

## SEASONAL PATTERNS IN ROOSTING FLOCKS OF STARLINGS AND COMMON GRACKLES

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**ABSTRACT.**—Communal roosting is often a regional phenomenon that involves wide-ranging and long-lasting relationships among associations. We examined roosting behavior on a scale sufficiently large to detect regional and seasonal patterns. For five roosting seasons (June–November), we studied the population dynamics of all roosting flocks of European Starlings (*Sturnus vulgaris*) and Common Grackles (*Quiscalus quiscula*) located within a 1,000-km<sup>2</sup> census area in central New Jersey. Roosts were active from 3–20 weeks and ranged in size from 2,000 to over 100,000 individuals. The total roosting population (TRP) in “major” (>2,000 birds) flocks increased through early summer, generally achieving maximum size in mid-August when the largest number of roosts was active. When TRP was largest, size of major roosts varied greatly (range 2,000–100,000 individuals). Through late summer and early fall, size and number of major roosts and TRP declined. By late fall few major roosts were active, but those remaining were large (>30,000). Movements of individual birds (radio-tagged) suggested that changes in size of TRP resulted largely from exchange of the local population between small, “minor” roosts (largely undetected and not included in roost censuses) and major flocks. Current hypotheses concerning the functional basis of communal roosting do not adequately explain patterns of roosting behavior that we observed.

Communal roosting behavior occurs in birds of diverse taxa and habitats. Important functional role(s) are suggested by the often large flock sizes and long roosting seasons. Several explanations for communal roosting have been offered (Lack 1968, Siegfried 1971, Tast and Rossi 1973, Ward and Zahavi 1973, Weatherhead 1983) and some tests have been performed (DeGroot 1980, Loman and Tamm 1980, Fleming 1981), but for most species the functional role of this behavior remains poorly understood.

Few quantitative data are available for examining this behavior on a scale (temporal and spatial) sufficiently large to detect regional and seasonal patterns. Previous studies have either examined activity at individual roosting associations (e.g., Hamilton and Gilbert 1969, Swingland 1976), determined the distribution of roosts for a given species during only part of the roosting season (e.g., Marples 1934, Eastwood et al. 1962, Hein and Haugen 1966), or provided few data (e.g., Brown 1946, Gadgil and Ali 1976). These investigations have generally neglected regional relationships among roosts or seasonal variations in roosting behavior.

We examined the post-breeding population dynamics of all roosting flocks of European

Starlings (*Sturnus vulgaris*) and Common Grackles (*Quiscalus quiscula*) within a 1,000-km<sup>2</sup> census area. We investigated patterns of activity at individual roosts and population dynamics on a regional basis over five consecutive seasons. Our objectives were to quantify the seasonal patterns in the size of individual roosting flocks, to determine the interrelationships among these flocks, and to analyze the spatial and temporal distribution of the roosting population on a regional basis. Our goal was to provide an adequate descriptive basis for testing current hypotheses explaining communal roosting behavior.

### STUDY AREA AND METHODS

Field work was conducted during the local roosting seasons (June–November) of 1977–1981. A region within the piedmont and inner-coastal plain provinces (Robichaud and Buell 1973) of central New Jersey (Fig. 1) was rigorously censused (one to three times per week) for all major blackbird roosts: i.e., those containing at least 2,000 birds. The minimum size of “major roosts” (>2,000) represented the smallest aggregation regularly detected in our surveys. We counted some smaller roosts, but only at sites where they had formerly numbered over 2,000 birds. Roost sites were usu-

