FORAGING BEHAVIOR OF THE STARLING (*STURNUS VULGARIS*) IN MARYLAND

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The Starling (*Sturnus vulgaris*) has few equals in terms of success as an invader of large areas of the earth. Since the introduction of the Starling in New York in 1890, its spread to new locations and habitats and increase in numbers has been phenomenal (Kessel 1953; Davis 1960). Elton (1958) postulated that the Starling had found a new "feeding niche" in the United States and thus did not compete actively with native birds. It seems an equally plausible hypothesis that a species so numerous, and so capable of range expansion, has almost certainly affected the numbers and distribution of other open-ground foraging birds.

Delineating the foraging behavior of the Starling would appear to be the key in measuring the importance of this species' presence to native ones, and in determining the nature and extent of suspected interactions.

This paper presents the results of a study designed to provide baseline information on the foraging behaviors of this species throughout a year, as well as a more detailed analysis of foraging strategies of Starling flocks under various environmental conditions. We introduce a technique, the fixed grid, which appears generally useful for delineating the foraging strategies of open-ground feeders. A critique of this method is included.

MATERIALS AND METHODS

ROADSIDE CENSUSES

A 25-mile roadside route in Anne Arundel County, Maryland, was established for censusing Starlings and their ground-foraging associates. The objective was to determine seasonal variations in the terrestrial foraging behavior of Starlings including flock size, spacing of individuals, habitat preference, and associations with other species of birds.

The census route passed through the four major vegetation types where Starlings foraged. A total of 68 census points were selected along the route including 25 lawns, 16 grazed fields, 13 meadows, and 14 fields planted in corn or wheat. Twice weekly censuses (2.5–3.0 hr each) were conducted during the morning (starting from 07:00–08:00) from 15 September 1970 through 15 September 1971. When Starlings were observed on the ground at any census point, the following data were recorded: date, time, weather conditions, size of flock (by count, or estimation if over 100), presence and number of individuals of other species of birds, average distance between individual Starlings and between Starlings and members of other species, vegetation type (as listed above), and vegetation height (measured with a ruler at three points and averaged).

Starlings seen flying or perching above the ground were not counted. Starlings were also observed foraging arboreally for fruits, gleaning foliage for arthropods, and engaging in aerial foraging and hawking for insects. However, as foraging on the ground was by far the most common strategy, it was selected as the focus for this study. Additional records of Starling feeding behavior were collected by random observations throughout the study.

THE GRID TECHNIQUE

One census site was selected for more intensive and critical examination of habitat exploitation by this species. A grid (320 × 200 ft) was laid in lime on a section of lawn at the Nationwide Insurance Company building, Parole, Maryland. This site was selected because Starlings were often observed foraging on the lawn; the second story of the building provided a convenient location from which to make observations, and the lawn was mowed twice weekly and provided a continuous cover of low vegetation which facilitated observations.

The grid was marked by crosses, spaced at 20-ft intervals and laid on north-south and east-west lines. Each arm of the cross was approximately 3 ft long and 2 inches wide. Fresh lime was placed on the grid as needed. Observations of foraging behavior on the grid area were made 3 days a week during two periods: 25 June through 26 July 1971, and 8 January through 2 March 1972 (approximately 540 hr total).

Between September and December, Starlings were never observed on the grid. Hence, during the winter period the grid was initially baited with bread in an attempt to attract birds. Prior to the observation period, for 8 days over a 3-week period, large pieces of bread were strewn randomly on the grid. By that time, Starling flocks were often observed foraging on the lawn; and subsequently, small (crouton-sized) pieces of bread were placed every 10 ft along north-south grid lines at the start of every observation day.

