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GUANO DEPOSITION IN AN OKLAHOMA CROW ROOST

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Biodeposition is an important geochemical process, especially where large numbers of animals gather. The economic importance of this process is known for oceanic islands, caves, and along coastal areas (Hutchinson 1950). Recently, the effects of biodeposition have been studied (Gillham 1960, Haven and Morales-Alamo 1966, Frankenburg 1967, Kraeuter 1976). In some environments, the excreta (often mixed with egesta) do not undergo bacterial breakdown, but accumulate in geochemically significant deposits—such accumulations are termed guano (Hutchinson 1950). Measurements of guano deposition have been used to estimate the number of birds occupying a roost (Stewart 1973). My objectives were to determine if such measurements could be used to illustrate relative bird densities within a crow roost and to determine if guano deposition significantly increases soil nutrients.

The Common Crow (*Corvus brachyrhynchos*) roosts in concentrated populations in winter. Winter crow populations in Oklahoma have increased over the past 60 years despite the imposition of diverse management and control activities (Aldous 1944, pers. observ.). Crows have been known to roost for approximately 45 years in the Fort Cobb area in Oklahoma (Iams 1972). Iams (1972) reported that the total roost population around Fort Cobb Reservoir had increased from 1,128,509 to 2,108,903 birds between winter 1966 and spring 1970 as indicated by flyway census counts. Crows typically arrive from the north in October and depart in late March or early April (Kalmbach 1938, Iams 1972).

METHODS

Fort Cobb Reservoir (35°10′N, 98°27′W) resulted from impoundment of Cobb Creek in Caddo County. During the 1976–77 winter season, crows roosted at two sites at this reservoir. The north roost was approximately 4.6 km north-northeast of the south roost. Canopy vegetation in both is dominated by blackjack oak (*Quercus marilandica*) and post oak (*Q. stellata*) while the understory is dominated by skunkbrush (*Rhus aromatica*) and buckbrush (*Symphoricarpos arbiculatus*). The soils of these roosts have been described as Eufaula fine sand (Moffatt 1975). Up to 15 cm of leaf litter and decomposing leaf litter cover the soil.

At the north roost, I selected two groups of roosting trees to measure guano deposition by counts and by weight. Preweighed plastic quadrats 0.5 m^2 in size were situated so as to cover the entire area under the tree crowns (11.0 m^2). These quadrats were put in place in the afternoon before the crows arrived and were collected the following morning after counting the number of guano depositions. Sample quadrats were dried for two weeks at room temperature, then dried at 30°C for 96 additional hours under a vented hood (Stewart 1973). Guano weights were then determined. Photographs of the roost canopy were used to estimate the amount of guano intercepted by tree branches. Tree densities were measured at nine selected transect points and related to guano deposition rates.

The south roost (Fig. 1) encompassed approximately 460,000 km^2 (or 360,000 km^2 if open fields are disregarded). During November 1976, 33 sample quadrats (0.09 m^2) made of black masonite were evenly spaced (100 m apart) along nine transects in this roost. Quadrats were placed under the roosting tree nearest the transect at a random distance from tree trunks. Fields were not sampled and were assumed to have no guano deposition. Measurements consisted of counts of guano depositions on each sample quadrat (a guano deposition was equivalent to one bird dropping). Sampling intervals varied from two days to one month between 24 November 1976 and 7 January 1977. Precipitation (3.8 mm during the entire sampling period) did not interfere with sampling.

Rates of guano deposition were estimated with a topographic map computer program. This program estimated rates at non-sampled areas by a weighted average method with data from the six nearest transect points. Maps of these estimates were constructed with the program SYMVU (developed by the Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University; as implemented at the University of Oklahoma). These maps helped to show the variable pattern of guano deposition in the south roost.

Three sites were selected for soil nutrient analysis of nitrate, available phosphorus, and potassium. A non-roosting site was selected that was similar to the roosting areas, and was used as a control (Fig. 1). The other two samples were taken from central locations in roosting areas (Fig. 1). All soil samples were a composite of the 0–15 cm soil horizon. Initial samples were taken 13 February 1977 and duplicate samples were taken two weeks later. Guano and leaf litter samples were taken from the north roost only. All samples were air dried, finely ground and analyzed by the Soil and Water Service Laboratory, Oklahoma State University. Nitrate concentrations were determined with a nitrate specific ion electrode. Available soil phosphorus was measured by a Bray extraction-ammonium molybdate colorimetric method and expressed as P_2O_5. Potassium ion concentrations were measured with atomic absorption spectroscopy and expressed as K_2O.

