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OBSERVATIONS ON WATERFOWL CARCASSES DURING A BOTULISM EPIZOOTIC

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ABSTRACT: Several features related to waterfowl carcasses were studied at Eyebrow Lake, Saskatchewan, Canada, during a botulism epizootic in the summer of 1989. Dummy carcasses, constructed by stretching duck skins over wooden forms, were used to assess the reaction of waterbirds to carcasses. There was no significant difference in the number of American coots, ducks, grebes, or total birds present when dummy carcasses were or were not present. Only one of 42 freshly-dead bird carcasses marked and observed twice each day was removed by a scavenger prior to the development of large maggots. Maggots developed in all carcasses and were visible externally a mean of 3.9 days after placement of the carcasses. The effectiveness of carcass collection and disposal operations was tested by marking carcasses on the day prior to two scheduled clean-ups. Only 32% of marked carcasses were recovered. Large carcasses and carcasses on or near islands were recovered at a higher frequency than were small carcasses and carcasses not near islands, respectively.

Key words: Botulism, waterfowl, carcass, scavenging, management.

INTRODUCTION

Collection and disposal of carcasses is used in the management of disease outbreaks among wild waterfowl, with the rationale that carcasses are a source of infection in diseases such as avian cholera and substrate for toxin production in botulism. Carcasses also may attract or decoy live birds to the area (Rosen, 1971; Friend, 1987), although McLandress (1983) observed the opposite reaction. Removal of carcasses from the site of a disease occurrence seems correct intuitively but the recovery rate of carcasses during clean-up operations and the efficacy of carcass removal in reducing or preventing further disease have not been tested. The occurrence of a botulism epizootic in a wetland which we were studying for other purposes provided an opportunity to investigate some aspects related to carcasses. We determined the response of live birds to carcasses, the persistence of waterfowl carcasses, and the proportion of previously marked carcasses collected during clean-up procedures.

MATERIALS AND METHODS

The study was conducted during summer 1989 at Eyebrow Lake, a 850 ha wetland in south-central Saskatchewan, Canada (50°55′N, 106°08′W). Using the classification system of Cowardin et al. (1979), the lake was a diked, oligohaline (conductivity is about 1,500 μS), semipermanently flooded, palustrine, emergent wetland, with mineral soil and with *Scirpus* spp. as the dominant plant. Artificial nesting islands were present throughout the marsh. Large botulism epizootics occurred in this marsh in 1981 and 1988, with less severe mortality caused by botulism in at least two other years during the past decade (G. Wobeser, unpubl.). A duck suspected to have botulism was found 17 July 1989 and the diagnosis was confirmed by a mouse protection test (Wobeser, 1981). Sick or dead birds were observed throughout the marsh within a few days. The epizootic continued through July and August, and botulism was confirmed in birds examined periodically during this period.

To assess the response of live birds to carcasses, a 2-ha section of open water (0.5 to 1.0 m in depth) in basin B of the lake was measured and divided into four 50 × 100 m units (Fig. 1), the perimeter of which was marked by stakes. A tower, constructed during May 1989, on the dike that forms one border of the area was used to observe the units. An observer could approach and enter the tower without being seen by birds on the water. Actual duck carcasses were not used because of a risk that they might serve as additional substrate to exacerbate the botulism outbreak. Dummy carcasses were constructed by stretching preserved skins of either mallard (*Anas platyrhynchos*) or lesser scaup (*Aythya affinis*) over wooden forms. Dummies were weighted so that they floated low in the water, resembling a carcass floating upright with the

