SEASONAL DIRECTIONAL PATTERNS OF MOVEMENTS AND MIGRATIONS OF STARLINGS AND BLACKBIRDS IN NORTH AMERICA

By Harold E. Burtt and Maurice L. Giltz

The practice of Starlings (*Sturnus vulgaris*), Common Grackles (*Quiscalus quiscula*), Red-winged Blackbirds (*Agelaius phoeniceus*), and Brown-headed Cowbirds (*Molothrus ater*) coming together each autumn in common roosts and dispersing each spring to their breeding territories, challenges ornithologists to determine origin of the birds, seasonal movements, and migrations. We have analyzed the distance and direction of the recoveries of over 120,000 birds that we banded from a decoy trap on the Ohio State University Farm in Columbus, Ohio (Burtt and Giltz, 1969c and 1972). We noted some species differences in directional patterns (Burtt and Giltz, 1970) and found it desirable to explore these differences in other flyways with larger samples from the files of the U. S. Fish and Wildlife Service. Accordingly, the Migratory Bird Population Center furnished the banding data on the recoveries of 22,467 Starlings, 12,151 Brown-headed Cowbirds, 10,664 Red-winged Blackbirds, and 31,172 Common Grackles which were filed between 1954 and 1973.

We determined the distance and direction that each bird took from its banding site to the recovery site and summarized these distances and directions in species, seasonal, and geographic samples. The summaries of these samples then lend credence to predictions concerning the stability and direction of movements and migrations of feeding and roosting flocks of birds from any one season to any other season up to one year after which their annual migration will be completed.

The computerized programs that we employed to calculate distances and directional movements and migrations from the latitudinal and longitudinal coordinates on file with the banding data would make similar determinations of any migratory bird species on file at the Migratory Bird Population Center. This information should be basic to control of any species.

VECTOR DIAGRAMS

We have constructed vector diagrams (Burtt and Giltz, 1969a) of species, seasonal and/or geographic samples that show the proportionate movement between all bandings and recoveries in the sample (Figs. 1 through 5). We believe that this method is superior to the conventional method of drawing lines between each bird's banding location and recovery location on a map because it may take seasonal movements into account and the vectors do not obscure the map with lines when large samples are used.

In order to determine the vectors for the diagrams from a sample, the distance (in miles) between the latitude and longitude of each bird's banding and the latitude and longitude of its recovery was calculated. The total distances of all birds in each 20° sector of the

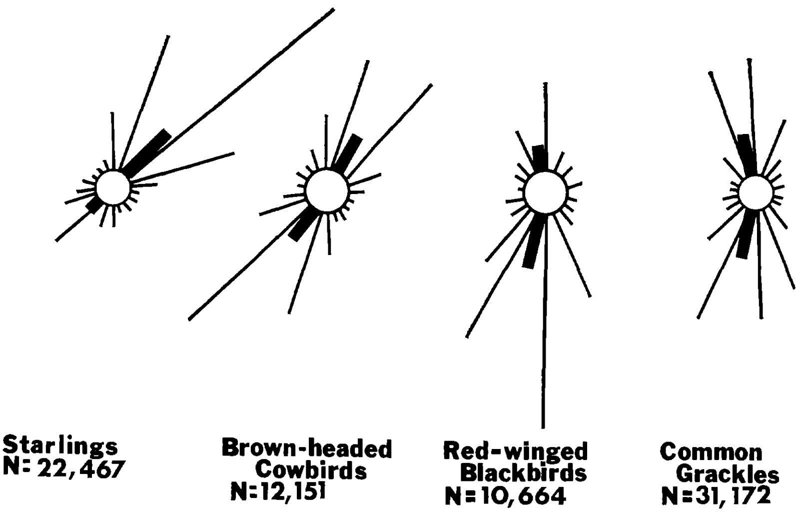

FIGURE 1. The proportionate distance and directions between banding locations and recovery locations of all Starlings, Brown-headed Cowbirds, Red-winged Blackbirds, and Common Grackles in North America without regard to dates of banding, dates of recovery, or the flyways. The radii of the circles represent local recoveries and are proportionate to the vectors of each diagram. N = the number of each species in the sample. Average vectors north and south of 90°-270° axis are indicated by heavy lines on each diagram.

compass, when taken as a percent of the distances in all sectors, were used to get the magnitude of the vectors. All vector diagrams were drawn to the same scale including the circle at the center which has a radius equal to the percent of recoveries in the same 10 minute block of the bird's banding. These are designated as "local recoveries." They contribute nothing to the directional pattern but are of interest because they reflect the stability of the birds in the sample. The vectors begin at the circumference of the circle and extend outward along the appropriate azimuths.