RESULTS

Nighttime observations and guano measurements indicated that crows roosted primarily in blackjack oak, post oak, and southern hackberry (*Celtis laevigata*). The average rate of guano deposition at the north roost sample site was 6.96 g guano$\cdot m^{-2} \cdot day^{-1}$ (16.8 guano depositions$\cdot m^{-2} \cdot day^{-1}$). Counts

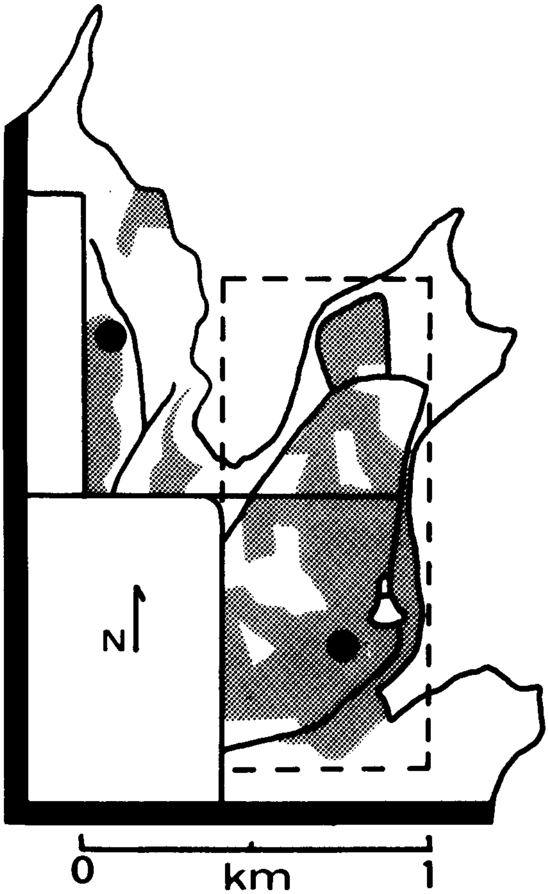

FIGURE 1. South roost area and nearby non-roosting areas. Dotted line encloses south roost study area and corresponds to map in Figure 2. Wooded areas are designated by gray areas. Upper left dot indicates the non-roosting soil sample site. Lower right dot shows the south roost soil sample site.

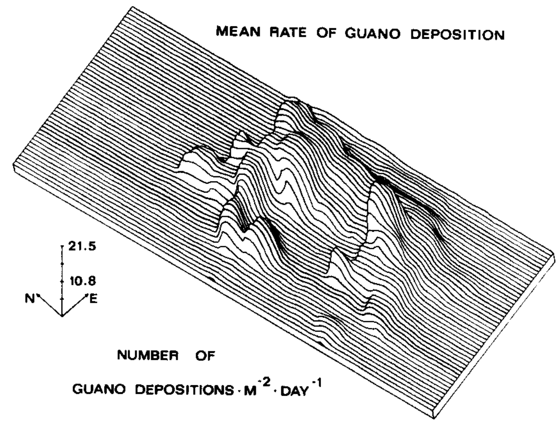

FIGURE 2. Estimated mean guano deposition rates, 24 November 1976 to 7 January 1977. Base area (dotted line in Figure 1) is equal to 0.90 km^2. View is from the southwest of the south roost area.

were related to weight measurements to compare the south roost samples. A linear regression analysis indicated for the north roost that the number of guano depositions was related to the guano weight ($r = 0.50$, $df = 22$, $P < 0.05$) by the equation:

$$Y = 1.90 + 0.30\,X,$$

where X is equal to the number of guano depositions per meter squared per day. Assuming this relationship is valid for the south roost area, the average guano deposition rate at the south roost soil sample site was 10.65 g guano·m^{-2}·day^{-1}. From limited observation I estimated that a single crow would deposit 10 g guano per day. The analysis of tree canopy photographs suggested that approximately 25% of the droppings were intercepted by tree limbs. Highest rates of guano deposition did not correlate well with the areas of most dense tree cover ($r = 0.50$, $df = 9$, $P > 0.05$).

A map of estimated mean guano deposition rates for the south roost from 24 November 1976 to 7 January 1977 is shown (Fig. 2). Similar maps were made for all transect sample periods and were used to indicate the most dense areas of the roost population. These maps aided in the selection of the soil sample site in the south roost.