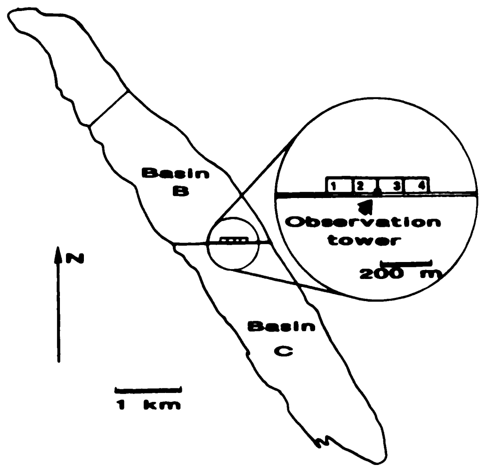

FIGURE 1. Map of Eyebrow Lake showing the location of basins and of the units used for observation of carcasses.

head and neck submerged. Two densities of dummy carcasses were tested: 0 or 5 carcasses/unit. Dummy carcasses were anchored within a 25 m diameter area near the center of the unit. The trial ran from 19 to 23 August and was performed as a two period cross-over carried out in two Latin squares (Fleiss, 1986). Within each replicate, one unit contained five dummy carcasses during the first 2-day time period (19, 20 August) and no dummy carcasses during the second time period (22, 23 August). The other unit had dummy carcasses in the reverse sequence (Table 1). Dummy carcasses were removed from all units on 21 August to reduce carryover effects. Observations consisted of a 1-min examination of each unit at 15 min intervals during 3 hr each in morning (08:00 to 11:00), afternoon (13:00 to 16:00) and evening (18:00 to 21:00), providing a total of 39 observations of each unit in a day. At each observation period, the number and species of bird within the units were recorded. Binoculars or telescope were used to identify birds. The number of birds observed in each unit during each 2-day observation period was used for comparison. Birds were segregated into four groups for analysis: American coots (*Fulica americana*); ducks; grebes, including pied-billed grebes (*Podilymbus podiceps*), eared grebes (*Podiceps nigricollis*) and horned grebes (*Podiceps auritus*); and total birds. Analysis was by the method of Fleiss (1986) for cross-over designs. Data were examined first to determine if there was significant differential carryover effect related to the sequence in which dummy carcasses were placed in units. If there was no significant carryover effect, the effect of treatment (presence of dummy carcasses) and of time periods was examined by *t*-tests (Brockett and Levine, 1984). Significance was assumed at $P < 0.05$.

TABLE 1. Experimental cross-over design used for study of the reaction of live waterbirds to dummy carcasses on the study units in Eyebrow Lake illustrated in Figure 1.

Unit	Number of dummy carcasses present	
	19, 20 August	22, 23 August
1	5	0
2	0	5
3	5	0
4	0	5

To measure the rate of carcass disappearance, carcasses of 42 recently dead birds (20 mallards, 9 blue-winged teal (*Anas discors*), 8 American coots, 2 northern pintails (*Anas acuta*), 1 American wigeon (*Anas americana*) and 2 unidentified ducklings) were collected on 9 August. The birds likely had died during the preceding night and none of the carcasses had fly eggs or maggots evident. Each carcass was weighed and marked with a small numbered metal tag (Ketchum Manufacturing, Ottawa, Ontario, Canada) placed on one wing, close to the body. After marking, the carcasses were replaced in the marsh, with 21 carcasses in each of basin B and C. Ten carcasses in each basin were placed on shore at the water's edge and 11 were placed in 30 to 50 cm deep water within 15 m of shore. A strand of nylon monofilament with a breaking strength of <1 kg was used to fasten carcasses placed in water to emergent vegetation. One end of the line was tied to the bird's leg and the other end was tied loosely about vegetation to prevent the carcass from floating away, while offering minimal resistance to a scavenger. Carcasses were observed twice each day (06:00, 18:00) for development of maggots and evidence of scavenging. Each carcass was removed and destroyed when large (>1 cm) maggots were observed on it, so that we did not contribute to the extent of the ongoing botulism outbreak by leaving maggot-filled carcasses in the area. The time at which maggots were first observed and when each carcass was removed were recorded. Differences in the mean time at which maggots developed in carcasses of various types were tested for significance with a *t*-test (Brockett and Levine, 1984). Significance was assumed at $P < 0.05$. During the period in which carcasses were observed the maximum daily temperature was ≥30 C each day.