The vector diagrams shown in Figure 1 were made from all recoveries in North America. Diagrams in Figures 2 through 5 were made with flyway and species samples and were placed on the map of the United States in the proper flyway but without regard to the average banding location.

GENERAL SPECIES DIRECTIONAL MOVEMENT PATTERNS

With samples of the present size it seems legitimate to speak of the vector diagrams as movement patterns that indicate directional tendencies. Certain geographical features, such as lakes, oceans, or mountains, and ecological habitats such as marshes and rivers, may influence the direction of the movements and migrations of the birds and will be used to help interpret these movement patterns. However, equally important in influencing the patterns are the

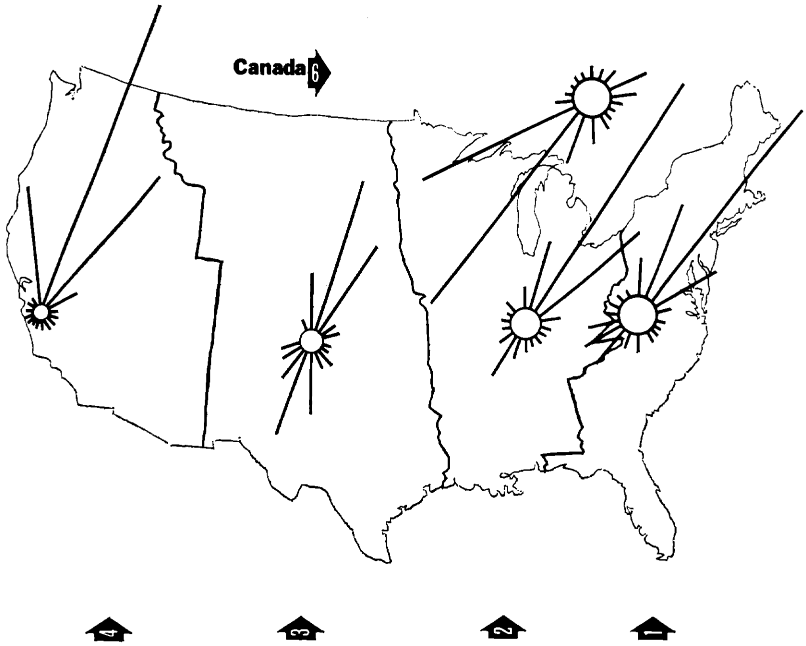

FIGURE 2. The movement of Starlings between banding and recovery in each flyway designated by numbered arrows. Radii of the circles represent local recoveries and are proportionate to the vectors of each diagram.

motives and diligence of the people who place the bands on the birds and the motives of the people and the human population in each part of a species' range who recover the bands. The blackbirds and Starlings analyzed in this study are notorious for destroying crops, creating a nuisance, desecrating residential areas with their droppings, and endangering aircraft. It is in the vicinity of these conflicts with man that most bandings and recoveries were made. Although it is obvious that the vectors are not randomly distributed, Chi-square was computed for the Starlings using the lengths of the vectors as the observed value and the average of these lengths as the expected value for each of the 18 sectors. The Chi-square value is 877 whereas only 40.8 is needed for $P < .001$. (Chi-square was not computed for the other three species.)

