as Wilson or Audubon, left an imprint on American ornithology that time is not likely to erase, and it is fitting to pay him honor by observing the bicentennial of his birth.

So far as known to me only one likeness of Vieillot is extant, a bust in the bird division of the Paris Museum. Dr. J. Berlioz, Curator of Birds, has kindly furnished me a photograph of this bust for reproduction herewith. Dr. Paul Leverkühn[1] refers to a portrait of Vieillot that he had in his collection of ornithologists' portraits at Euxinograd Castle, Bulgaria, but this turns out to be another view of the aforementioned bust. The Deane Collection of Ornithologists' Portraits in the Library of Congress now has prints of both views.

Grateful acknowledgment is made to the following for information furnished in connection with this summary: Dr. J. Berlioz, Curator of Birds in the Muséum d'Histoire Naturelle, Paris; the Librarian of the Paris Museum; the Librarian of the Blacker Library of Zoology, McGill University, Montreal; Capt. Jean Delacour, of the American Museum of Natural History; Dr. Herbert Friedmann, of the United States National Museum; and Dr. T. S. Palmer. John P. Harrington, Bureau of American Ethnology, has helped me with the translations.

Smithsonian Institution
Washington, D. C.

PASSERINE BIRD POPULATIONS OF THE SAVANNAH RIVER REFUGE, SOUTH CAROLINA[2]

