RESPONSES OF BLUE-WINGED WARBLERS AND GOLDEN-WINGED WARBLERS TO THEIR OWN AND THE OTHER SPECIES' SONG

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BLUE-WINGED Warblers (*Vermivora pinus*) and Golden-winged Warblers (*V. chrysoptera*) are extensively sympatric and hybridize in areas of overlap (Berger, 1958; Short, 1962, 1963). Despite introgression, ethological reproductive isolating mechanisms are operating in this complex (Ficken and Ficken, 1968). Experimental analysis of auditory species discrimination is relevant to an understanding of the reproductive relationships in these since song is probably of some importance in species recognition. Some experiments on auditory species discrimination in Blue-winged Warblers have been conducted by Gill and Lanyon (1964). They found that if Blue-wings were given a choice between Blue-winged primary song and Golden-wing primary song, they responded to their own species' song. We felt that weak responses to the other species song might better be detected by a "no-choice" technique. The purpose of this study was to determine if Blue-wings and Golden-wings would respond to the other species' primary song.

Both species possess a primary and a secondary song. The primary song in both species is given by undisturbed males and predominates early in the nesting cycle, while secondary song is more prevalent after incubation and during and immediately following territorial encounters (Ficken and Ficken, 1966). Thus it is the primary song that is probably important in species recognition. The primary song of the Blue-wing is a short *bee* note followed by a *buzz*, and that of the Golden-wing a *zee* followed by several short *bee* notes. The primary songs of the two species, although distinctive, have some common characteristics (see spectrographs in Ficken and Ficken, 1966). The *bee* notes in the songs of the two species are very similar as are the pitches of the songs and the temporal relationships between notes. The secondary songs are more similar and in both species usually consist of a trill followed by a buzz (Gill and Lanyon, 1964).

METHODS

Studied populations—Experiments were conducted with Golden-winged Warblers on Cheat Mountain (Pocahontas Co.), West Virginia from 19 May to 21 May 1967. Blue-winged Warblers have never been reported breeding in this area, nor have hybrids been reported (Brooks, 1944). An effort was made to test all the singing males that were located on Cheat Mountain.

Blue-winged Warblers were studied in the Catoctin Mountains near Thurmont (Frederick Co.), Maryland on 7 May and 14 and 15 May 1966. Although Golden-wings

are found only 20 miles away (Stewart and Robbins, 1958) this was a Blue-wing population. However, during 1958–1965, some hybrids (both "Lawrence's" and "Brewster's" types) were noted in this colony so at least one interspecific mating had probably taken place. In 1966 only phenotypic Blue-wings occurred, but there is the possibility in view of Short's findings (Short, 1962, 1963), that there was introgression in this population.

Males of both species were tested shortly after arrival on the breeding grounds when most had recently acquired mates but nests were probably not yet completed.

Experimental procedure—The experimental procedure was similar to that used by Milligan (1966). First, an initial baseline, which served as a control, was taken. Then the song of the other species was played, another baseline taken, and finally the conspecific song was played. Baselines and playbacks lasted six minutes each. Songs were played at 10 second intervals, with a total of 36 songs of each species. In addition, in experiments with Golden-wings, one minute after cessation of playback of Golden-wing songs, 10 Blue-wing songs were played in an effort to determine if Golden-wings would respond to Blue-wing songs after they had been stimulated by conspecific song. During baselines and playbacks the number of songs given by males and their type (primary or secondary) was noted, as was the location of the male with respect to the speaker. At the time of playback all males were 50 to 100 feet from the speaker.

The stimulus songs were obtained from the Federation of Ontario Naturalists record of warbler songs. Tapes were played at 7.5 i.p.s. with a Uher 4000 S tape recorder. A Nagra DH amplifier-speaker was used. We tried to keep the volume of playback songs similar to that of a bird singing normally.

RESULTS

There were two separate response measures. The number of playbacks spent closer than 30 feet to the speaker, closer than 10 feet and the number of flights over the speaker were tabulated. The category of number of playbacks closer than 30 feet to the speaker also included playbacks closer than 10 feet to the speaker and flights over the speaker, while the number of playbacks closer than 10 feet also included flights over the speaker. The number of playbacks until the first approach to the playback song was also noted. In addition to approach responses, song changes were also noted.