AVERAGE VECTORS

The movement patterns are bipolar, understandable in the light of traditional seasonal migrations. This fact suggested computing average vectors for the northerly and southerly portions of the diagrams in order to compare the average species movements in North America. Accordingly, the tip of each vector, x and y, was determined in Cartesian coordinates and the average x and average y for all sectors north and for all sectors south of the 90° - 270° axis, were determined. This computation yields the same azimuth,

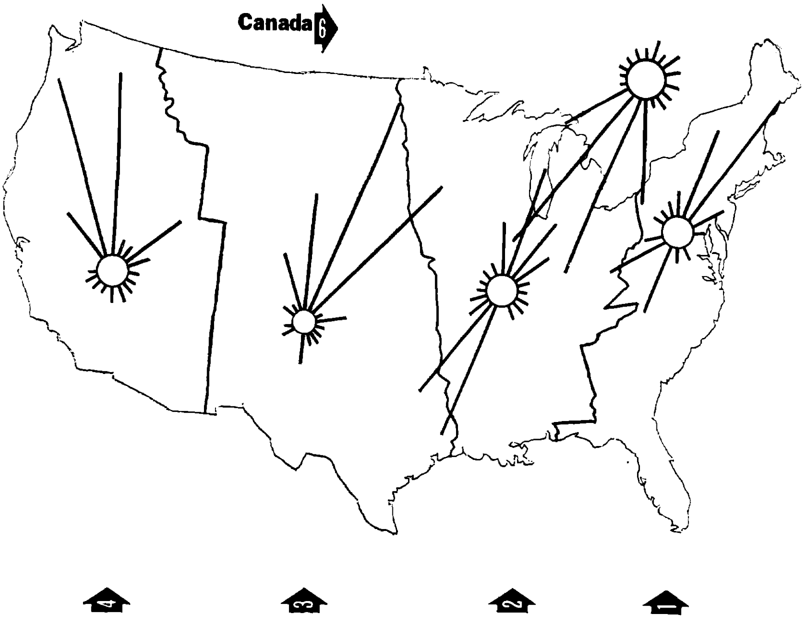

FIGURE 3. The movement of Brown-headed Cowbirds between banding and recovery in each flyway designated by numbered arrows. Radii of the circles represent local recoveries and are proportionate to the vectors of each diagram.

as Batschelet's "mean angle" (Batschelet, 1965), except that here the total distance in each sector may be considered as a weighting for that sector or azimuth. The average vectors are shown by heavy lines beginning at the circumference of a circle like the other vectors in Figure 1.

The most striking aspect of Figure 1 is that Starling and cowbird recoveries tend to be northeast and southwest of the banding station, whereas the directional tendencies for red-wings, and grackles are northward and southward with little difference in the eastward and westward aspects. The average vectors further emphasized these species differences. The foregoing is a major result of our study and will be discussed further at this point before exploring various subsamples. Vector diagrams representing geographic samples have been placed on maps wherever convenient and represent all stations in the flyway without regard to locations.

Starling Movement Pattern: An investigation of Starling recoveries prior to 1951 in the files of the Migratory Bird Population Center concluded that west of the Appalachians the trend was northeast-southwest, but along the east coast it was north-south (Kessel, 1953). Another sample along the coast corroborated this latter aspect (Davis, 1960). The northeast-southwest trend was found by Thomas (1934) in the early 1930's and later in our own study in central Ohio (Burtt and Giltz, 1969a, 1970). The sample of 22,467