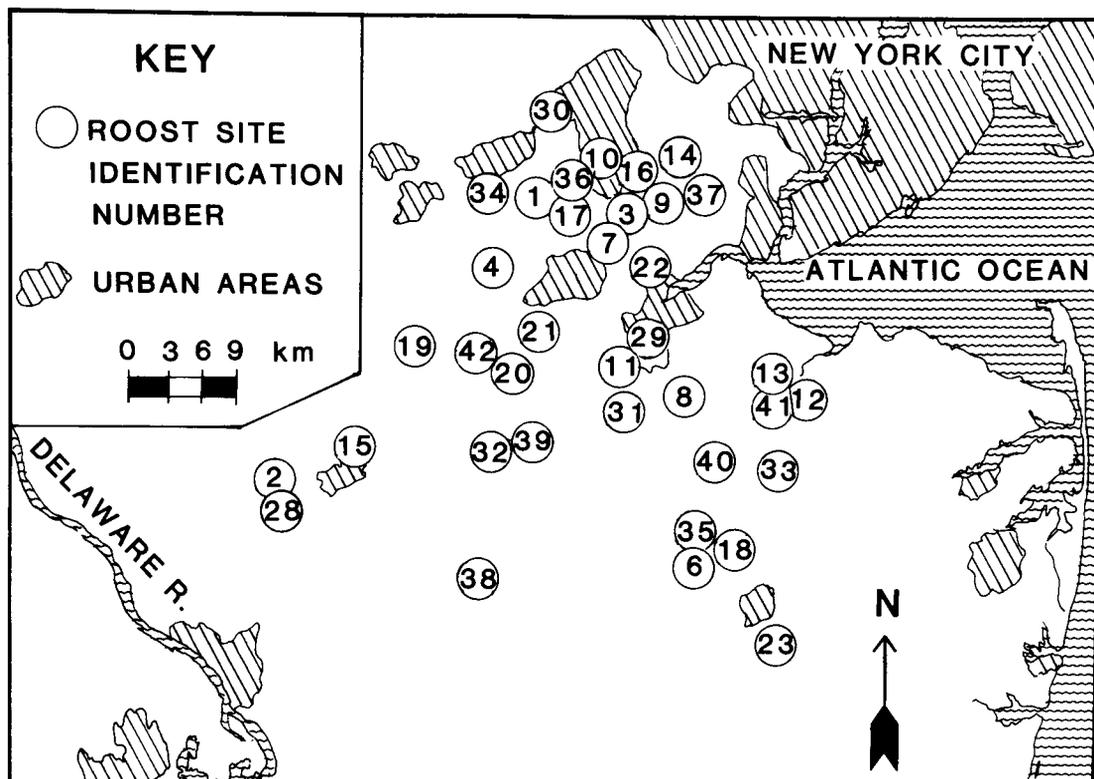


FIGURE 1. Map of the census area indicating location of the roost sites. Numbers inside circles are roost site identification numbers.

ally located during our surveys by following flightlines of birds returning to roosts in the evening. Some "minor roosts" (<2,000 birds) were found when radio-tagged birds went to them, but the small size and inconspicuousness of minor roosts made them difficult to detect and we made no effort to find them. We did not include minor roosts in size estimates of the roosting population.

The size of the census area (approx. 1,000 km<sup>2</sup>) was defined initially by the limits of our ability to conduct thorough censuses. After establishing the distribution of roosting flocks (1977), we confined our searches to the area bounded by lines connecting the seven outermost roost sites.

Active roosts were visited every 7–14 days. In order to estimate roost size, one to four observers were stationed along flight lines near roosts. Birds were counted by species as they arrived in the evening or departed in the morning. The total roosting population (TRP) represents the sum of all birds in the census area using major roosts (>2,000 birds). TRP was calculated at five-day intervals by summing sizes of individual flocks that were active at the beginning of each period. Counts during inclement weather were not included in pop-

ulation estimates, as roosting activity was then erratic. We developed our field methods in 1977 (Lyon 1979).

Eighteen starlings and eight grackles were equipped with radio transmitters (AVM Instrument Company) in 1980–1981. Birds were captured at roost sites using either mist-nets atop 15-m poles or decoy traps in foraging areas. Five starlings and three grackles were lost soon after release and two starlings and one grackle were found dead (one predatory loss, one poisoned, one accidental). The 14 remaining birds were monitored three to five times weekly on foraging areas during the day and at roosts at night for periods ranging from 13–139 days (mean 82 days).