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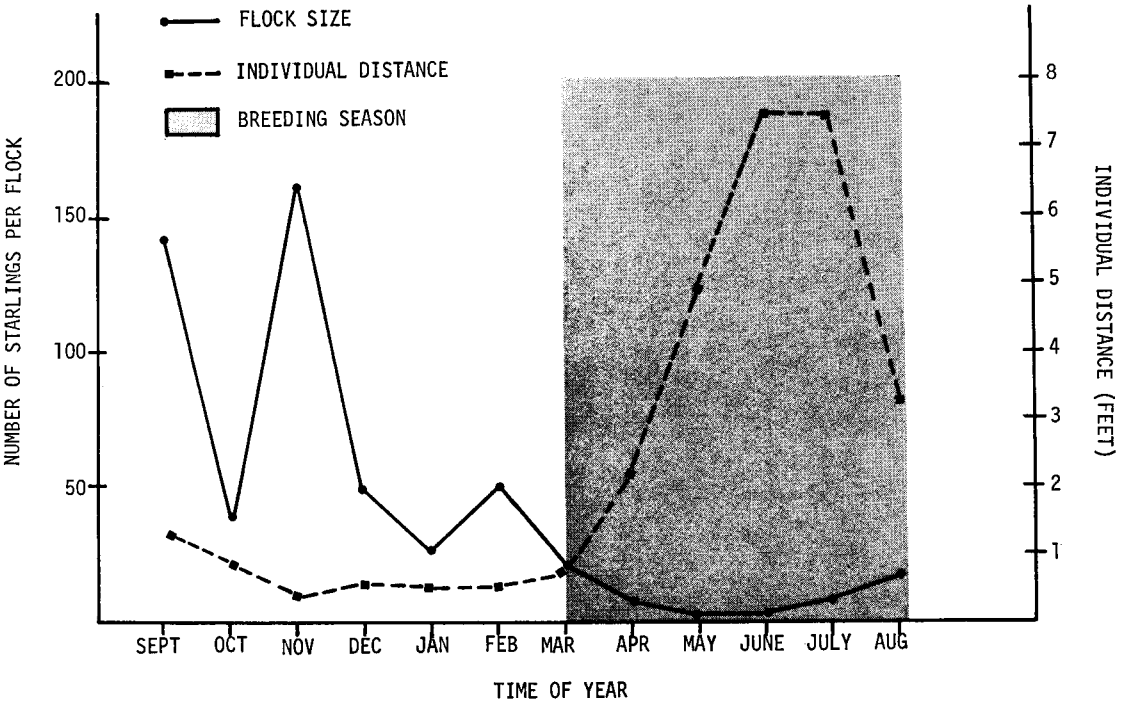

FIGURE 1. Changes in flock size and individual distance of Starlings with time of year.

Close inspection revealed no apparent differences in the foraging behavior of birds on a baited and unbaited lawn. Furthermore, Starlings continued to forage on the lawn after the bread was eaten.

Birds on the grid were observed from a second story window with 7 × 35 binoculars. The exact positions of birds (1–25 individuals) were recorded at 30-sec intervals on scale "grid sheets." All birds on the grid or within 20 ft of the outside lines were included in these recordings. Similar information on larger flocks was obtained by taking still photographs (35 mm camera) of the grid at 30-sec intervals. Time of day and duration of feeding sessions were routinely recorded.

There are several problems associated with the lime grid method. The use of a single grid in a single location has obvious disadvantages. It is difficult to rule out the possibility that behavioral patterns relate to peculiarities of that location. There is no way of determining whether one is observing the same sample of birds day after day. If there were such repeated associations between the same individuals, behavioral traits might relate to learned or habitual patterns of specific flocks and not to the species as a whole. Such an hypothesis is unlikely, however. In 1970 and 1971, as part of this study, over 100 Starlings were color-marked in a decoy trap. No more than two color-marked individuals were subsequently seen in the same flock, thus indicating that there is shifting of individual flock associates.

RESULTS

ROADSIDE CENSUSES

Starlings fed in flocks throughout the year. The size of feeding flocks varied in a fairly regular fashion over the year; larger flocks (mean size 21–161) in fall and winter, and smaller flocks (mean size 2.9–22) in spring and summer (table 1). Our observations revealed smaller, more widely spaced flocks during the breeding season (fig. 1). Observations of large flocks in September and November appeared to correspond to the large aggregations of birds in the area prior to the two periods of fall migration. The consequent drop in flock size in October and December was most likely due to nonresident birds migrating out of the area. These data also correspond with the observations of other workers (e.g., Davis 1970; Kessel 1957).

TABLE 1. Annual variation in flock size of Starlings.

