

serves a useful purpose provided it does no harm. A crucial answer might be obtained with populations of captive starlings by watching for "migratory restlessness" by the usual technique of recording automatically the perching on different sides of the cage.

Meanwhile we have shown that those of our Columbus starlings that migrate follow the N.E.-S.W. axis just like their predecessors of many generations ago.

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BEHAVIOR OF MYRTLE WARBLERS IN CAPTIVITY

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Although many parulids form interspecific flocks after the breeding season, Myrtle Warblers (*Dendroica coronata*) are one of the few wood warblers that exist in conspecific flocks at that time. The original purpose of this study was to determine if there are any behavioral mechanisms which enhance flocking and which are absent in other parulids which we had studied previously which do not form conspecific flocks (Ficken, 1962b; Ficken and Ficken, 1962). Since displays often reduce fighting and other high intensity agonistic acts, an increase in the complexity of displays might be expected in social species. For example, the Common Grackle (*Quiscalus quiscula*) which is social even during the breeding season has a larger display repertoire than many nonsocial icterids (Ficken, 1963).

We made preliminary observations of winter flocks in the wild, but the birds were difficult to observe closely and we therefore decided to study them in captivity. This paper describes the agonistic behavior, both visual and vocal, of this species, and the change which occurred with an artificial increase in light. In addition, we obtained information on comfort movements and feeding patterns which had not been previously described in this species. Finally, there is a discussion of the behavioral mechanisms related to flocking in the Myrtle Warbler.

METHODS

The Myrtle Warblers were obtained from an Operation Recovery station on the south-east tip of Kent Island, Maryland, on October 13, 1963. The sexes were distinguished by wing length. Birds with wing lengths from 74 to 76 mm. were judged to be males, those with wing lengths from 70 to 73 mm., females. However, it was later found that the bird with a wing length of 73 mm. was a male. Seven males and five females were color banded and released into a room (9' x 9' x 9') in which two erect saplings were placed. A sheet was tacked over the door and observations were made through a small opening.

The diet contained a continuous supply of mashed egg yolk and Sluis insectivorous mix. In addition, the birds were given bayberries and small pieces of seedless green grapes. About thirty wax moth larvae (*Galleria mellonella*) were given daily.

By the end of three days in captivity, the birds had received approximately 15 hours of light in addition to the normal day length. For the next period (Oct. 17 to Dec. 15) they received ten hours of light daily but it was increased to 11 hours in the last month of the study.

RESULTS

Maintenance Activities

These warblers had a stretching movement not previously described for passerines. In most passerines the tail is stretched, usually on one side, during a stretching of a wing and corresponding leg sideways (Nice, 1943; Ficken, 1962a). Tail stretching also occurred in this context in the Myrtle Warbler, but a symmetrical stretching of the whole tail also more rarely occurred alone. Stretching usually consisted of a sequence of two acts, the stretching of both wings upward followed by stretching of a wing, leg and tail sideways. The same sequence was also observed in two other species of warblers but differs from that of some other passerines (Ficken, 1962a).

Myrtle Warblers prepare wax moth larvae for ingestion in a very stereotyped manner. The bird seizes the insect by the thorax, runs it through the bill and then holds the tail while banging the head of the larva on the perch (sometimes this is repeated several times) and then swallows it head first. Deviations from this pattern occurred in fewer than 10% of the over 50 cases observed. This sequence is the same as that of the Bay-breasted Warbler (*Dendroica castanea*) but differs from the American Redstart (*Setophaga ruticilla*), in being more stereotyped (Ficken, 1962a).

General Social Behavior

We noted the behavior of each bird as soon as it was released from the individual carrying cage into the large cage. The first birds released Harsh Chipped, tail flicked, and flew around the cage much more than birds put in later. There is evidently some immediate reduction of fear correlated with increase in group size. The flocking

tendency was particularly marked with regard to food. When one bird flew to a food source several others usually followed immediately. This synchrony of movements is one of the characteristics of flocking (e.g., Crook, 1964). In the wild, this following response may include other species as well. Kilham (1961) noted that individual migrant Myrtle Warblers are quickly attracted to food sources, particularly berries, where other species are feeding.