## RESULTS

### PATTERNS OF ROOSTING BEHAVIOR

Roost sites first became active in early June (Fig. 2). The number of active sites increased through mid-August, then declined until the end of the local roosting season (early November). Individual roosts were active for 3–20 weeks (Fig. 2). Generally the same sites were used in successive years and their heaviest use occurred over similar dates. Some sites were

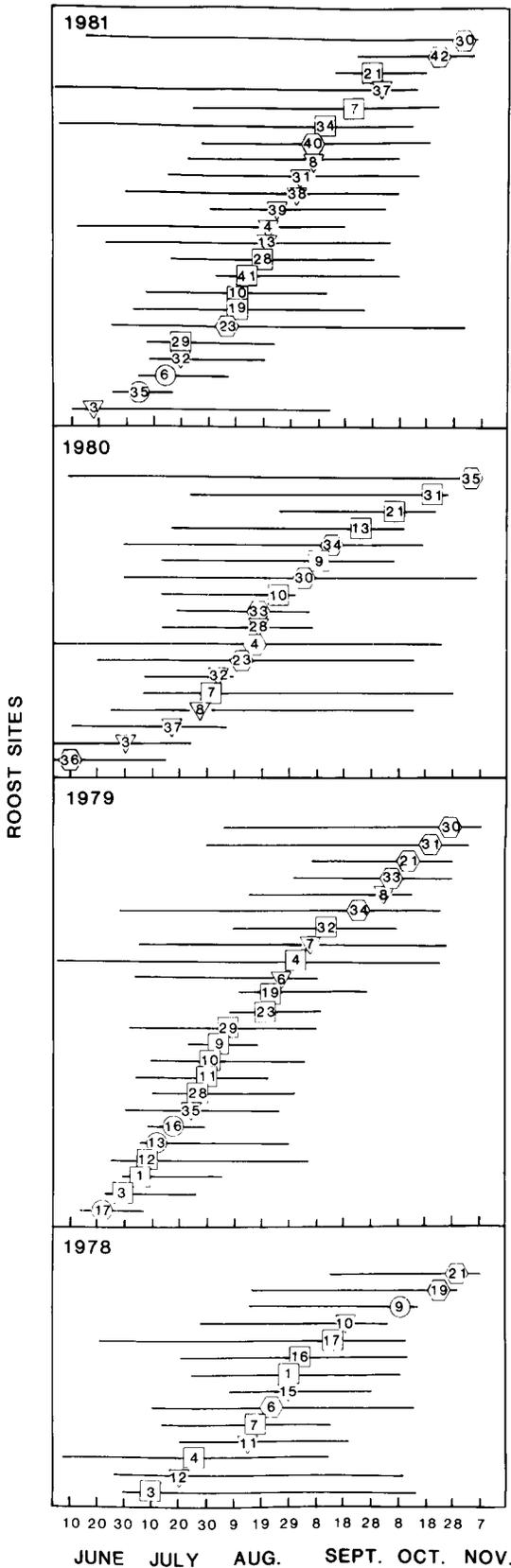


FIGURE 2. Activity periods (solid lines) of individual roost sites for each year of the study. Each roost site iden-

abandoned (sites 4, 12, 14, 22, 25) after their vegetation was cleared, but others (sites 2, 6, 18, 20, 33, 35, 36) were abandoned without apparent physical changes in the sites or their surroundings. The size of individual flocks was usually similar among years, but several of them grew over the years from intermediate to very large (sites 21, 23, 42). We witnessed the opposite trend as well (sites 4, 6, 21).

All roosts were composed primarily of starlings and grackles (Fig. 3). Starlings were generally more abundant, although either species could represent more than 80% of an individual flock during the early growth or late decline phases of the activity cycle. Only once did we encounter a flock in which one species composed 99% of the population: at the beginning of the 1980 roosting season, site 36 was composed mainly of juvenile starlings. We also counted 11 secondary species roosting communally at these sites, but their roles were small, either because of their low numbers or their relatively brief stay (Caccamise and Fischl, unpubl. data).