Carcass collection and disposal by personnel of Ducks Unlimited Canada provided an op-

TABLE 2. Number of birds of various types observed in each of four 50 × 100 m units of Eyebrow Lake when dummy carcasses were or were not present. The values are the sum of 78 observations made during each 2 day period.

Unit	19, 20 August				22, 23 August			
	Coot	Duck	Grebe	Total	Coot	Duck	Grebe	Total
1	1,247	70	111	1,428[a]	974	38	30	1,042[b]
2	376	33	89	498[b]	342	22	36	400[a]
3	269	19	113	401[a]	328	8	18	354[b]
4	155	21	17	193[b]	189	196	15	400[a]

[a] Five dummy carcasses present in unit.
[b] No dummy carcasses present.

portunity to assess the effectiveness of this technique. A two-person crew, using an airboat, searched the marsh at 3 to 5 day intervals between 25 July and 31 August, and collected carcasses to reduce the amount of substrate available for toxin production. Carcasses were burned. We marked carcasses in the marsh on the day preceding two such clean-up operations. For this purpose, basins B and C were searched by the authors, using a canoe, until approximately 100 carcasses were found and marked. Each carcass was marked with numbered metal tags, as described previously, placed about the proximal tibia of each leg. When in place, tags were covered by feathers and were inconspicuous. Where the condition of the carcass required, tags were placed about the proximal humerus rather than on the legs. Each carcass was replaced immediately in the location and position in which it had been found. On 24 July, 112 carcasses were marked: 70 in basin C and 42 in basin B. On 31 July, 103 carcasses were marked: 43 in basin C and 60 in basin B. The two persons conducting the carcass collections were aware that carcasses had been marked and left in in situ the previous day but they did not know the number or location of marked carcasses. The same individuals were involved in collecting carcasses on 25 July and 1 August and they spent approximately 6 hr searching for carcasses each day. The shoreline back from the water's edge was not searched, except on nesting islands, while marking carcasses or during the carcass collection. We examined all carcasses collected during the clean-up for tags and to determine the species collected, prior to burning. The efficiency of the clean-up was estimated by calculating the proportion of marked birds that were recovered. The recovery rate of mallards and other species was compared using a chi-square (χ^2) test and the species composition of the marked and collected samples were tested for goodness of fit using χ^2 corrected for continuity (Brockett and Levine, 1984). Significance was assumed at $P < 0.05$.

RESULTS

During 4 days of observation a total of 4716 birds, comprised of 3880 American coots (82.3%), 429 grebes (9.1%) and 407 ducks (8.6%), were recorded on the units. There was no consistent pattern of usage in relation to the presence or absence of dummy carcasses (Table 2) and the number of coots, ducks, grebes, and total birds present on the units during the observation periods when dummy carcasses were present was not significantly different from the number present when no dummy carcasses were present. There was no significant difference attributable to carryover effect and only in the case of grebes was there a difference between periods, with significantly ($P < 0.05$) more grebes present during 19, 20 August than during 22, 23 August ($t = 36$, 2 df).

Only one of the 42 marked, freshly dead carcasses placed in the marsh was removed by a scavenger before large maggots were present. This bird, a coot placed on shore, disappeared on the first day after placement. One mallard carcass placed on shore was partially eaten but not removed; maggots subsequently developed in the carcass. Fly eggs were noted on most carcasses during the first day and numerous maggots developed in all 41 carcasses. Maggots were evident externally on some birds as early as 3 days after placement; other carcasses had no maggots obvious until day 5. The mean (±SE) time at which maggots were first observed was 3.9 ± 0.1 days. The mean time at which large and small carcasses were removed, because of the presence of large maggots, was significantly different: 4.3 ± 0.1 days for the 20 mallards (mean weight = 933 ± 24 g), 3.7 ± 0.1 days for the 22 smaller birds (mean weight = 277 ± 47 g). Maggots developed slightly later in carcasses in water than than in birds on the shore (mean time: mallards in water = 4.5 ± 0.1 days, on shore = 4.2 ± 0.2 days; other birds in water = 3.8 ± 0.2 days, on shore = 3.5 ± 0.2 days) but the difference was not significant.