BY ARNOLD B. ERICKSON

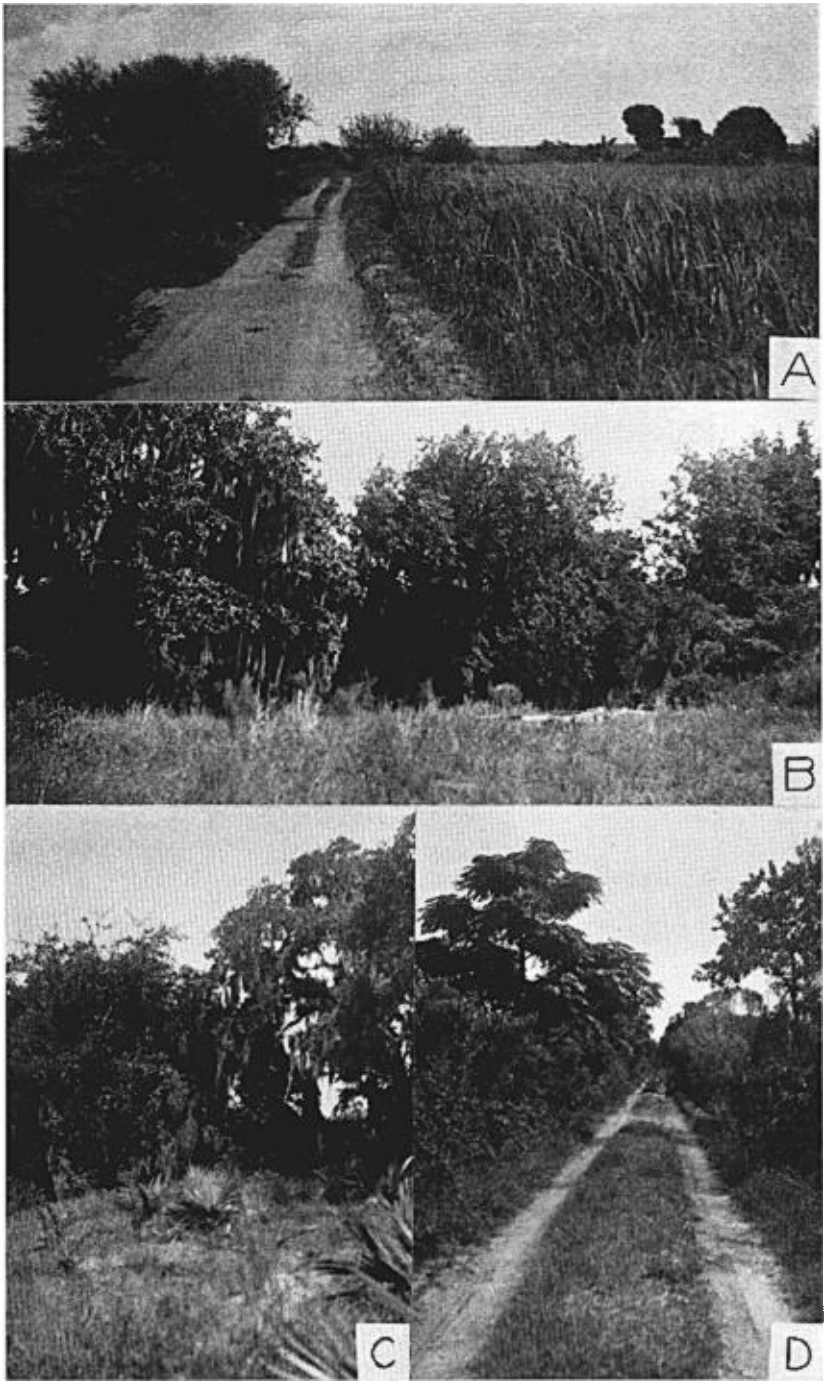
Plate 17

INTRODUCTION

A STUDY of breeding bird populations on the Savannah River Refuge, South Carolina, was conducted from March 26 to August 8, 1946, as part of an extensive investigation on the effects of weekly airplane applications of DDT on wildlife. The U. S. Public Health Service and the U. S. Fish and Wildlife Service coöperated in the investigation. The negative effects of the sprayings on birds have been reported elsewhere (Erickson, 1947). The present paper is concerned with

[1] 'Ornithologists, past and present.' Papers Presented to the World's Congress on Ornithology, pp. 199–208. Chicago, 1896.

[2] From the Communicable Disease Center, Technical Development Division (Savannah, Georgia), in Coöperation with the U. S. Fish and Wildlife Service.



SAVANNAH RIVER REFUGE, SOUTH CAROLINA. (Legend on opposite page.)

bird populations as determined by weekly censuses of singing males and weekly counts of birds on certain islands and dykes of the refuge.

The Savannah River Refuge consists of 1200 acres of marsh lying along the Savannah River about 17 miles from the sea. Before the Civil War and for 20 years thereafter, much of the area was planted to rice (*Oryza sativa*), and some rice is still grown there.

Population studies of breeding birds were confined to a group of small islands and dykes (upland area) near the refuge headquarters and to sections of marsh (lowland area) which paralleled the dykes and extended out 100 feet from them. The 100-foot limit was chosen since birds singing beyond this point might not be heard.

VEGETATION

The dominant plants of the lowland areas, the earliest stage in succession, are cut grass (*Zizaniopsis miliacea*), maiden cane (*Panicum hemitomon*), pickerel weed (*Pontederia lanceolata*), lotus (*Nelumbo lutea*), water lily (*Nymphaea odorata*), jussiaea (*Jussiaea leptocarpa*), and alligator-grass (*Alternanthera philoxeroides*).

The upland areas of the refuge are of two types—hammocks or small islands, the highest stage of succession, and the man-made dykes connecting them. The dominant trees of the islands include live oak (*Quercus virginiana*), water oak (*Quercus nigra*), sweet gum (*Liquidambar Styraciflus*), pignut hickory (*Hicoria glabra*), hackberry (*Celtis laevigata*), and loblolly pine (*Pinus taeda*). Dominant trees of the dykes are Chinaberry (*Melia Azedarach*), Chinese tallow tree (*Sapium sebiferum*), and black willow (*Salix nigra*). Dominant shrubs of the islands and dykes include dwarf palmetto (*Sabal minor*), bayberry (*Myrica cerifera*), alder (*Alnus rugosa*), blackberry (*Rubus* sp.), winged sumac (*Rhus copallina*), yaupon (*Ilex vomatoria*), pepper vine (*Ampelopsis arborea*), St. Andrew's cross (*Ascyrum hypericoides*), French mulberry (*Callicarpa americana*), button bush (*Cephalanthus occidentalis*), elder (*Sambucus canadensis*), and silverling (*Baccharis halimifolia*). Dominant herbaceous plants include small cane (*Arundinaria tecta*), spiderwort (*Tradescantia pilosa*), Spanish moss (*Tillandsia usneoides*), inkberry (*Phytolacca americana*), partridge pea (*Chamaecrista* spp.), periwinkle (*Vinca major*), May-pop (*Passiflora incarnata*), dog fennel (*Eupatorium capillifolium*) and lettuce (*Lactuca* spp.).

