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Food and winter territories of Northern Mockingbirds.—In the northeastern United States, the Northern Mockingbird (*Mimus polyglottos*) may be the only species that maintains a territory throughout the winter. Mockingbirds localize their activities within small territories centered on fruit resources that are defended against conspecifics and often against other frugivorous species (Moore 1978). The fruit resources decline through the winter due to consumption and fruit drop. Despite the food decline, the birds generally are able to remain on a single site throughout the winter. This suggests that the birds have been selected for an ability to compensate for the decline. Two possible proximate mechanisms to achieve this are: (1) assessment of the fruit supply in the fall with establishment of a territory large enough to contain sufficient resources for the winter, or (2) continual adjustment of territories during the winter as the fruit supply declines. This study was designed to test whether mockingbird behavior was consistent with the first mechanism and to document the pattern of food decline through the winter. The primary winter food resource for mockingbirds in the northeast is multiflora rose fruit (*Rosa multiflora*) (Stiles 1982).

To test the hypothesis that mockingbirds establish initial territories with sufficient food resources to survive the winter, we: (1) determined the multiflora rose berry supply on several territories, (2) monitored the changing availability of this resource, and (3) determined the territory size periodically through the winter. If the hypothesis was correct, we should find that each territory, regardless of size, encompasses at least some threshold minimum in the amount of food resources and, that the density of food resources is inversely proportional to territory size. Furthermore, there should be little change in territory size through the winter, and any changes in territory size should have no relationship to the pattern of declining food resources.

Methods.—We studied seven mockingbirds on the Purchase College campus of the State

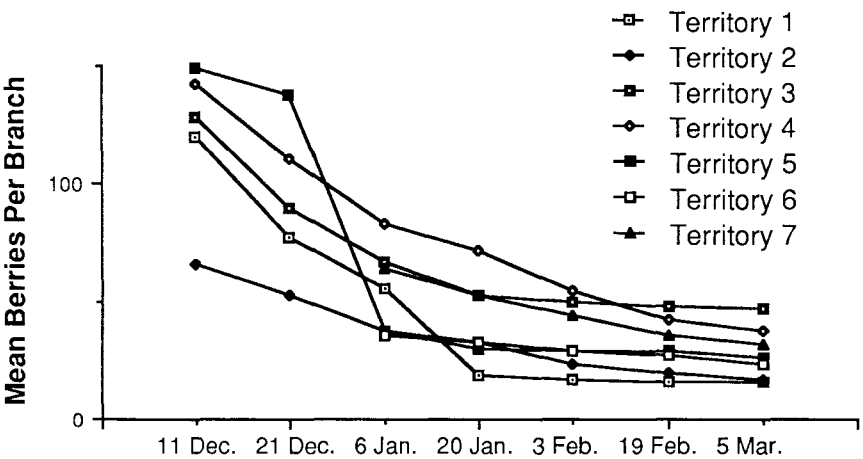

FIG. 1. Decline in mean number of berries on tagged branches in seven mockingbirds' winter territories.

University of New York in southeastern New York State. Much of the area is abandoned pasture containing abundant multiflora rose. Five birds were color banded in November and two in January. Each of these birds occupied a separate area; none was paired. Birds' movements were recorded on maps during 68 h of observation during 8 December 1976–5 March 1977. Additional casual field observations were made through the fall and winter. Each bird was observed sequentially during morning, midday, and late afternoon in each of four observation "periods." An observation period was a calendar interval within which each bird was observed for a minimum of three, one-hour periods; one during morning, one at midday, and one in late afternoon. The four observation periods were: 8 Dec.–20 Dec., 6 Jan.–18 Jan., 19 Jan.–2 Feb., 22 Feb.–5 March. Territory boundaries were drawn around all typical defended habitat within the outermost observed sites of each bird. When drawing these lines we excluded undefended areas such as roads and woodlands which intruded into the polygon formed by connecting outermost points. Territory size was measured from these maps using a planimeter. We termed the areas which mockingbirds initially established and defended from late November through December "original territories." We use this term to differentiate areas defended early in the season, the time when territory defense and singing are most vigorous (Breitwisch et al. 1986), from those used later in the winter, when territoriality waned and there was some shifting of the areas occupied.