During the clean-up operation on 25 July, 119 carcasses were collected and 43.8% of the marked carcasses were recovered, including 28 of 70 in basin C and 21 of 42 in basin B. During the clean-up on 21 August, 85 carcasses were collected but only 19.4% of the marked carcasses were recovered, including 10 of 43 in basin C and 10 of 60 in basin B. The efficiency of the combined clean-ups was 32.1% (69/215 marked carcasses were recovered) and results were similar in the two basins (30.4% in basin B, 33.6% in basin C). The people doing the clean-ups appeared to concentrate their efforts about artificial nesting islands present in both basins and there was a significantly ($P < 0.05$) greater recovery of carcasses on or around islands (39.6%) compared to those not associated with islands (24%) ($\chi^2 = 13.34$, 1 df). A significantly ($P < 0.05$) greater proportion of marked mallards (52.6%, 30/57) than of other, smaller species (24.7%, 39/158) were recovered ($\chi^2 = 29.2$, 1 df). There was a significant ($P < 0.05$) difference ($\chi^2 = 60.7$, 7 df) in the composition of the marked and collected samples; mallards, blue-winged teal and American wigeon were proportionately more numerous, and coots, ducklings, northern pintail and green-winged teal (*Anas crecca*) less numerous in the collected than in the marked sample (Table 3).

TABLE 3. Comparison of the representation of commonly found species among the carcasses marked prior to clean-ups and among all of the carcasses collected during clean-ups.

	Proportion (%)	
	Marked (n = 215)	Collected (n = 205)
Mallard	26.5	42.2
American coot	26.0	15.7
Unidentified duckling	12.0	2.0
Blue-winged teal	9.8	12.3
Northern pintail	7.4	5.9
Green-winged teal	6.5	2.9
American widgeon	2.3	4.4
Other species	9.5	14.6

DISCUSSION

The effectiveness of carcasses in attracting waterbirds apparently has not been tested previously and field observations by others are contradictory. Rosen (1971) and Friend (1987) indicated that carcasses attract live waterfowl, while McLandress (1983) found that healthy lesser snow (*Chen caerulescens caerulescens*) and Ross' geese (*C. rossii*) avoided dead or dying birds. Our study was very limited in extent but there was no evidence that the presence of dummy carcasses increased use of the units by waterbirds. It is possible birds recognized that the dummies were not actual carcasses and that the response might have been different to actual carcasses. It also is possible that maggots associated with real carcasses might be an attractant but this was not tested. Carcasses were present in other areas of the marsh during the study and also might have influenced the results. The role of carcasses in attracting waterbirds deserves further study if it is considered part of the rationale for carcass collection and disposal.

Persistence of 98% of the observed carcasses (41/42) in an undisturbed state until large maggots were present was unexpected because others have reported rapid scavenging of waterfowl carcasses. For example, more than 50% of lesser snow goose carcasses disappeared within 4 days under spring conditions in Saskatchewan (Wobeser et al., 1982) and more than half of waterfowl carcasses observed in Missouri (USA) during autumn disappeared within 4 days (Humberg et al., 1986). The most directly comparable studies are those of Stutzenbaker et al. (1986) and Pain (1991). In the first, marked duck carcasses were placed in a Texas (USA) marsh during February. Carcasses on the shore of levees persisted 1.4 days, on average; 50% of carcasses placed under vegetation disappeared within 1 day. Birds anchored in open water persisted an average of 11.2 days. The second study was done in the Camargue, France during September. Mallard carcasses in exposed positions on land persisted an average of 1.5 days; carcasses on land but concealed by vegetation persisted an average of 3.3 days and those exposed in water persisted 7.6 days. Differences in the number and type of scavengers present in the various situations may be responsible for some of the difference in persistence of carcasses. Twice-daily observation of the carcasses may have affected scavengers but our methods were not substantially different from those of Stutzenbaker et al. (1986) and Pain (1991) in which the disappearance rate was much more rapid. Our observations were made in the midst of an epizootic when carcasses were abundant and the scavenging system may have been satiated, as may occur when the density of carcasses is great (Linz et al., 1991). We conclude that during the botulism epizootic under study most carcasses would persist sufficiently long to develop maggots and that maggots would develop in most carcasses. We are not aware of other quantitative information on the persistence of carcasses or the frequency of maggot development during a botulism outbreak. We did not test maggots that developed in these birds for the presence of botulinum toxin; however, soil in Eyebrow Lake contains many spores of *Clostridium botulinum* (Wobeser et al., 1987) and maggots from six of ten duck carcasses collected during an outbreak in 1988 contained toxin (Wobeser, unpubl.), suggesting that maggots from many of the test birds would contain toxin.