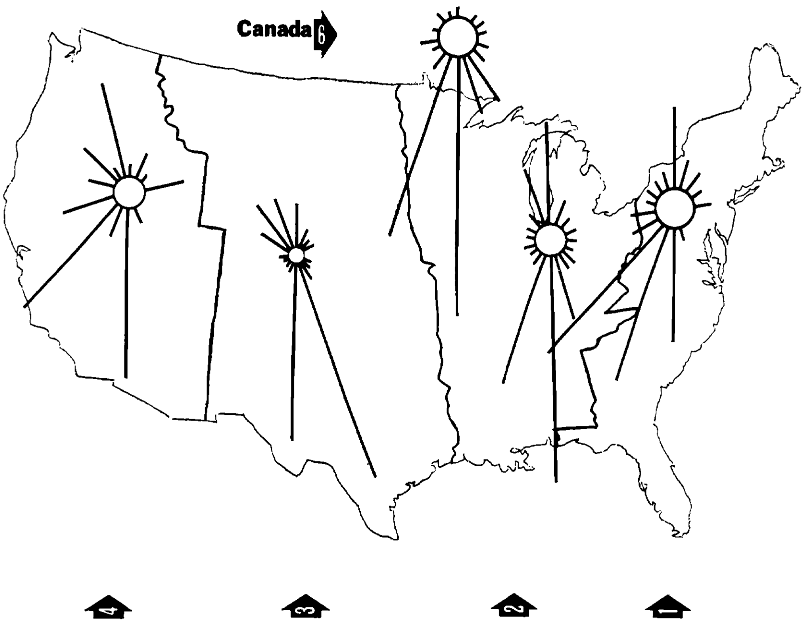

FIGURE 4. The movement of Red-winged Blackbirds between banding and recovery in each flyway designated by numbered arrows. Radii of the circles represent local recoveries and are proportionate to the vectors of each diagram.

Starling recoveries reported in the present study and diagrammed in Figure 1 is nationwide.

This northeast-southwest movement is sometimes attributed to a genetic tendency that evolved in the European ancestors of our Starlings (Thomas, 1934). Whereas some Starlings in Europe apparently have different migratory pathways and even some sedentary tendencies, nevertheless a substantial northeast-southwest trend is indicated. Dorst (1962) gives maps (on p. 70, 72, and 213) showing this type of migration. Perdek (1958) cites displacement experiments in the fall in which young Starlings continued to the southwest. Kramer (1951), recording the *Zugunruhe* of Starlings in October, found their orientation was to the southwest and in the spring the orientation was northeast for at least 10 days. So, possibly some Starlings with this genetic orientation were among those imported to this country around 1890. Considering the United States as a whole, there would be only a limited number of factors that would select *against* this genetic tendency, and it might persist although it no longer had much survival value. The fact that Starlings have relatively recently been introduced in North America and are still expanding their range westward without developing a deep south "winter home" may be related to their practice of using buildings for roosting in inclement weather.

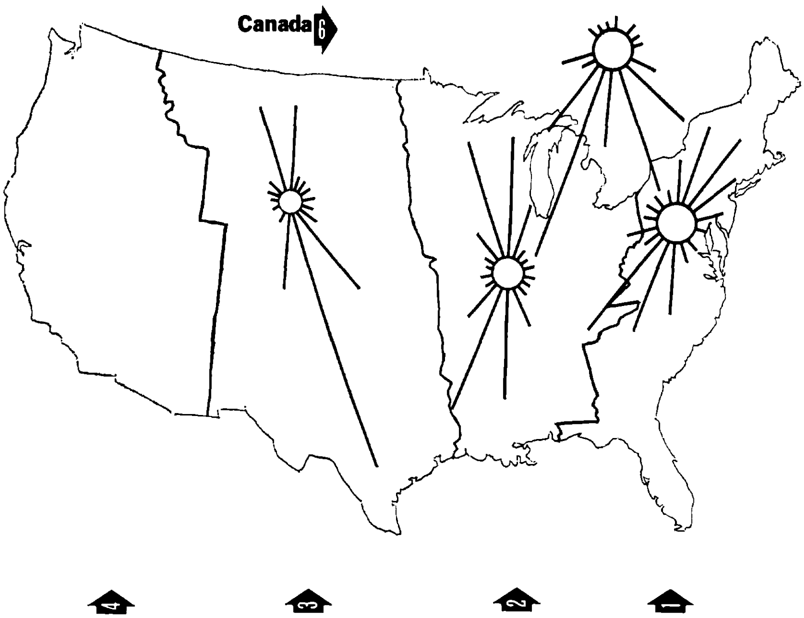

FIGURE 5. The movement of Common Grackles between banding and recovery in each flyway designated by numbered arrows. Radii of the circles represent local recoveries and are proportionate to the vectors of each diagram.

In addition to the comments concerning average Starling movements in North America, a breakdown of Starling movements by flyways indicates that the tendency toward the northeast is greater than that toward the southwest (Fig. 2), suggesting more postnuptial wandering and/or nesting farther south than the icterids. For a possible explanation of this, it is necessary to anticipate the discussion of seasonal movements (infra).