The islands, dykes, and the 100-foot-wide marsh strips formed three ecological types. The islands (live oak forest) with their mature trees (Plate 17) and understory of vines and shrubs are at present the climax stage. The marsh (cut grass, pickerel weed, jussiaea marsh) with its various aquatic plants (Plate 17) is a widespread early seral

stage. The dykes (raspberry, silverling, tallow tree shrubs), which are artificial structures (Plate 17), may be regarded as an intermediate stage with shrubs the dominant form plus a few introduced trees like Chinaberry.

STUDY METHODS

In February, before the nesting season began, the islands near the refuge headquarters were mapped, and numbered stakes were set out in rows 100 feet apart, with 100 feet between the stakes in each row. One row of numbered stakes was also placed on each dyke with 100-foot intervals between the stakes. One hundred feet of marsh on each side of the dyke were included in the dyke census areas. The stakes on both islands and dykes were used as location markers for the census of singing males and for live trapping mammals.

A bird census of one study area was conducted each Wednesday morning from March 25 to August 8, between 6 and 10 o'clock. On Thursday mornings the second area was censused. Fresh maps of each individual island and dyke were used for each census. Census routes followed the line of numbered stakes on the islands and dykes. The location of singing males was easily determined by referring to the stakes, and the positions of the birds were then readily plotted on the maps. The weekly observations of individual singing males were consolidated at monthly intervals on maps, one for each species. At the end of the season these maps were used to determine the number of pairs of breeding birds on the study areas.

A count of the total number of birds seen or heard or both (not singing) was made on each weekly census trip. These counts were used as a check against the number of singing males in determining the number of pairs of birds on the area. In this way, too, it was possible to determine the number of pairs of certain non-singing birds. The singing-male census cannot be used alone to determine total populations.

BIRD POPULATIONS

On 35 acres of census islands there were 215 pairs of breeding birds as determined by census of singing males and sight records. Calculated on the basis of 100 acres (40 hectares) there would be 614 pairs of breeding birds on the islands. On the 47.48 acres of dyke and marsh, which areas were studied as a unit, there were 177 pairs of breeding birds. On the basis of 100 acres there would be 373 pairs of breeding birds on the dykes and marsh. Considering the study area as a whole, there were 392 pairs of breeding birds on 82.48 acres.

On the basis of 100 acres there would be 463 pairs of birds. This information is summarized in Table 1.

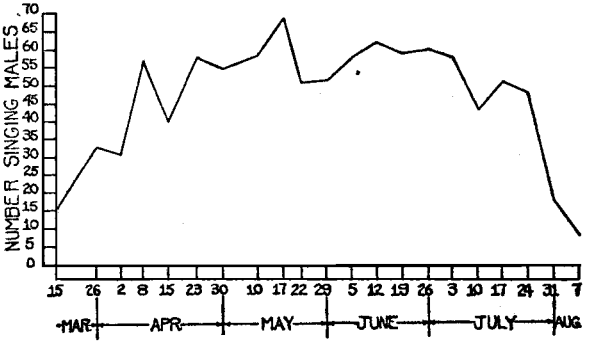
TABLE 1

NUMBER OF PAIRS OF BREEDING BIRDS ON 35 ACRES OF ISLANDS AND 47.48 ACRES OF DYKES AND MARSH ON THE SAVANNAH RIVER REFUGE, SOUTH CAROLINA