To monitor the change in relative abundance of the available berries through the winter, we counted berries on sample branches biweekly. On each territory ten multiflora rose bushes were randomly selected and one branch on each bush was marked with an aluminum tag. Tags were hidden to minimize the possibility that mockingbirds or potential competitors were affected by them. The berries on each of these tagged branches were counted once every two weeks.

In early February we estimated food supplies on each territory by belt transect sampling of multiflora rose and Japanese barberry bushes across the length and width of each bird's original territory. Within the transects, height and width of bushes were measured. Berries were sampled at heights of 30, 50, 90, and 120 cm on randomly chosen portions of each bush. At these sampling sites, a 15 × 15-cm square was placed vertically against the bush

TABLE 1
INITIAL TERRITORY SIZE AND FOOD SUPPLY CHARACTERISTICS FOR MOCKINGBIRD TERRITORIES

Bird	Territory size (ha) 24 Nov.–20 Dec.	Number of berry bushes	Estimated number of berries (1000s)	Berry bush basal area (m^2)	Percent of territory covered by berry bushes	Berry bush surface area (m^2)
1	0.35	78	757	459	13	1265
2	1.65	80	80	495	3	1108
3	0.99	68	646	489	5	1611
4	0.42	113	673	851	21	6871
5	0.40	165	517	1100	27	3728
6	0.28[a]	196	286[b]	2443	86	6668
7	0.37[a]	78	182[b]	451	12	1761

[a] Territory size not determined until January.
[b] First estimate was not made until January.

surface, and all berries extending horizontally inward from the square toward the center of the bush were counted. The total number of berries on each bush could be estimated by determining surface area based on height and width (assuming the bushes were roughly cylindrical) and extrapolated from the number of berries sampled in a known area of bush. This February food supply estimate was used in conjunction with our relative abundance index from tagged branches to yield estimates of fruit abundance on each territory from the time of territory establishment until the termination of field work. We ended the study in March when warm weather caused the emergence of insects on which the mockingbirds began to feed heavily. Initial territory size was determined for the five mockingbirds which we color banded in November. We did not measure the other two territories during territory establishment.

Results.—Territorial defense (chasing to the territory boundary) was directed only at other mockingbirds, American Robins (*Turdus migratorius*), and European Starlings (*Sturnus vulgaris*). These were the only birds seen foraging on the same fruits.

The five original territories ranged from 0.35 to 1.65 ha (mean ± SE = 0.76 ± 0.56, Table 1). Three of the five birds had similar, small territories, while the other two birds had distinctly larger territories, thus providing a range of variation for analysis.

The original sizes of mockingbird territories (N = 5) appeared unrelated to the number of fruit-bearing bushes (Spearman Correlation $r = -0.20$), the amount of ground covered by these bushes ($r = 0.10$), or surface area of the bushes themselves ($r = -0.30$). However, inverse correlations suggesting relationships between territory size and food resources were found between the sizes of original territories and the number of berries present ($r = -0.70$), the percent of territory area covered by the bushes ($r = -0.70$), and the density of bushes ($r = -0.70$). Although food supply parameters were not constant among the territories (Table 1), a minimal threshold of fruit-bearing bushes in each territory is suggested. Despite their size disparity, territories 1–3 had similar numbers of bushes (68–80), area covered by fruit bushes (460–495 m^2), and fruit bush surface area (1100–1600 m^2).

Over the winter, food supply declined rapidly on four of the five original territories (Fig. 1). Most berries disappeared in December and early January, coincident with the first winter snow storms. By mid-January the rates of decline on 6 of the 7 territories were quite low, but they had already lost over 50% of their early December food resources. The size of

utilized territories changed during the winter, but there was no consistent pattern of increase or decrease in size.