Month	Mean flock size	Range	No. of flocks observed
January	27	2–65	49
February	50	2–200	67
March	22	13–25	55
April	9	1–50	76
May	2.9	1–8	55
June	3.9	1–25	75
July	7.8	1–100	101
August	15.7	1–100	49
September	144	25–300	35
October—Early	21	4–50	25
October—Late	55	10–250	27
November	161	5–2000	89
December	49	5–200	70

Note: where Starlings were observed foraging with individuals of other species, the size of the entire flock was estimated.

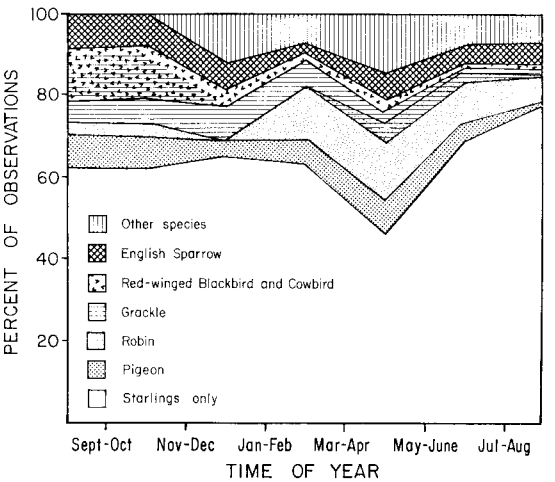

FIGURE 2. Annual pattern of Starling foraging associations. (The overlap in patterns indicates the frequency with which the two species in question were seen together. The "Starlings only" category indicates percentage of time when Starlings were observed foraging in monospecific flocks.)

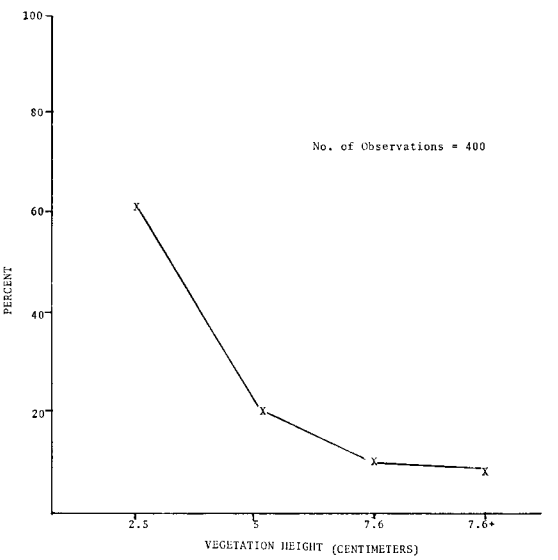

FIGURE 4. Frequency distribution of Starlings observed foraging by vegetation height.

Spacing between individual Starlings varied inversely with flock size and was greatest during the breeding season (fig. 1). Starlings were observed foraging in conspecific flocks over 50% of the time (all time average, 64.7%). This trend was most marked during the height of the breeding season (May through August) when Starlings were observed feeding in monospecific flocks from 70 to 78% of the time. Feeding associations with other species of birds varied with time of year: from September through January, Common Grackles (*Quiscalus quiscula*), Red-winged Blackbirds (*Agelaius phoeniceus*), and Brown-headed Cowbirds (*Molothrus ater*) were the most common flock associates; from February through August, Starling-Robin (*Turdus migratorius*) flocks were most common. Other species of birds seen feeding with Starlings included the Rock Dove (*Columba livia*), House Sparrow (*Passer domesticus*), Killdeer (*Charadrius vociferus*), Common Flicker (*Colaptes auratus*), Mourning Dove (*Zenaida macroura*), Cardinal (*Cardinalis cardinalis*), and Common Crow (*Corvus brachyrhynchos*). A graphic depiction of the observed shifts in flock associations is shown in figure 2.