The ratio of starlings to grackles (Fig. 3) varied seasonally and independently of TRP for all roosts in the census area. Values were high early in the season because starlings began roosting first, but grackles joined the roosts while the TRP was still relatively small. Starlings generally exceeded grackles through most of each season, although sometimes (especially in late fall) grackles became more abundant. The proportion of starlings was much higher in 1978 than in any other year. We were not able to determine whether the grackle population was actually depressed in 1978 or the census area did not include the major grackle roosts.

The dynamics of total roost population were similar each year of the study with respect to both maximum size (210,000–270,000 birds) and seasonal pattern of growth and decline (Fig. 3). In each year (including 1977, Lyon 1979) except 1979, the TRP was largest in mid-August. In 1979, TRP grew more slowly and the maximum size was reached much later (3 October). Peaking so soon before migration, the population also declined more rapidly than in other years.

The number of active roosts in the census area increased from June through mid-August (Fig. 2). The increase in TRP through this pe-

tification number (see Fig. 1) is located at the date of largest flock size. Shape of border around roost site identification number indicates roost size class: circle <2,000; square 2,000–10,000; triangle 10,000–30,000; hexagon >30,000.

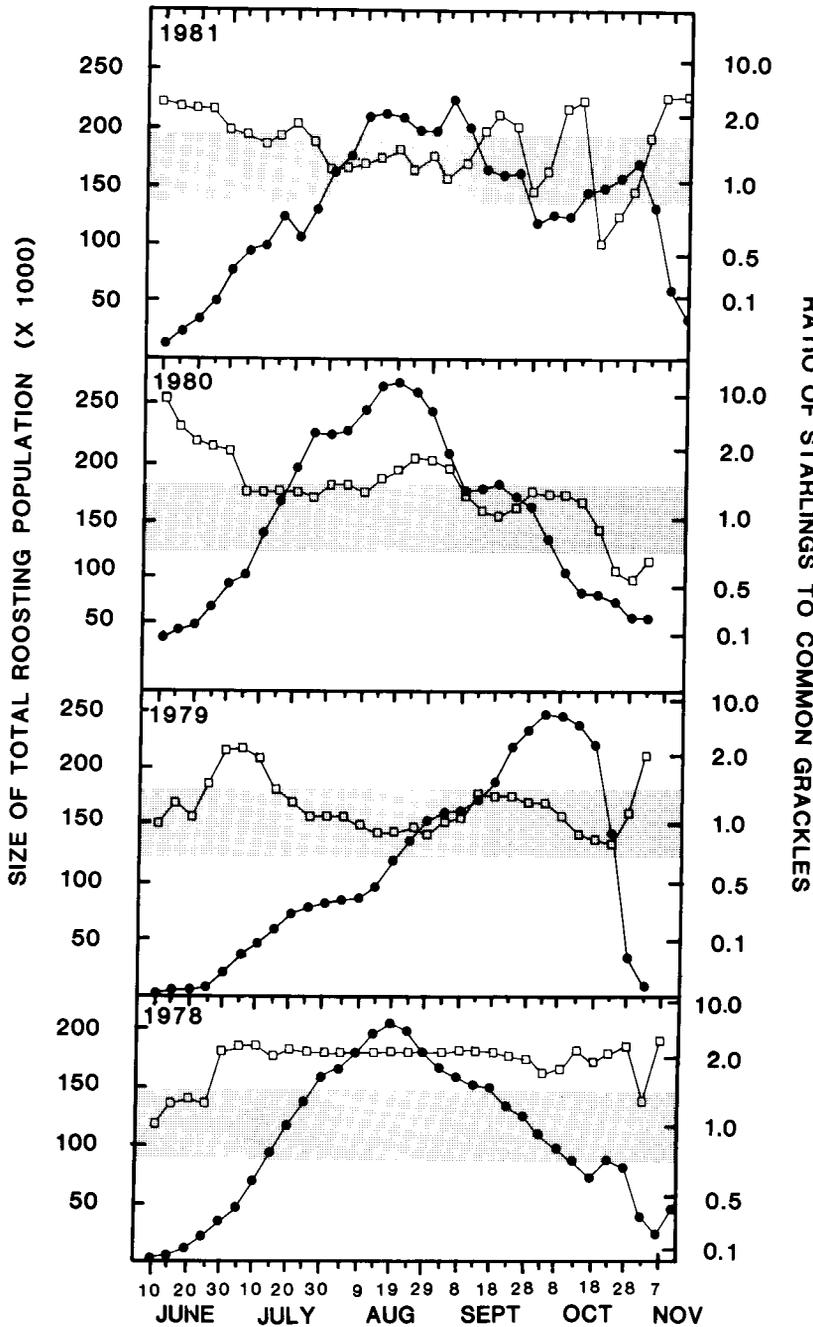


FIGURE 3. Total number of starlings and grackles (solid circles) and relative species composition (open squares) of all roosting flocks (ratio of starlings/grackles) within the census area. Shaded areas highlight ratios close to equality.

riod resulted from not only the establishment of new sites but also the enlargement of individual roosts once they were active. Nevertheless, the peak in number of sites generally coincided with the peak in TRP.

The distribution of birds among roosts of different sizes changed seasonally (Fig. 4). Early in the season, large roosts (>30,000 birds) increased more rapidly than small ones. Thus, when TRP was greatest, the largest proportion

of roosting birds was in large roosts. Roosts of the smaller size categories were always active through the early season, and at times collectively accounted for more of the total roosting population than the largest size category (Fig. 4).

Following the peak in TRP, the size of individual roosts began to decline, eventually leading to the abandonment of many sites (Fig. 2). Few new roosts became active beyond mid-

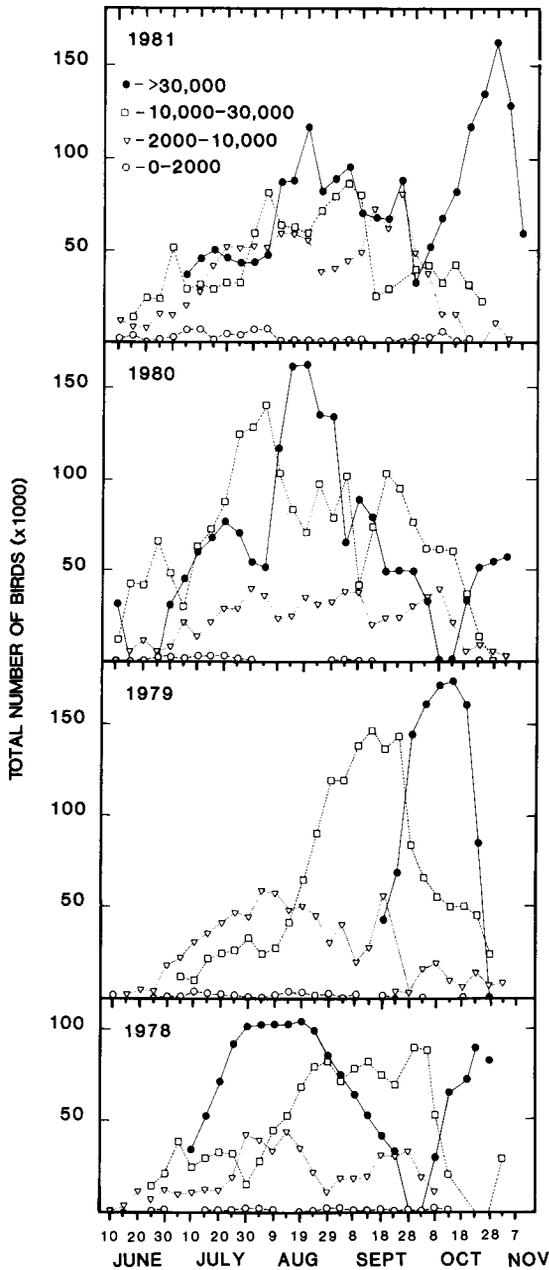


FIGURE 4. Total number of starlings and grackles within the census area according to their distribution among roost size classes (open circles 0-2,000; triangle 2,000-10,000; square 10,000-30,000; solid circle >30,000).