Responses of Blue-winged Warblers—Nine Blue-winged males were tested and seven spent some time closer than 30 feet to the speaker during playback of Golden-wing songs (Table 1). Seven males also responded to Blue-wing primary songs. In addition to the two Blue-wings that responded only to Golden-wing song, one individual responded more strongly to Golden-wing song than to Blue-wing song. All others spent more time closer than 30 feet to the speaker during playback of their own species' song rather than to Golden-wing songs. Totalling the approaches of all males that approached closer than 30 feet, response was significantly stronger to their own primary song than to that of Golden-wings (Using χ^2 tests, $p < 0.001$ for number of playbacks closer than 30 feet and number of playbacks closer than 10 feet). The number of flights over the speaker was similar during playbacks

TABLE 1
APPROACH RESPONSES OF BLUE-WINGED WARBLERS TO PLAYBACK OF GOLDEN-WING SONGS AND THEIR OWN SONGS

Male No.	Playback of Golden-wing song				Playback of Blue-wing song			
	No. of playbacks to first approach	No. of playbacks closer than 30 feet	No. of playbacks closer than 10 feet	No. of flights over	No. of playbacks to first approach	No. of playbacks closer than 30 feet	No. of playbacks closer than 10 feet	No. of flights over
1	4	1	0	0	22	9	8	0
2	22	4	3	1	2	5	0	0
3	4	6	6	0	–	0	0	0
4	–	0	0	0	4	29	12	3
5	2	16	6	3	10	1	1	1
6	8	6	6	0	–	0	0	0
7	–	0	0	0	5	29	25	2
8	12	9	0	0	3	34	11	0
9	1	9	7	1	24	13	11	0
Total	53	51	28	5	70	120	68	6

of both songs, but was too small to test statistically. There was no significant difference ($p > 0.05$) in the number of playbacks until first approach for the two songs.

All songs given by males during the baselines were primary songs. During Golden-wing playback some secondary songs were noted and these were even more frequent during Blue-wing playback (Table 2). There was no change in the total number of songs during the two playbacks as compared to the initial baseline, although there was a significant decline in song following Golden-wing playback ($p < 0.01$).

Responses of Golden-winged Warblers—Three individuals out of the seven tested showed very weak approaches to Blue-wing song (Table 3). However, the approaches were not nearly so marked as during playback of Golden-wing songs to Blue-wings. All seven individuals tested approached the

TABLE 2
NUMBER AND TYPE OF SONGS GIVEN BY MALE BLUE-WINGED WARBLERS DURING BASELINES AND PLAYBACKS

	No. of primary songs	No. of secondary songs	Total songs
First baseline	159	0	159
Playback Golden-wing songs	141	12	153
Second baseline	95	0	95
Playback Blue-wing songs	120	21	141

TABLE 3
APPROACH RESPONSES OF GOLDEN-WINGED WARBLERS TO PLAYBACK OF BLUE-WINGED SONGS AND THEIR OWN SONGS

	Playback of Blue-wing songs				Playback of Golden-wing songs			
Male No.	No. of playbacks to first approach	No. of playbacks closer than 30 feet	No. of playbacks closer than 10 feet	No. of flights over	No. of playbacks to first approach	No. of playbacks closer than 30 feet	No. of playbacks closer than 10 feet	No. of flights over
1	–	0	0	0	2	35	30	14
2	–	0	0	0	2	35	33	16
3	–	0	0	0	3	33	25	20
4	–	0	0	0	2	32	18	7
5	35	2	0	0	8	29	29	6
6	7	5	1	1	6	29	21	20
7	28	2	0	0	2	35	26	2
Totals	70	9	1	1	25	228	182	85

speaker during Golden-wing song playback. No males approached to 30 feet when Blue-wing song was played again after the conspecific song.

Only primary songs were given during both baselines and the playback of Blue-wing song. During Golden-wing playback most of the songs were secondary songs (Table 4). The total number of songs also increased during Golden-wing playback as compared to the baseline ($p < 0.01$) but not during Blue-wing playback ($p > 0.05$).