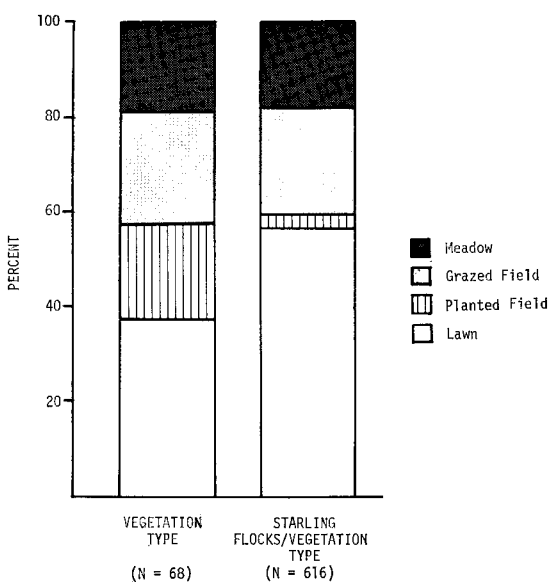

FIGURE 3. Frequency of occurrence of vegetation types censused compared with frequency of occurrence of Starlings at each type.

One hundred and four censuses were conducted of the 68 sites, 7072 site observations in all. Starlings were observed feeding at these sites a total of 616 times (8.7% of the site recordings). Starlings preferred to forage on lawns and rejected planted fields. Meadows and grazed fields were used in proportion to their availability (fig. 3). These trends were correlated with the marked preference of Starlings to forage in low vegetation (fig. 4). The most frequently observed tactics included probing in the soil or picking items from the surface.

GENERAL OBSERVATIONS OF STARLING FEEDING BEHAVIOR

The foraging behavior of Starlings was strikingly different depending on time of year, number of individuals foraging, and the species composition of the flock. The following trends emerged from the present study.

Spring and summer. Starlings were seldom seen foraging alone at any time of year. The few solitary feeders were most often observed in the spring and summer (March through August). These birds appeared to feed in a more leisurely manner and to remain at one site for longer periods than did flocks of any size. Single birds were less perturbed by such stimuli as passing cars, to which flocks invariably responded by flying up; and consistent patterns of movement such as those noted for large flocks (see below) were not observed.

Starlings aggregated into smaller flocks in the spring and summer than in fall and winter. Individuals in these flocks were often spaced in pairs (with less distance maintained between individuals of a pair than between pairs). When adults were feeding fledglings, flocks were spaced in clusters of two or three individuals. However, these family units responded as a flock and moved as a unit.

Small numbers of Starlings were often observed with other species of foraging birds. This was particularly noticeable with Robins, which tend to feed at one site for a number of hours at a time (Young 1951), but was noted for other foraging associates as well. The feeding behavior of Starlings appeared imitative of the other ground-foraging species in a flock including spacing of individuals, length of feeding sessions, and rate of foraging. Usual tactics were modified in the direction of the other species present. This phenomenon of imitating the behavior of associates was most marked in fall and winter.

Fall and winter. The large conspecific flocks (100 birds or more) seen during fall and winter exhibited a predictability and range of foraging behaviors not seen in small flocks, solitary individuals, or flocks of mixed species. These large groups of Starlings ignored other species of birds, and their active searching maneuvers to locate food were unique, i.e., the exploitation of a feeding site was more efficient and included:

a. foraging in lines which moved as a unit across a field by "leap-frogging," or in circles or arcs which moved radially outward;
b. a consistent direction of movement of the flock across a field (lawn, etc.);
c. individual distance extremely close and maintained;
d. the rate of foraging movement constant and more rapid;
e. formation of "active flocking swarm," i.e., the birds, startled while foraging, wheel and turn together in the air, and members alternately increase and decrease individual spacing. When the individuals are tightly packed, the flock rapidly swoops down to within inches of the ground, and either lands and forages or wheels sharply up again and repeats the sequence of behaviors. This swooping may be repeated many times before landing or may result in the birds moving to a new area where the sequence is reinitiated. (In addition to noting this behavior in the study area, we have also seen it in Maryland, Colorado, New Mexico, and Massachusetts, and in association with a variety of habitat types.)