General Agonistic Behavior Under "Fall-winter" Conditions

During the first three days in captivity, there was a very low level of agonistic behavior. There were no agonistic encounters at the standard food source of bayberries, fruit, egg yolk, and insectivorous mix. However, if the birds had been deprived of wax moth larvae for a day and only a few were thrown into the cage, there were immediate chases of those who had obtained larvae. If enough were tossed in so that each bird easily obtained at least one, this did not happen. Thus, deprivation of a favorite food apparently led to an increase in aggression. In the wild, food deprivation apparently may lead to a reduction in flocking. Woolfenden (1962) noted that during an abnormally cold spell when insectivorous species were suffering from the lack of food, a Myrtle Warbler apparently left a flock and formed a winter "territory". When weather conditions became more favorable again, it rejoined a flock. Kilham (1961) observed migrant Myrtle Warblers in the fall, chasing several different species including woodpeckers when the other species had food in the bill or were near a food source (e.g., poison ivy berries) utilized by the warbler.

When not feeding, the birds usually perched 3 to 7 inches apart. We recorded how close birds tolerated an approach without Gaping or other agonistic behavior (Table 1). Approaches closer than 3

TABLE 1. INDIVIDUAL DISTANCE DURING "FALL-WINTER" AND "SPRING" CONDITIONS AS DETERMINED BY NUMBER OF AGONISTIC ENCOUNTERS FOLLOWING APPROACHES AT DIFFERENT DISTANCES

	Number of Inches			
	1-2	3-4	5-6	7-8
"Fall-winter"				
Number of times encounters occurred	4	1	0	No data
Number of times encounters did not occur	1	5	12	No data
"Spring"				
Number of times encounters occurred	*	7	17	3
Number of times encounters did not occur	*	1	6	3

*The birds were never observed this close together

inches usually elicited agonistic reactions. The bird that was approached usually turned its head and directed a Gape at the "intruder". Sometimes the defending bird also raised the crown feathers slightly (Crown Raising). Individual distance has been defined by Conder (1949) as "an area around a bird, which moves with it, has no topographical reference, and into which no other individual is allowed to come." There did not seem to be any sexual differences in individual distance.

The only displays observed were Crown Raising, Gaping and the characteristic Harsh Chip. This vocalization is also prominent in winter flocks of birds in the wild.

*Agonistic Conditions Under "Spring" Conditions
(After Increased Light)*

The agonistic behavior of the birds changed markedly after approximately 15 hours of additional light. All of the behavioral changes (Table 2) were noted within a day or two. This indicates that causal factors underlying all these behavior patterns are linked.

TABLE 2. A COMPARISON OF AGONISTIC BEHAVIOR DURING "FALL-WINTER" AND "SPRING" CONDITIONS. 0 = NOT OBSERVED, + = OBSERVED

Agonistic Behavior	"Fall-winter"	"Spring"
Harsh Chips	+	+
Metallic Chips	0	+
Bill Snaps	0	+
Snarls	0	+
Zeeps	0	+
Subsong	0	+
Crown Raising	+	+
Lunges	0	+
Chases, not concerned with food	0	+
Fights	0	+
Gaping	+	+
Mutual Gaping	0	+
Head Raising	0	+

The vocal repertoire increased from one to six vocalizations. A very muted warble was given by two different males. This bore little resemblance to the territorial song of this species and was probably what is termed "subsong" (Thorpe, 1961). Other vocalizations formerly absent were sibilant Zeeps which commonly occurred during flight, Metallic Chips when the birds were alarmed, and Snarls and a snapping of the bill (Bill Snaps) during chases and fights. Agonistic encounters no longer involved simply the defense of individual distance by a perched bird. Now a bird often flew out toward another and gave chase. Chases and fights were common.

There was a marked increase in individual distance (Table 1). Approaches closer than five to six inches were no longer tolerated and sometimes birds approaching as far as eight inches away were attacked. Earlier, Gaping had been the principal display used in

the defense of individual distance and was very effective in causing the intruder to leave. The effectiveness of Gaping as a threat decreased now that the birds were more aggressive (Table 3). Mutual Gaping also occurred in which the bird that had approached, as well as the defending bird, gaped. Then, if neither left, as was usually the case, fights or chases ensued. Mutual Gaping probably indicates that both birds are very aggressive. During Mutual Gaping, one bird often lifted the head higher than the opponent and this was usually the bird that was the more aggressive and won the encounter by causing the other to leave. Sometimes, individual distance was defended by lunges and Bill Snaps at the opponent.