Soil, litter and guano nutrient data are given in Table 1. Statistical analysis (independent t-test) indicated that the phosphorus level in the non-roost soil was significantly different from both north and south roost soil levels ($N = 2$, $P < 0.01$). The nitrate level in the non-roost soil was significantly different from only the south roost soil level ($N = 2$, $P < 0.01$). Other soil nutrient relationships gave insignificant results ($N = 2$, $P > 0.05$). Average guano deposition at the south roost soil sample site was 10.65 g guano·m^{-2}·day^{-1}. This was equivalent to deposition of 0.29 mg NO_3-N·m^{-2}·day^{-1}, 3.28 mg P_2O_5·m^{-2}·day^{-1}, and 17.2 mg K_2O·m^{-2}·day^{-1}.

DISCUSSION

Hutchinson (1950) reported that Guanays (*Phalacrocorax bougainvillii*) in the Ballestas Islands, Peru produced 9,647 kg guano·100 m^{-2}·y^{-1} or 240 g guano·m^{-2}·day^{-1}, if deposition was uniform over the year. Stewart (1973) reported that 91.7 g guano·m^{-2}·day^{-1} were deposited in an area of a roost occupied chiefly by Common Grackles (*Quiscalus quiscula*) and 53.1 g guano·m^{-2}·day^{-1} in an area occupied by

TABLE 1. Soil, litter and guano nutrient data. All soil values represent an average of two samples.

Material	pH	Nutrient (ppm)		
		NO_3	P_2O_5	K_2O
Non-roosting soil	7.5	4.25	14.00	93.25
South roost soil	4.6	64.75	126.50	246.25
North roost soil	5.6	30.50	143.25	131.50
Guano and litter layer	6.7	5.50	410.50	1,138.00
Crow guano	6.4	27.00	308.00	1,611.50

Brown-headed Cowbirds (*Molothrus ater*). These rates are substantially greater than the rate of guano deposition in either roost in the present study. Assuming guano deposition over the entire south roost area was between 6.96 and 10.65 g guano$\cdot m^{-2} \cdot day^{-1}$, deposition for the entire roost would range from 2,576 to 3.941 kg guano per day. With these values, I estimated that during peak roosting, the south roost would have a nightly population between 250,000–394,000 crows or 0.7–1.1 crows/m^2 of roosting-tree canopy. Aldous (1944) reported similar crow roost population sizes in Oklahoma and that 5.4 crows/m^2 were common. Stewart (1973) reported 56 birds/m^2 in a part of a roost dominated by Common Grackles. The Fort Cobb roosts appear to be less densely occupied than others previously studied.

In my study, the roosting areas had fewer annual and perennial plants than non-roost areas. Few dead trees were present, even in the heavier roosted areas. The effect of nutrient enrichment by guano on roost vegetation is not pronounced and may not have any deleterious effects on the roost vegetation. Hutchinson (1950) stated that on tropical islands, bird colonies could have an adverse effect on vegetation. He further reported that when rainfall was at least 2,000 mm per year, a rich arboreal vegetation developed. Even when arboreal vegetation was established some birds apparently destroy the trees in which they breed. Bernard et al. (1971) concluded that the major factor controlling the development of the vegetation in a Herring Gull (*Larus argentatus*) colony was the gull population itself. Weseloh and Brown (1971) found that in a heron and egret nesting area, moderate concentrations of guano appeared to benefit some plant species but that the total number of individual plants diminished as guano deposition increased. Onuf et al. (1977) found in a mangrove (*Rhizophora mangle*) ecosystem with a breeding colony of pelicans and egrets that high nutrient areas had increased primary production. Nutrients and vegetation in the Oklahoma crow roosts must be studied in detail before the effects of these roosts on the surrounding vegetation can be appraised.

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RECENT PUBLICATIONS

Animal Behavior/An Evolutionary Approach. Second edition.—John Alcock. 1979. Sinauer Associates, Inc., Sunderland, Mass. 532 p. $16.00. Although the first edition of this textbook was published only four years ago, the author deemed a revision desirable in order to reflect new thinking about animal behavior as based on the logic of natural selection. His central theme is that "all aspects of animal behavior have evolved and therefore can be expected to have certain properties." Chapters deal with the genetics, physiology, ecology, and evolution of behavior. Birds are used for many examples. A well-written, attractive, and up-to-date text. Illustrations, lists of films, references, indexes.

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