Species	*Islands*	*Basis of 100 Acres*	*Dykes and Marsh*	*Basis of 100 Acres*
Red-wing	31	88.5	57	120
Yellow-throat	21	60.0	29	61
Long-billed Marsh Wren	7	20.0	22	46
Purple Grackle	23	65.7	5	10.5
Mourning Dove	14	40.0	7	14.7
Brown Thrasher	9	25.7	7	14.7
Orchard Oriole	10	28.5	6	12.6
Kingbird	8	22.8	7	14.7
Cardinal	10	28.5	5	10.5
Carolina Wren	9	25.7	5	10.5
Mockingbird	9	25.7	3	6.3
Yellow-billed Cuckoo	9	25.7	3	6.3
Crested Flycatcher	8	22.8	1	2.1
Blue Jay	7	20.0	0	0.0
Catbird	3	8.5	3	6.3
White-eyed Vireo	3	8.5	3	6.3
Flicker	4	11.4	2	4.2
King Rail	0	0.0	6	12.6
Parula Warbler	5	14.0	0	0.0
Yellow-breasted Chat	3	8.5	2	4.2
Painted Bunting	5	14.0	0	0.0
Carolina Chickadee	2	5.7	2	4.2
Red-bellied Woodpecker	3	8.5	0	0.0
Downy Woodpecker	3	8.5	0	0.0
Yellow-throated Warbler	2	5.7	0	0.0
Blue-gray Gnatcatcher	0	0.0	2	4.2
Starling	2	5.7	0	0.0
Barred Owl	1	2.8	0	0.0
Chuck-will's-widow	1	2.8	0	0.0
Loggerhead Shrike	1	2.8	0	0.0
Red-eyed Vireo	1	2.8	0	0.0
Summer Tanager	1	2.8	0	0.0
Total	215	612.6	177	371.9

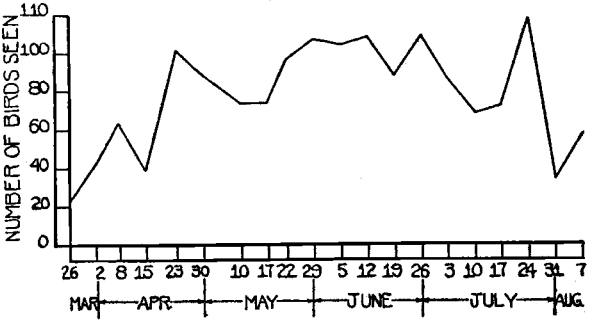
The large population of 392 pairs of birds, mostly passerines, on 82.48 acres resulted from the variety of habitat. The marsh area contributed heavily to the population with its many pairs of Long-billed Marsh Wrens, Yellow-throats, and Red-wings. The population on the highest developmental stage, the islands with mature deciduous

trees, was also large—215 pairs on 35 acres or 614 pairs per 100 acres. Bird populations in beech-maple forests in various northern states are usually much smaller (Kendeigh, 1944).



TEXT-FIGURE 1.—Showing by weeks the number of singing males heard on 56.3 acres of islands, dykes, and marsh of the Savannah River Refuge, South Carolina.

The number of singing males, 20 species, heard from March 15 to August 7, on the 56.3 acres of islands, dykes and marsh in the area near the Refuge headquarters is shown by weeks in Text-figure 1. Singing males increased from a low point at the beginning of the nesting season, fluctuated mildly during the season, and then dropped off at the end of the season.



TEXT-FIGURE 2.—Showing by weeks the number of mature birds seen or heard calling or both on 56.3 acres of islands, dykes, and marsh of the Savannah River Refuge, South Carolina.

The number of birds, 14 species, seen or heard calling or both (not singing) on the weekly census of the headquarters area (56.3) acres

from March 26 to August 7, is given in Text-figure 2. Populations increased rapidly from the low of March 26, to a peak between April 23–30, the height of the migration, and then fell to a lower level by May 1. A new wave of migration brought the population up again after May 17. For the remainder of the breeding season the population fluctuated mildly, and then spurted up near the end of the season when some immature birds were probably counted with adults.