August, but of those that did, most came to hold large fall flocks (e.g., sites 42, 21, 33). By early October, few roosts were still active. Of these, one to three became large pre-migratory flocks, while the others dwindled until they were abandoned. With the roosting population (individuals occupying roosts >2,000 birds) concentrated into a few large associations, the smaller roosts were essentially absent from the census area. This contrasts with the period near

maximum TRP, when roosts of all sizes were represented.

In each year except 1981, the increase in the largest category during October was nearly equal to the decrease in the other categories (Fig. 4). In 1981, the largest category attained a maximum size that was about 60% greater than the number of individuals in the smaller categories.

#### MOVEMENT OF RADIO-TAGGED BIRDS

Of 14 birds that were radio-tagged successfully (10 starlings, 4 grackles), five remained in the same roost through the observation period. We verified roost site changes for seven starlings and two grackles. Three of the seven starlings used the same sites through the end of the local roosting season. After the main population migrated, these individuals moved to minor roosts within the census area. The remaining six individuals changed roost sites from one to five times during the roosting season.

Starlings often used minor and major roosts alternately. Movement from one communal roosting flock to another was often interspersed with one to several nights' stopover at a minor roost (Fig. 5, starling). Seven of the radio-tagged starlings, and one grackle used minor roosts at some time during the season. Before the peak in total roost population, individuals generally remained in a single roosting flock. After the peak in TRP, they switched roosts more often as the number of active sites was declining. The radio-tagged birds abandoned the declining sites, moving either to developing major roosts or to minor roosts (e.g., Fig. 5).

In 1981 one radio-tagged starling moved from a declining site (site 39) that had achieved a maximum size of 15,000 birds to a site (site 21) that never became larger than 8,500 birds (Fig. 5). Movement from one declining site to another was unusual, but can be explained by considering the history of site 21 over the previous five years. From 1977, when we first encountered this site, until 1981, site 21 progressed yearly from a moderately-sized fall roost to the major pre-migratory concentration in the central part of the census area. By 1981, it returned to relative insignificance (maximum roost sizes: 1977-38,000; 1978-60,000; 1979-64,000; 1980-24,000; 1981-8,500). The radio-tagged starling moved to this site in early October, about when the large fall flock had developed in previous years. The large association did not develop in 1981 and the starling returned to its minor roost (Fig. 5, starling) after only two nights. Soon thereafter it appeared in the major fall roost for 1981 (site 42). This site had held small flocks in

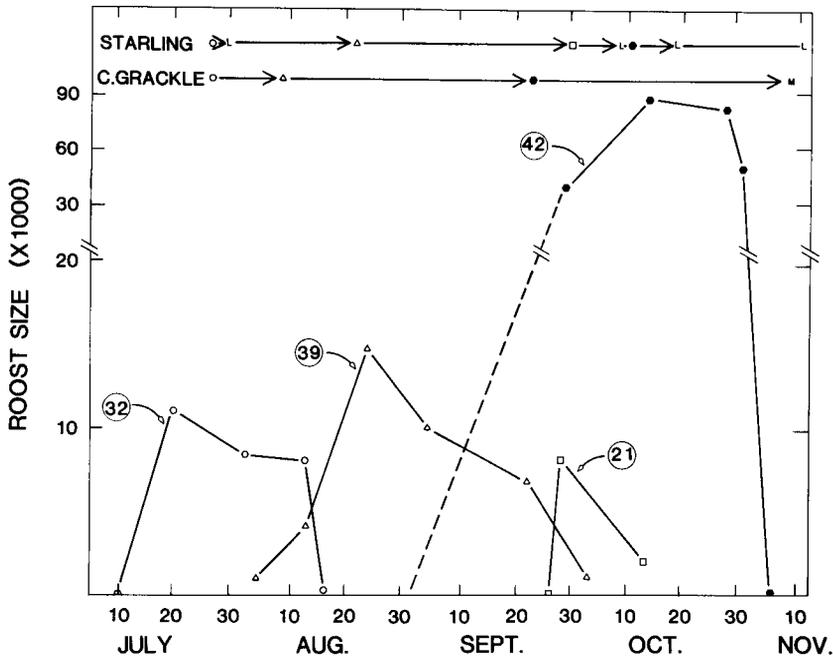


FIGURE 5. Activity cycle (flock size) of roosts used by a radio-tagged starling and a grackle. Horizontal lines at top indicate when roosts were used by each radio-tagged bird (L indicates a minor roost, arrows indicate when the birds changed roosts).

former years, but 1981 was the first year that a major roost developed there. When site 42 was abandoned for the season, the starling returned to its minor roost.