Cowbird Movement Pattern: We have found no study of directional patterns for cowbirds except our own study of cowbirds banded in central Ohio (Burtt and Giltz, 1970). Our birds clearly show the northeast-southwest pattern similar to the 12,151 recoveries in the North American sample used to make Figure 1. The following is suggested as a possible explanation. Brown-headed Cowbirds came originally from South America (Friedmann, 1929, p. 151 ff.). "*Molothrus* is essentially a neotropical genus only one member of which (*M. ater*) has come to inhabit North America." Of two possible routes of entry, Central America or the West Indies, Friedmann considers the former more likely. This would bring the birds through Mexico and Texas and in a generally northeastern direction. "The routes followed by migrating birds involve quite clearly in some cases the paths by which the species historically reached a given breeding area" (Van Tyne and Berger, 1959, p. 192). It is possible that the cowbirds represented in Figure 3 are retracing the historical pathway of their invasion of the North American continent.

Red-winged Blackbird Movement Patterns: The overall Red-winged Blackbird movement pattern (Fig. 1) may be interpreted as receiving the southwest vectors from the birds in Flyway 1, the north-south vectors from the birds in Flyway 2, and the south and southeast vectors from the birds in Flyway 3. Flyway 6 also contributes to the southern and southwest vectors whereas Flyway 4 is almost a complete anomaly (Fig. 4).

We believe that the Red-winged Blackbirds in Flyways 1, 2, 3, and 6 have a common winter home that extends along the northern coast of the Gulf of Mexico and influences these movement patterns. It is also our belief that the divergence from the direction of the common winter home by the birds in Flyway 4 is associated with the western subspecies which may have different winter homes. We also feel that the smaller proportion of local recoveries in Flyway 3 is due to some promiscuous banding attention of the Red-winged Blackbird population and does not reflect the sample's true stability.

Common Grackle Movement Patterns: The overall grackle movement pattern (Fig. 1) is similar to the overall red-wing pattern and also to the Flyway patterns (Fig. 5). The trends in both species indicate a common winter home along the Gulf of Mexico. Although we have no evidence, three strong vectors south may indicate varieties or subspecies with different winter homes in these two populations. The absence of grackles in Flyway 4 indicates that they do not nest, winter, or migrate through this Flyway.

LOCAL RECOVERIES

The vector diagrams in Figs. 1-5 show some differences in the size of the circles. Although local recoveries (indicated by the circle around the stations), within the same 10-minute block as the banding station, have no directional component and contribute nothing to the major aspect of the study, they do reflect the length of time a species remains in the vicinity of the station where it was banded.

When a comparison of local recoveries was made between the grackles, red-wings, cowbirds, and Starlings, and the human population of each flyway, it was found that there were more red-wings recovered locally (Chi-square test, $P < .01$). We have not analyzed the season in which the birds were banded in relation to local recoveries, but we feel that the red-wings remain around the banding stations for longer periods of time and are therefore more likely to be recovered within the same 10-minute block.

Goldman (1969) noted that females remain closer to their breeding territory except during winter months. Jackson (1970) and

Dolbeer (1976) have observed them renesting nearby. The fact that the males return from migration earlier than the females, and leave the breeding territories later, extends the period when the species may be recovered in the breeding season.

Cowbirds throughout the year often roost at some distance from their daytime sites (Friedmann, 1929), thus reducing the time available for local recovery. Starlings characteristically are "on the move." In the decoy trap they fly back and forth restlessly for long periods of time. In an experiment where complacency agitation was measured with individual birds in an observation cage, Starlings were significantly more agitated and restless in captivity than the other three species (Burtt and Giltz, 1969b). In a study of the behavior of birds when released after banding, Starlings and grackles flew the greatest average distances before alighting (Burtt and Giltz, 1974). Some of the foregoing features may also contribute to the slightly larger percent of local recoveries for redwings.

TABLE 1.

The percent of local recoveries (within 10-minute block) compared to the human population in each flyway.