The large conspecific flocks appeared more skittish than small flocks or solitary individuals, perhaps due to the frequent active, flocking swarm maneuvers. Birds were more sensitive to any disturbance (passing car, loud noises, etc.) and responded by flying up. The overall impression was thus one of frenetic activity, short bouts of feeding interspersed with swarming and/or shifts to new locations. Individuals in smaller flocks (2–50) exhibited behavior intermediate between solitary individuals and large flocks. These flocks remained conspecific or joined other species with equal probability. In mixed species flocks, Starlings were repeatedly observed imitating the foraging behavior of the species with which they associated (see above). On many occasions, Starlings were seen foraging with larger flocks of Red-winged Blackbirds, Brown-headed Cowbirds, Common Grackles, or some combination of these species.

THE GRID METHOD OF ANALYSIS

Starlings were observed on the grid a total of 34 hr out of the 540 hr of observation time. Comparison of foraging behaviors of Starlings on the experimental grid in winter and summer revealed several significant differences. In winter, Starlings tended to forage in larger and more cohesive flocks than in summer (table 2). Foraging sessions (length of time spent on the grid) were significantly shorter in winter (table 2). Starlings were seen only rarely foraging alone in winter and after such sightings were often observed to join flocks of birds feeding on other parts of the lawn.

Foraging Starlings tended to move in a consistent direction. This trend was most marked in winter flocks, although it was found in winter and summer, and in groups of all sizes. The meander ratios (closeness of fit of moves to a straight line) are indicated in figure 5. Rates of movement were erratic at all times of the year and for flocks of all sizes (table 2).

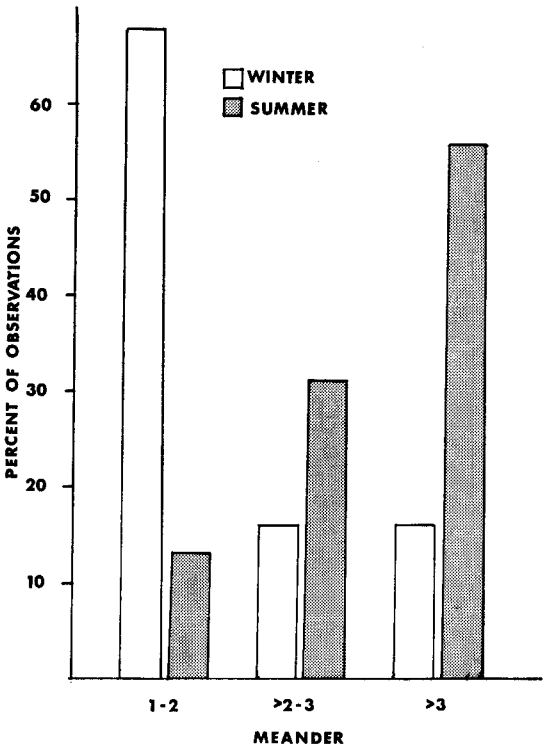

FIGURE 5. A comparison of meanders in foraging moves at two times of year. (The tendency for Starling flocks to move in a straight line is here expressed by a meander ratio:

$$\frac{\text{actual distance moved}}{\text{straight line distance between 1st and last moves}}$$

and compared in summer and winter. A meander of 1.00 is equal to movement in a straight line. Higher numbers indicate the degree of deviance from this tendency.)

DISCUSSION

FORAGING BEHAVIOR OF STARLINGS

This study compared several parameters of Starling foraging behavior. Regular observations over a 1-year period revealed apparent differences in this species' exploitation of space relating to time of year, size of flock, and ground-foraging associates. In particular, Starlings foraged in a more predictable fashion when in larger flocks, apparently employing consistent patterns of movement. Rates of movement and individual spacing varied seasonally and between conspecific and mixed species flocks. Starlings foraged very differently in winter and summer; flock size was larger and individual spacing closer in winter. These differences have been attributed to the level of sex hormones in the blood (Davis 1970). The data presented from the fixed grid indicate in more detail the nature of these differences by showing the direction and degree of change in the component parts of Starling foraging behavior. The more predictable but frenetic behavior of winter flocks was attributable to significantly shorter feeding sessions, significantly greater movement of flocks in a consistent direction, and a maintained cohesiveness of foraging flocks. These data are a first step toward delineating patterns of foraging movement and their underlying causes. They also provide a base against which the behavior of other ground-foraging birds can be compared.