Comparison of Blue-wing and Golden-wing responses to conspecific song—Golden-wings responded more strongly to playback of their own conspecific songs than did Blue-wings to conspecific song ($p < 0.001$ for number of playbacks closer than 30 feet, $p < 0.01$ for number of playbacks closer than 10 feet, and $p < 0.001$ for number of flights over the speaker). Golden-wings also responded more quickly to conspecific songs than did Blue-wings ($p < 0.001$ for number of playbacks to first approach). Golden-wings gave significantly more secondary songs during playback of conspecific song than did Blue-wings ($p < 0.001$).

TABLE 4
NUMBER AND TYPE OF SONGS GIVEN BY MALE GOLDEN-WINGED WARBLERS DURING BASELINES AND PLAYBACKS

	No. of primary songs	No. of secondary songs	Total no. of songs
First baseline	95	0	95
Playback Blue-wing songs	97	0	97
Second baseline	101	0	101
Playback Golden-wing songs	21	128	151

DISCUSSION

These experiments give some insight into the basis of interspecific song responsiveness in the Blue-wing population. Since males in the Maryland Blue-wing population had not, at least within the last eight years, been exposed to a singing Golden-wing, it seems probable that their responsiveness was not learned but rather had a genetic basis.

Our findings differed from those of Gill and Lanyon (1964) who found that in a choice situation Blue-wings on Long Island did not respond to Golden-wing playback. There are two possible explanations, and the difference in our findings was probably due to a combination of both. Golden-wing contact with Blue-wings on Long Island occurred to a limited extent in the more distant past than in the Maryland colony (e.g. Short, 1963). Although we have no comparative data from our Maryland population, it is probable that introgression there is more marked than the slight introgression Short (1963) found in a Blue-wing population on Long Island. However, it seems unlikely, in view of the history of the Maryland Blue-wing colony, even assuming complete genetic control of song responsiveness, that such a large proportion of the males would be affected by Golden-wing genes for this particular behavior. So while introgression may be partly responsible for their responsiveness to Golden-wing song, it may not be the whole answer. Another reason why we detected responses of Blue-wings to Golden-wing songs to a more marked extent that Gill and Lanyon (1964) is that the no-choice experiment probably detects weak responses more readily than the choice experiment where the bird responds only to the stronger stimulus.

The fact that males in at least some Blue-wing populations are weakly responsive to Golden-wing song may have a bearing on reproductive relationships within this species complex. If females in the population show similar responsiveness, chances of interbreeding would be increased by responsiveness to the other species' song, especially in areas where conspecifics were scarce.

SUMMARY

Blue-winged Warbler males in a population in Maryland, which probably had some introgression of Golden-wing genes, responded weakly but significantly to playback of Golden-wing primary song in a single stimulus test. Golden-winged Warblers, on the other hand, in a population in West Virginia which had probably never been in contact with Blue-winged Warblers showed almost no responsiveness to Blue-wing primary song playback. Each species responded more strongly to playback of its own song. It is suggested that responsiveness to the other species' song probably has at least in part a genetic basis.

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LITERATURE CITED

BERGER, A. J. 1958. The Golden-winged—Blue-winged Warbler complex in Michigan and the Great Lakes area. Jack-Pine Warbler, 36:37–71.

BROOKS, M. 1944. A check-list of West Virginia birds. West Virginia Univ. Agricultural Experiment Station Bull. No. 316.

FICKEN, M. S. AND R. W. FICKEN. 1966. Singing behaviour of Blue-winged and Golden-winged Warblers and their hybrids. Behaviour, 28:149–181.

FICKEN, M. S. AND R. W. FICKEN. 1968. Reproductive isolating mechanisms in the Blue-winged Warbler-Golden-winged Warbler complex. Evolution, 22:166–179.

GILL, F. B. AND W. E. LANYON. 1964. Experiments on species discrimination in Blue-winged Warblers. Auk, 81:53–64.

MILLIGAN, M. 1966. Vocal responses of White-crowned Sparrows to songs of their own and another species. Anim. Behav., 14:356–361.

SHORT, L. L., JR. 1962. The Blue-winged Warbler and the Golden-winged Warbler in central New York. Kingbird, 12:59–67.

SHORT, L. L., JR. 1963. Hybridization in the wood warblers (*Vermivora pinus* and *V. chrysoptera*). Proc. 13th Internatl. Ornithol. Congr., 147–160.

STEWART, R. E. AND C. S. ROBBINS. 1958. Birds of Maryland and the District of Columbia. N. A. Fauna No. 62. Washington, D.C.

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