle Farms++	35	20	57
Nonlivestock Farms	108	16	15
Hogs+ (Actual Nos.)	7012	5089	73
Cattle++ (Actual Nos.)	2717	1928	71

+May have cattle present on farm also.

++May have hogs present on farm also.

Table 4. Observation of starlings with radio-transmitters foraging in four different activity locations.

Foraging Locations	Number of Times Observed	Percent
Hog Lots	172	40
Cattle Lots	69	16
Fields	71	17
Other	115	27
TOTAL	427	100

Table 5. Identification of roost sites selected by starlings with radio-transmitters.

Site	Number of Observations	Percent of Observations	Number of Birds
Barn	199	79.9	17
Pole Barn	16	6.4	1
House Attic	14	5.6	1
Evergreens	12	4.8	2
Silo	4	1.6	1
Corn Crib	2	0.8	1
Small Building	1	0.4	1
Tree	1	0.4	1
TOTAL	249	99.9	

Table 6. Prediction of starlings moving to a defined type of location.

	Probability of Movement to			
	Livestock Farm	Non-livestock Farm	Hog Farm	Non-hog Farm
Area A				
Period I (Nov 15 - Dec 15)	0.69	0.31	0.66	0.34
Period II (Jan 15 - Feb 15)	0.84	0.16	0.59	0.41
Total Area A	0.78	0.22	0.62	0.38
*Area A'				
Period II (Jan 15 - Feb 15)	0.89	0.11	0.89	0.11
Total Area A + A'	0.81	0.19	0.70	0.30
Area B				
Period I (Nov 15 - Dec 15)	0.70	0.30	0.61	0.39
Period II (Jan 15 - Feb 15)	0.73	0.27	0.60	0.40
Total Area B	0.72	0.28	0.61	0.39

*Area A' = Starlings were trapped at a second farm during Period II in order to observe movements of the birds using two major roosts in Area A.

Table 7. Observations of tagged starlings at the two areas.

	Number Tagged	Number Seen after Tagging	Number Seen at Tagging Location	Number Seen at Location Other Than Tagging Site	Average Distance Seen From Tagging Site
Period I*					
Area A	25	23	21 (91%)	19 (83%)	1.36 mi
Area B	39	30	19 (63%)	24 (80%)	0.69 mi
Period II**					
Area A	50	50	45 (90%)	50 (100%)	1.06 mi
Area B	25	25	25 (100%)	23 (92%)	0.73 mi
Total					
Area A	75	73	66 (90%)	69 (95%)	1.15 mi
Area B	64	55	44 (80%)	47 (85%)	0.71 mi

*November 15 through December 15.

**January 15 through February 15.

vectors of livestock diseases provided mammalian pathogens can survive in or on avian species. Isolations of bacteria such as Salmonella and Mycobacteria have been accomplished on several occasions but isolations of viruses have been less successful. Nevertheless, some cattlemen have been concerned about transmission of viruses with tropism for the respiratory tract and pork producers have believed that starlings serve as vectors of transmissible gastroenteritis (TGE) virus specifically. Because of the preference observed by starlings for hog farms, we investigated the potential role of birds in the epidemiology of TGE.

Experiments were carried out in which starlings were exposed to swine and were allowed to associate freely with susceptible pigs. Although some alterations of the virion may have occurred within the abnormal avian host, the virus remained virulent for swine after passage through the birds and concentrations of virus released were sufficient to constituent a pig infectious dose, at least when the animals were confined to a limited space so much interaction occurred between the species. Less interspecies association may occur in natural situations. Furthermore, the virus used as challenge was a highly virulent virus, probably more infectious than that generally associated with outbreaks of the disease in the field.

In one experiment starlings became ill and died after exposure to diseased pigs. Although it cannot be unequivocally stated that these birds suffered fatal infections with TGE virus, the pathogen was isolated from the dead starlings. Necropsy did not indicate any other cause for the morbidity and mortality, and the birds had been acclimated to captivity prior to the test and were thriving. Additional starlings from the captive colony that were exposed to uninfected control swine, remained healthy.

A field study was also carried out to investigate the potential role of birds as vectors of TGE virus. Starlings and English sparrows were captured at five farms on which TGE was occurring among swine, five TGE-free farms and a roost, and attempts were made to isolate externally and internally carried virus from the birds. Serosurveys were also carried out to establish history of exposure to the pathogen. Viable virus was isolated from external surfaces of 4% of the starlings captured at all sites and from the alimentary tract of 14% of the birds (Table 8). Frequent perching activities, walking the snow and preening and bathing probably remove virus from the surfaces of birds. Isolation of the virus from homogenized intestinal epithelial cells and observation of seroconversion indicative of invasive antigen were evidence that actual infection of the starlings can occur under natural environmental conditions. This implies a longer period of time during which the birds can serve as a threat to sympatric swine than would be the situation if starlings carried the virus only mechanically.

A greater rate of isolation of the virus from starlings at one farm, prior to an outbreak of TGE at that site than at the same farm while disease was prevalent among the pigs (Table 9) may suggest that the birds were involved in introduction of the disease onto the premises. However, isolation of TGE virus from starlings at other TGE-free areas at a rate similar to that for diseased farms indicates that the mere presence of TGE virus in the birds, while a necessary condition, is not a sufficient condition for an epidemic of disease to occur in swine. Farm management practices that influence the nature of interaction between the two species and amount and characteristics of the virus carried by the starlings probably are significant factors in determining the consequence.