TABLE 3. EFFECT OF GAPING ON THE SUBSEQUENT BEHAVIOR OF THE OPPONENT

Behavior	"Fall-winter"	"Spring"
Opponent remains	0	8
Opponent leaves	7	7

Banding enabled us to determine if there were sexual differences in agonistic behavior. During the "fall-winter" period, no such differences had been noted. We determined which sex initiated encounters by flying at or chasing another bird. The participation of males and females was about the same. However, there were differences in vocalizations. Only males sang. Only females gave Snarls, which occurred during chases and fights, although both sexes gave Bill Snaps in the same contexts.

DOMINANCE

During the first three days, and immediately after the changes in light, there was no indication of a dominance hierarchy. All birds defended individual distance and no one individual seemed to initiate fights or chases more than others. However, by early January, one male had obviously become dominant over all other birds in the cage. He initiated 91% (39 out of 43) of all encounters observed after this time. He attacked males and females with equal frequency and did not seem to attack some individuals more than others. It was easy to identify this male even without looking at his band. His usual posture, contrasted to the other birds, included sleeked feathers and a crouched position. This resembled a flight intention movement, and he often made flying attacks on others, even those perched far away from him.

Despotism such as exercised by this male probably does not occur in the wild. By the time that the birds are very aggressive in the spring, the flocks have probably dispersed. This points to the danger in extending, indiscriminately, conclusions from observations on captive birds to the behavior of the same species in the wild.

MOLT

We did not follow the pre-nuptial molt of the birds in detail, but one note on the sequence seems worthy of mention. The first signs of molting appeared in the crown. This was more marked in males initially, but a week later the females also showed yellow crowns. The face and flank feathers were molted later.

DISCUSSION

The agonistic displays of the Myrtle Warbler are very similar to those of other *Dendroica* which have been studied (Ficken and Ficken, 1962; Ficken and Ficken, 1965). In fact, all the vocalizations have similar sounding counterparts given in similar contexts by other members of the genus. The postures and displays associated with agonistic behavior are similar. Agonistic behavior patterns appear to be evolutionarily conservative in this group and have not diverged in the Myrtle Warbler, despite winter sociability.

The small individual distance of birds under winter conditions is a reflection of a low level of agonistic motivation. Although low levels of aggressiveness after the breeding season are characteristic of many non-social passerines, the very low aggressiveness of the Myrtle Warbler and its small individual distance may be related to flocking. There are, evidently, no special displays facilitating flocking. In fact, there are very few agonistic displays given during the fall and winter, and only later, probably early spring under field conditions, do an increased number of displays appear, concomitant with an increase in individual distance and general aggressiveness.

In the fall and winter, the only conspicuous marking in the Myrtle Warbler is the yellow rump which is present in both sexes and is exposed when in flight. The fact that a rump patch is not found in many other species of warblers, is present in the otherwise dull winter plumage, and is exposed in flight suggests that it aids in the synchronization of the movements of the flock. The crown patch, which was the first conspicuous marking to appear in the pre-nuptial molt, makes the crown more conspicuous during Crown Raising, an agonistic display of both sexes often associated with Gaping. In the winter, the birds show no indications of sexual recognition by differences in responsiveness. Face markings which appear during the spring molt are more prominent in the male and may function in sexual recognition. The flank markings are very conspicuous during the male courtship displays of this species (Townsend, 1920). Thus, the color patterns of this species all seem to be releasers serving somewhat different functions and only one (the rump) seems to be involved in flocking.

The Harsh Chip which occurs through the fall and winter, as well as spring, probably enhances flocking. Field observations indicate that it often is given by a bird just before, during or following a flight. Thus, it could stimulate following by other individuals.

It was been suggested that flocking reduces predation and enhances the utilization of an abundant food source (Crook, 1964). Since the Myrtle Warbler feeds principally on locally abundant

berries (particularly bayberries) during the winter months, flocking in this species would seem to be adapted for the synchronous use of this type of winter food.

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