Our data on the success of carcass collection are limited but represent, to our knowledge, the only attempt to measure the effectiveness of this common management practice. While an overall recovery rate of 32.1% of marked carcasses seems distressingly low, it is perhaps not surprising considering that searchers found only 6% of duck carcasses placed 30 minutes earlier in a Texas marsh (Stutzenbaker et al., 1986). The assumption that all of the marked carcasses were present and available for collection on the day after marking was not tested, so the actual efficiency may have been somewhat greater than estimated. However, since only one of 42 carcasses in the carcass persistence study was removed, error as a result of carcass loss to scavengers probably was small. The difference in effectiveness between the two collections (43.8% vs. 19.4%) may be partially related to increased density of vegetation in the marsh as the summer progressed but why this should have affected searches by canoe and airboat differentially is unknown.

Assuming that each carcass has the potential to produce hundreds to thousands of maggots within about 4 days, that at least some of these maggots will contain toxin, and that as few as two to four toxin-bearing maggots may poison a duck (Locke and Friend, 1987), there was likely an abundance of toxin available to birds in Eyebrow Lake. It is questionable whether collection of about one-third of the carcasses present, at 3 to 5 day intervals, would have a significant impact on the disease under these conditions. The method used for carcass collection on this marsh in 1989 was similar to that used in other outbreaks on wetlands in Saskatchewan during the past decade (G. Wobeser, unpubl.) but it is dangerous to extrapolate because the efficacy of any clean-up will vary with many factors, including the intensity of the procedure, density and type of carcasses, and the nature of the marsh. Carcass collection and disposal is labor-intensive and expensive; for example, the estimated cost to

Ducks Unlimited Canada for each of more than 5000 carcasses collected over a 2 month period during a botulism outbreak at Eyebrow Lake in 1981 was $2.80 (Smith-Windsor and Duffus, 1982). This did not include the value of volunteer labor and assistance from other agencies. Further study is required to measure the efficiency of carcass collection and to determine the effectiveness of this management procedure relative to other potential methods for controlling botulism.

The number of carcasses collected often is the only quantitative information available to assess the significance of a disease occurrence. Evaluation of the size of the outbreak in Eyebrow Lake, based solely on the number of carcasses collected, would seriously underestimate its extent. Based on our results, underestimation would be most severe for less conspicuous species. The total population of carcasses in the marsh (N) could be estimated by capture\recapture methodology using the formula $N = Mn/m$, where M is the number of marked birds, m is the number of marked birds recovered, and n is the total number of carcasses recovered (Davis and Winstead, 1980). The 95% confidence interval could be calculated by a method described by the same authors. Using this formula, an estimated 272 carcasses (95% confidence interval, 212 to 332) were present at the time of the first clean-up and 438 carcasses (95% confidence interval, 352 to 524) were present at the time of the second clean-up. Even these must be considered conservative estimates of the actual number of carcasses present because only the water area was searched and no attempt was made to search the shoreline.

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