Grackles migrated in early November. Their decline at site 42 (1981) coincided with the disappearance of the radio-tagged grackle using this site (Fig. 5). A large proportion of the starling population was resident over the winter. Five of the radio-tagged starlings returned to minor roosts near the end of the season where they remained at least until their transmitter batteries were exhausted.

## DISCUSSION

### SEASONAL FLUCTUATION IN TOTAL ROOST POPULATION

The total roost population typically grew to a mid-summer peak and declined through late summer and fall. While 1979 was somewhat anomalous in that the peak occurred later in the season, the overall pattern remained similar. Changes in the size of TRP could reflect changes in the size of either the resident roosting population or the population within the census area. Since the roosting season follows the nesting season, we consider the young of the year to be members of the resident population. Therefore, changes in the size of the resident population would have to result from immigration or emigration. The early season increase of TRP is unlikely to have resulted

from immigration, from either migratory movements or more local movements of birds residing outside the census area. The total roost population grew too early in the season to be affected significantly by migration. In addition, the census area is large and encompasses habitats representative of central New Jersey, so there is no reason to believe it is more or less attractive to vagrants than any other area. For these reasons, we believe that the early-season increase in TRP probably reflects changes in the proportion of the local population associated with major roosts (>2,000 birds).

Observations of radio-tagged birds suggest that the early season increase in TRP resulted primarily from the movement of resident birds to major roosting associations. For example, an adult male grackle that was captured in its foraging area and radio-tagged on 17 June 1981 remained here for 17 days using a nearby roost of fewer than 25 individuals. When this minor roost dispersed, we were unable to relocate the radio-tagged bird until seven days later, when we found it at major roost 23. At this time, site 23 was approaching its maximum size for the year (>50,000 birds).

Total roost population usually began to decline in August, long before the major migratory exodus. Movements of the radio-tagged birds also suggest a largely resident adult population through this period. Of 12 radio-tagged birds under observation (5 grackles, 7 star-

lings) from mid-August to mid-October, only 5 were lost possibly due to migration. However, during this period many roosts were being abandoned (Fig. 2) and therefore considerable movement among sites normally occurred. Some or all of the lost birds may have actually moved to sites undetected or beyond the census area and did not really migrate. Conservatively then, only a fraction of the five lost birds may have migrated. Taken together, the 13 radio-tagged birds suggest that only a small fraction of the total population could have migrated. We conclude, therefore, that a migratory exodus was probably not the primary cause for the mid-summer decline in TRP.

The large roosts (> 30,000 birds) that formed near the end of the season are likely to have resulted from the coalescence of local birds rather than a migratory influx. Some migrants may have been present in fall roosts, but based on the general decline in TRP through the fall, their contribution was probably minor. Only in 1981 did TRP increase substantially near the end of the season. However, with so few roosts active in the fall, our estimates of TRP were more susceptible to sampling error. For example, if a roost had formed near the edge of the census area, it would have been likely to attract many birds from outside the census area. This would have inflated TRP, making the increase appear as a migratory influx. In 1981 the increase in the size of the TRP in October largely resulted from the growth of site 42, which was the major fall roost in the northern part of the census area. Birds from inside the census area (Fig. 5), and likely from outside as well, joined this flock.

Roosts in the largest size category (Fig. 4) formed twice during the season: in August when TRP was largest, and in late fall just before migration, when TRP was declining. While the large roosts (> 30,000 birds) were outwardly similar during both periods, the patterns of development and the distribution of individuals among roost size classes (Fig. 4) were quite different. Prior to the peak in TRP, birds moved into developing roosting flocks mostly from scattered locations, which were likely near their breeding sites. During this time, the number and size of active sites were increasing and roosts representing all size categories were active.