Whereas vocal mimicry is well known in the Starling (Bent 1950), behavioral imitation of flock associates has not been previously recorded for this species. If the Starling does modify its behavior to resemble that of other species, it is interesting to speculate on the adaptive advantage of such a tactic.

The observed ability to modify its foraging behavior would be of obvious advantage for the Starling, especially in new locations and/or habitats. Interspecific aggression would likely be reduced, and, perhaps more importantly, this species could benefit from the

TABLE 2. Seasonal variation in foraging behavior of the Starling.[a]

Measurement	Summer			Winter			Level of significant difference[b]
	$\bar{x}$	Range	N	$\bar{x}$	Range	N	
Flock size	2.9	1–13	45	15.8	1–84	56	$P < 0.01$
Individual distance (spacing, in meters)	7.6	2.4–33.5	19	3.8	1.9–9.7	13	$P < 0.01$
Cohesiveness (least center to bird distance in meters)	3.8	1.5–7.9	19	1.6	0–4.5	46	$P < 0.05$
Length of foraging session for Starlings feeding alone	4′4″	4′0″–12′6″	15	0′36″	15″–1′40″	8	$P < 0.02$
Length of foraging session for flocks of Starlings	9′9″	1′41″–23′35″	17	2′16″	15″–10′5″	29	$P < 0.01$
Rate of movement of flocks, meters/min.	5.7	0.5–13.5	Combined N = 100				N.S.

[a] Data from observations of fixed grid.
[b] Statistical test for significance—Wilcoxan matched-pairs signed-ranks test.

exploitation patterns of associate flocks. If the benefits of flock foraging accrue to an individual through the more efficient behavior of the flock, then behavioral imitation would in turn be the most efficient tactic for the Starling.

THE GRID METHOD OF ANALYSIS

The grid method described in this paper permitted precise measurement of various parameters of terrestrial foraging in the Starling. The fixed grid, in addition, lends itself uniquely to experimental manipulation of known foraging sites (for example, by introducing food items in known patterns on the grid, or creating shade or perches in several positions). Such manipulation seems a logical next step in answering such questions as: to what factors does the Starling respond in choosing a foraging site, how variable are foraging patterns in this species, and under what conditions do they change?

Birds were observed only 6% of the observation time on the one grid. Observations during the roadside censuses indicated a similar finding; birds were observed foraging at the same 68 sites a total of 8.7% of the time. Thus, with one grid, much time is spent waiting for birds to appear. Two alternative solutions would be (1) to set up and maintain several fixed grids, and/or (2) to develop a portable grid system. Several problems associated with each of these are discussed below.

The presence of lime did not appear to affect foraging behavior of Starlings; i.e., there was no noticeable difference in the behavior of birds on ungridded and gridded sections of lawn. However, the maintenance of the grid was time-consuming as was initial surveying. These factors precluded the use of more than one grid.

A portable grid system might consist of a 35-mm camera with a grid constructed on the lens. Such a system would permit the observer to include several locations in a study, and to increase efficiency by finding foraging birds instead of depending on flocks to come to a marked location. An optical grid would, however, make experimental manipulation of foraging sites difficult.

SUMMARY

From September 1970 through September 1971 a roadside census of ground-foraging Starlings was conducted biweekly along a 25-mile route in Anne Arundel County, Maryland. Information collected in that survey was supplemented by more precise measurements of Starling foraging behavior at one of the census sites. A fixed grid, marked in lime on a large lawn, facilitated observations and analysis of several parameters of the foraging behavior of this species.

Starlings fed in interspecific flocks throughout the year although this trend was less marked during the breeding season. Low vegetation was chosen consistently for feeding. The foraging behavior of Starlings was markedly different in winter than in summer; the size of flocks was larger and individual spacing closer in the winter. The larger winter flocks behaved in a more predictable fashion than did small flocks or solitary birds. This was attributable to significantly shorter feeding sessions, more moves in a consistent direction, and a maintained cohesiveness of foraging flocks in winter. Starlings were observed modifying their foraging behavior to resemble that of their ground-foraging associates when feeding in mixed-species flocks. Although this behavior was not analyzed in the present study, the fixed lime grid provides one method for doing so. The technique of the fixed grid appears generally useful for delineating foraging strategies of open ground feeders.

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