Local Recoveries	Starling	Brown-headed Cowbird	Red-winged Blackbird	Common Grackle	Human population per sq. mi.
All Flyways	50	54	62	55	
Flyway 1	59	57	76	68	156
Flyway 2	47	52	57	50	86
Flyway 3	26	31	26	41	18
Flyway 4	15	53	52		33
Flyway 6	62	55	62	57	

Table 1 shows obvious differences between the flyways in percentage of local recoveries. An explanation of these differences appears in the last column, the human population per square mile for each flyway (National Geographic Society, 1963). Such a figure for Flyway 6 would be meaningless because of the large uninhibited areas in the northern part of the birds' ranges. Flyway 1 has the largest percent of local recovery for each species and the greatest human population. Flyway 2 ranks second in both respects and Flyway 3 has the lowest ranks. If a given number of birds is available (e.g., dead) for recovery near a banding station, which is operated throughout the year and there are more people in the vicinity, more of the birds will be found. However, we cannot generalize from local recoveries to *all* the birds banded in a given flyway because some of them are recovered in a different flyway and we do not know the motives of the banders.

DIRECTIONAL MOVEMENTS FROM THE SEASON OF BANDING TO THE SEASON OF RECOVERY

In this part of our study we analyzed the banding data to reveal the same information that was used to make the vector movement patterns and in addition, we sorted the species samples according to the seasons in which the birds were banded and the seasons in which they were recovered. Because the eastward and westward movements were shown to be proportionately small for all of these species, the seasonal movements were summarized by calculating the percentage of all distances north or south of the 90° - 270° axis and designated them as "percentage of movement north" or percentage of movement south" (hereafter also called movements north or movements south). Because these species presumably make a complete annual migration south to their "winter home" and north to their "summer home," they may return to the banding site in a year's time. We divided the year into the four seasons that approximated the events in the life cycle of all four species rather than an accurate season for any one species. The months of each season are: March, April, and May - *Spring*; June, July, and August - *Summer*; September, October, and November - *Autumn*; December, January, and February - *Winter*. In order to find the movements from the season of banding to each of the next three succeeding seasons, we separated the seasons of the first year from the seasons in subsequent years. The percentages of the recoveries made in each season occurring in the first year following banding are shown in Table 2. The exception to this is the percentage shown in

TABLE 2.
The proportion of recoveries made in each season the first year following banding.

Season recovered	Starling Sp	Su	A	W	Brown-headed Cowbird Sp	Su	A	W	Red-winged Blackbird Sp	Su	A	W	Common Grackle Sp	Su	A	W
Banded Sp	**66**[1]	71	78	76	**74**	76	82	82	**61**	64	66	71	**59**	65	68	**72**
Banded Su	73	**59**	77	82	78	**69**	84	84	72	**51**	73	71	67	**59**	78	75
Banded A	74	69	**62**	79	76	80	**76**	82	69	74	**68**	80	71	67	**74**	81
Banded W	73	71	75	**67**	83	78	86	**74**	74	68	68	**74**	67	68	66	**70**

[1]Percentages (bold face type) are of birds banded and returned in the same season and in that season of following years.

the table for the percentages of recoveries made in the same season as banded. This percentage is made up of recoveries in the immediate season and that season one year later. We felt this was justified because approximately 50 percent of all recoveries for all species were made in the immediate season in which they were banded.

Diagrams of Seasonal Movements: Diagrams of movements of each species between the seasons of banding and the seasons of recovery within the first year are shown in Figure 6. The movements may

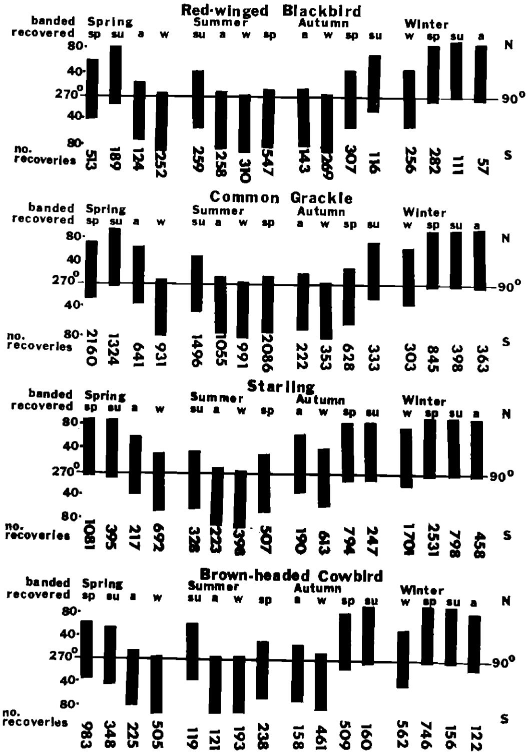

FIGURE 6. The percentage of each seasonal bar above the 90°-270° axis indicates northward movement and the percentage of each seasonal bar below the axis line indicates southward movement. The number of recoveries involved in the movement data for each category is shown below each bar.