Table 8. Summary of isolation of TGE virus from starlings captured at swine farms with and without TGE on the premises and at a roost site.

	Number Positive Birds / Number Negative Birds (% Positive)		
	External Virus	Internal Virus	Seroconversion
Farms with TGE			
1-TGE	ND	14/83 (17%)	2/88 (2%)
2-TGE	2/91 (2%)	4/91 (4%)	3/93 (3%)
3-TGE	6/49 (12%)	7/89 (8%)	1/90 (1%)
4-TGE	0/25 (0%)	14/115 (12%)	4/26 (15%)
5-TGE	3/52 (6%)	19/116 (16%)	3/128 (2%)
Total	11/217 (5%)	58/494 (12%)	13/425 (3%)
Farms without TGE			
1-C	ND	37/98 (38%)	2/118 (2%)
2-C	0/61 (0%)	18/110 (16%)	0/115 (0%)
3-C	0/49 (0%)	11/92 (12%)	0/97 (0%)
4-C	5/50 (10%)	5/89 (6%)	0/108 (0%)
5-C	0/30 (0%)	12/92 (13%)	0/99 (0%)
Total	5/190 (3%)	83/481 (17%)	2/537 (0.4%)
Roost	0/41 (0%)	6/91 (6%)	7/75 (9%)
Total all birds	16/448 (4%)	147/1066 (14%)	22/1037 (2%)

Table 9. Isolation and identification of TGE virus at a swine farm 6 weeks prior to an outbreak of TGE and at the time of the outbreak.

Time of Collection of Starlings	TGE Status of Birds	External Virus	Number of Birds: Internal Virus SI[a]	IW[b]	FA[c]
Prior to TGE Outbreak (1-C)	TGE-neg	ND[d]	61	57	120
	TGE-pos	ND	37 (38%)	33 (37%)	3 (2%)
	TOTAL	ND	98	90	123
At Time of TGE Outbreak (5-TGE)	TGE-neg	49	97	104	117
		3 (6%)	19 (16%)	9 (8%)	4 (3%)
	TOTAL	52	116	113	121

[a]Virus isolated from homogenized epithelium of intestine.

[b]Virus isolated from lumen contents of intestine.

[c]Virus identified in epithelium of intestine by staining with fluorescent antibody.

[d]ND = not done.
No attempts were made to isolate virus from external surfaces of birds at the earlier time period.

On the basis of our observations, some things that a herdsman might do to minimize the threat of TGE virus as well as other pathogens carried by birds to his swine are the following:

(1) Adjust feeding schedule of the pigs to minimize attractiveness of the farm to avian species. The energy requirement of birds, especially in cold weather, is such that they must be assured of of dependable food supply. A bird, based on observed differences in weights of starlings captured as a function of the time of day of trapping, probably consumes nearly half its weight in food each day. Hence, daily food ingestion is critical. Feeding of sows, whose caloric intake should be restricted anyway, on a three-day-per-week schedule would discourage foraging by birds on the premises.

    Changing the time of day at which hogs are fed may also affect the rate of foraging of birds, especially starlings, at a swine farm. Intensive foraging probably begins between one and two hours after a starling leaves the roost and maximal foraging probably occurs by noon. By midafternoon birds are spending much time loafing and preparing to return to the roost. Delay of feeding of pigs until late in the afternoon should discourage foraging on the premises by birds.

(2) The manner of feeding of pigs can be selected to minimize availability of food for avian species. Feeding boars and gestating sows on the ground is convenient for herdsmen and doesn't require any expenditure for equipment. However, it does result in grain being spread out over a larger area and there is a significant amount of waste for swine that is available for consumption by birds. Although feeding in troughs results in greater crowding of animals as they eat the ration there probably is less waste grain.

    At some facilities, feed to be distributed to the swine is stored in containers adjacent to hog pens. Simply providing bird-proof covers for these containers would eliminate one very favorable food source for the birds.

    In feeder pig operations, self-feeders are popular to provide the animals continually with grain and hopefully to achieve maximal rate of gain. Maintenance of the lids on the self-feeders in good repair would eliminate a food source for birds. Also there are differences among self-feeders in design that affect the amount of waste grain that occurs. Some spilled grain would remain near any of the feeders, however. Banging of the lids on the self-feeders as pigs eat has been observed to be disturbing to birds foraging nearby.

(3) Location of feeders or feeding is another factor that can influence foraging by birds in hog lots. Simply putting troughs, and possibly feeding on the ground, in properly designed opened sheds can make a site less attractive to birds. Starlings, sparrows and pigeons have been observed to feed preferentially in completely open areas rather than to forage within partially enclosed structures.

(4) Cats also were found to be quite effective in discouraging birds, especially English sparrows, from feeding at a given location.

(5) Closing or removing potential roost sites for birds can discourage their selection of an area for a winter range. This may be especially important early in the season when the birds can be more readily convinced to move elsewhere, but the stress of loss of a roost site can also be very traumatic for a bird during winter. It must be acknowledged that roost sites can be quite a distance from foraging areas (especially for starlings) and also that alternative roosts that cannot be readily controlled, such as evergreens, may be selected by birds although barns seem to be preferred in this region.

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