In the fall, large roosts (> 30,000 birds) arose from the coalescence of individuals from both the declining major roosts and individuals from minor roosts (five radio-tagged birds, Fig. 5). In addition, we often saw large groups of birds moving from declining to developing sites. While making counts at declining or recently abandoned sites, we commonly observed groups of birds briefly stopping there before

proceeding to active roosts. Often these groups only circled overhead before departing. Based on their departure bearing and our knowledge of active roosts in the area, we usually could tell where they were going. In some cases we were able to follow the flightlines as the flock grew and to verify its destination. We hypothesize that these birds had formerly used the other sites and had recently abandoned them in favor of expanding alternative roosts.

The smaller categories of major roosts were generally absent in the fall. In autumn, radio-tagged starlings used both minor roosts and major roosting flocks. Although our sample of radio-tagged grackles is small, we have no evidence that they used minor roosts in the fall. Thus in the fall, the local starling population was distributed between minor roosts and large major associations, while the grackles appeared to be concentrated in the large major flocks. For starlings, association with a large roost did not necessarily lead to migration, because several of the radio-tagged birds returned to minor roosts after the large flocks declined. Decline of the fall flocks, however, coincided with migration of the grackles. The decline proceeded rapidly for essentially all of the grackle population left the census area over a four- to six-day period.

#### THEORETICAL INTERPRETATIONS OF ROOSTING

Formation of large roosting assemblages has been attributed, at least in part, to the need for migratory assembly (Michael and Chao 1973) and to migratory influx (Davis 1970). In our study, roosts of the largest size category developed in mid-summer, long before migration, and these often declined in size or were abandoned before the large fall roosts developed. Furthermore, several radio-tagged starlings joined large fall roosting flocks but remained in the census area after the migration period. Three starlings remained through early to mid-December, returning to minor roosts after the large roosts were abandoned in early November. The peak in TRP occurred annually, well before the harsh winter weather. This also argues against explanations based on the need to select favorable microclimates (Brenner 1965, Francis 1976, Gyllin et al. 1977, Keltly and Lustick 1977, Walsberg and King 1980).

Under certain circumstances, a shortage of available sites could promote communal roosting. However, in our study area suitable roost sites were not limiting, as all of the known sites were never used simultaneously (Lyon and Caccamise 1981). Also, active sites often were near inactive sites (e.g., sites 3-7, 6-35, 32-39).

Theoretical considerations argue against explanations based on the hypothesis of protection against predators (Lack 1968, Gadgil 1972). Flocking should be beneficial at group sizes far below even the relatively small sizes (1,000 to several thousand) of roosting associations common in spring and summer (Pulliam 1973). While protection is probably greatest in relatively large groups, it is likely that by joining such flocks individuals incur other costs (e.g., longer commuting distances, more competition). Furthermore, the anti-predation hypothesis offers no apparent explanation for the observed variation in size of active roosting flocks either seasonally or at a single time in the season. If protection against predators were the most important factor, roosts should be much smaller and more consistent in size.

Our results are also inconsistent with the information center hypothesis (Ward and Zahavi 1973). A basic assumption of this theory is that the size of roosting associations is directly related to the need for information concerning location of foraging areas. We have shown that roosts of vastly different sizes often occur simultaneously (Fig. 4) and in close proximity (Figs. 1, 2). To interpret these results according to the information center hypothesis, one would have to assume that birds in different-sized roosts (simultaneously active and nearby) perceive current food distributions in very different ways. We know of no empirical evidence for this assumption.

Current hypotheses are inadequate to explain the patterns of roosting behavior we observed. Future studies should examine behavior on a scale sufficiently large to show temporal and spatial patterns on a regional and seasonal basis. Such studies would provide a foundation for the development of new and more satisfactory hypotheses, thereby furthering our understanding of communal roosting behavior.

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