be interpreted by comparing the position of the banding season's bar on the axis with the position of any other season's bar. The proportion of each bar above (north) or below (south) of the 90° - 270° axis line on the chart indicates the percent movement of the sample that was recovered northward or southward of the banding sites. Recoveries made in the same season as the season in which they were banded indicate how much northward or southward movement was made by the populations between banding and recovery both in that immediate season and that season of following years.

Movements Following Spring Banding: The movements northward and southward from season to season are quite similar for the Common Grackles and the Red-winged Blackbirds. The Brown-headed Cowbird differs from the grackles and red-wings by going southward following spring banding rather than northward, reflecting perhaps, more postnuptial wandering in the latter species. Starlings differ from the icterids in their movements following spring banding by going northward and remaining there throughout the summer after which they move southward but not to the same extent as the icterids.

In another study to determine the geographic source of birds composing winter roosts (Giltz and Burtt, 1976), it was found that the icterids and Starlings that were banded in the spring and recovered in the winter mostly nested north of the 30th parallel but some of the Starlings and cowbirds nested south and wintered north of the Red-winged Blackbirds and Common Grackles all of which moved toward the Gulf of Mexico Coast.

Movements Following Summer Banding: All species banded in the summer were recovered in equal numbers northward and southward of their banding stations in the same summer and subsequent summers. These birds all move southward for autumn and winter and return toward the north to their banding sites where 10 percent of red-wings and grackles and approximately 38 percent of the cowbirds and Starlings are found by the next spring.

Movements Following Autumn Banding: Following banding in the autumn, all species move south in the winter. The icterids all reflect their migrations toward the Gulf of Mexico by over 90 percent movement southward compared to the Starlings' 65 percent movement southward. In the spring the autumnal banded red-wings and grackles are still traveling northward since only 40 percent have reached the banding site at this season whereas cowbirds and Starlings are found 80 percent distances northward. In the summer all species have moved 80 to 90 percent northward of autumnal banding sites.

Movements Following Winter Bandings: The movements of the grackles, cowbirds, and the red-wings following winter banding are similar, all moving approximately 97 percent northward in the spring and remain there throughout the next three seasons. However, the cowbird again confirms its southern tendencies over the other icterids whereas the Starling remains 99 percent north throughout the next three seasons and returns farther north than the other species in subsequent winters.

SUMMARY

The directional and seasonal movements of Common Grackles, Red-winged Blackbirds, Brown-headed Cowbirds, and Starlings, were determined from banding data of 76,454 recoveries on file in the Migratory Bird Population Center. Vector diagrams were constructed for each species in each North American Flyway to show the magnitude of the migrations as well as the stability of each species.

The vectors from each banding station northward and southward were summarized on a chart from which the stability and/or transient nature of each species may be predicted from season to season.

Recoveries related to the season show northern summering, and southern wintering, as well as autumn and spring migrations. The

Starlings were shown to winter farther north, or nest farther south, and to migrate in a northeast-southwest direction whereas the icterids winter along the Gulf of Mexico and are in transit in the autumn and early spring. The northward movement of all species banded in and just after the nesting season suggests that post-nuptial wandering is common. This technique of determining the stability and movements of populations of birds may be of value to conservationists, game managers, and control agencies.

ACKNOWLEDGMENTS

We wish to thank the Instruction and Research Computer Center of The Ohio State University which programmed our data. We are equally thankful for the bird banding data furnished by the Migratory Bird Population Center. We also wish to thank every bird bander and everyone who returned a band because their acts made this study possible.

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Department of Psychology and Department of Zoology, Ohio State University, Columbus, Ohio 43210. Received 23 December 1976, accepted 17 May 1977.