Discussion.—Mockingbirds' multiflora rose food patches represent nonrenewing resources that are most abundant during the initiation of territorial behavior in the fall and decline dramatically through the winter when energy demands are the greatest. At least two alternative strategies for compensation of such a decline are possible: (1) establish as large a territory as is economically possible as long as it contains more than the minimum amount of food resources necessary for winter survival, or (2) adjust the territory throughout the winter as the food supply declines. If mockingbirds assess the food resources in the fall and establish territories containing sufficient food resources to assure survival through the winter, territory size should show an inverse relationship to food density. Such a pattern has been shown previously with other species in the breeding season (e.g., Stenger 1958, Simon 1975) and the nonbreeding season (Gibb 1956, Gill and Wolf 1975, Lederer 1977, Salomonson and Balda 1977). One would thus expect a threshold of minimum food resources as a requisite for territory establishment. That birds can predict long-term suitability of an area has been suggested (Wiens 1973; Stenger 1958). In our study, many berries remained on each territory at the end of the season despite the fact that the winter of 1977 was unusually harsh.

Two systems comparable to the mockingbird's have been studied. The Townsend's Solitaire (*Myadestes townsendi*) (Lederer 1977, Salomonson and Balda 1977) and the European Nuthatch (*Sitta europea*) (Enoksson and Nilsson 1983) are both territorial during the nonbreeding season and subsist on non-renewing food resources that can be assessed in the fall. These studies all found an inverse correlation between food availability and territory size. Supplemental feeding of the nuthatches reduced territory size, suggesting that the nuthatches established territories based on assessment of food resources. Our data for mockingbirds suggest that they may assess the suitability of an area based on a threshold of food resources. Some territories, including the largest ones, contained a similar minimum amount of food resources while others, including the smallest, seemed to contain an excess beyond this minimum.

F. C. Laskey (1933) and A. R. Laskey (1935) found fluctuating winter territory size in mockingbirds. We confirm this finding, and as we predicted, territory size fluctuations later in the season appear unrelated to food. Most birds modified the sizes of the area they used during two-week periods through the winter. Since the supply of berries constantly was declining, it seems unlikely that these expansions and contractions were directly related to the food supply. Logan (1987) found that changes in mockingbird winter territory sizes were related to weather. This further supports our prediction that changes in territory size should be unrelated to food supply decline.

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The correct name for the Olivaceous Cormorant, "Maiague" of Piso (1658).—Nearly 350 years ago, George Marcgraf (also spelled Marcgrave) and Willem Pies (Latinized as Piso), led by Johan Maurits of Nassau-Siegen, conducted natural history explorations in northeastern Brazil (see Whitehead 1979a). Many forms of plants and animals were described for the first time and documented by Piso and Marcgrave (1648) and Piso (1658), with over 500 illustrations based on watercolor and oil paintings (Whitehead 1976). Although specimens were collected on the expedition, no animal specimens are known to be extant (Whitehead 1979a). Some of the descriptions and illustrations from this early expedition were the basis for names introduced by Linnaeus, Gmelin, and others; several of these names have given rise to considerable controversy. Among these is *Procellaria brasiliana* (Gmelin 1789, p. 564), in the description of which Gmelin cited five references, all of which derive from the bird that Piso (1658, p. 83) called "Maiague" (sometimes rendered "Majaque").

Gmelin (1789) placed the "Maiague" as the species *brasiliana* in the genus *Procellaria* (=order Procellariiformes), but he never saw the original paintings (Whitehead 1979a). In one of the works cited by Gmelin, Willughby (1678, p. 334) stated that Piso's bird "seems to resemble" *Corvus aquaticus,* a name then in use for the Cormorant, now *Phalacrocorax carbo,* of the Old World. Latham (1785, p. 398), also cited by Gmelin, expressed doubt that Piso's "Maiague" was a petrel. Latham may have consulted the original paintings (Figs. 1 and 2), whereas Gmelin (1789) and the other authors Gmelin cited referred only to Piso's (1658) published woodcut (Fig. 3) (fide Whitehead, *in litt.*).

Lichtenstein (1817, p. 175) examined the original oil painting (Fig. 1) and water color (Fig. 2) of the "Maiague" that probably were the basis for the rather crude woodcut (Fig.