TERRITORY AND SONG

Catbirds, Brown Thrashers, Cardinals, and Towhees fill the air with their early morning territorial singing in the basswood-maple forests of Minnesota. At the Savannah Refuge and elsewhere in the South Carolina and Georgia Southeastern Coastal Plains Area, I missed the fervent outpouring of early morning song. There was singing by the species mentioned but never with the strength, challenge, and volume that I have heard in the singing of these species in Minnesota and Wisconsin. I am not trying to say that southern birds in the Southeastern Coastal Plains Area are more leisurely in their ways of life, but to me they did not sing with the same zest and abandon of birds of the basswood-maple forests of Minnesota.

What conditions or factors might cause these differences in quantity and quality of song? One important factor, it seems to me, is that certain sedentary species in the Southeastern Coastal Plain do not have to protect their territories by song and chase as valiantly as do these same species in the basswood-maple forests of the North. In the Southeastern Coastal Plain these sedentary species occupy much the same territories summer and winter despite occasional shifting about. At the beginning of the reproductive season they know pretty well where they fit in. The boundaries of their territories are already more or less established, and there is not the contest for space that results with the influx of a host of migrating birds such as come with the northern spring.

Nice (1941) cites several authors who emphasize that some sedentary birds maintain territories throughout the fall and winter. Also she quotes from Skutch (1940) who believes that Central American birds which "have the entire year in which to adjust conflicting territorial claims, to settle amorous disputes . . . may gradually come to an understanding without violence."

Some summer residents of the Savannah River Refuge, like the Red-eyed Vireo, Yellow-throated Warbler, Parula Warbler, and the Long-billed Marsh Wren, which migrate greater or lesser distances in the fall, sang much more consistently and provocatively on their territories

than the sedentary species. They sang as though they had territories that were in danger of invasion.

The long nesting season at Savannah—from February to August—is another condition influencing quantity and quality of song. Some species are through nesting or engaged in non-singing phases when others are just beginning to sing. In the deciduous forests of the North most species are competing and singing at the same time. Thus the volume of song uttered during any part of the long nesting season in the Southeastern Coastal Plains would be less than the volume of song poured forth during the relatively short nesting season in northern deciduous or coniferous forests.

Temperature is another factor that influences song. Dr. Eugene P. Odum tells me that in the deciduous forest region at Athens, Georgia, the morning chorus is definitely shorter than farther north in cooler temperatures, and that by June there is very little singing after 9 A. M. at Athens, and even by 6 A. M. many birds have stopped singing. One has to be on an area at dawn to get the full morning chorus.

At the Savannah River Refuge and on the outskirts of the city of Savannah I never heard what I considered a full morning chorus, despite the fact that the temperature was decidedly cool on many early mornings in April and May. A comparison of the quantity of song at 4 A. M. and 6 A. M. at the Refuge convinced me that it was preferable to start the census of singing males at six rather than at four because the volume of song was greater at the later hour.

The difference in species composition of the Southeastern Coastal Plain and a northern basswood-maple forest might also influence the quantity and quality of song. Warblers, vireos, sparrows, and thrushes of several to many species are persistent singers in northern hardwood forests. At the Savannah Refuge only four species of warblers, two vireos, three sparrows, and no thrushes were recorded. The warblers, vireos, and one of the sparrows are summer residents at the Refuge, and like other migratory species they did considerable singing.

Another factor that might influence quantity and quality of song is

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Plate 17

SAVANNAH RIVER REFUGE.—A. Dyke-marsh census area. Marsh is dominated by cut grass (*Zizaniopsis miliacea*), a favorite habitat of Long-billed Marsh Wren and Yellow-throat. B. Island with mature Live Oak and Water Oak. Yellow-throated and Parula Warblers nested in the Spanish Moss. C. Island with mature Live Oak, Pignut Hickory, and an understory of Dwarf Palmetto. Brown Thrashers and Towhees were common. D. Dyke with Chinaberry Trees, Chinese Tallow Tree, Silverling and other shrubs. Red-wings, Yellow-throats, Brown Thrashers, and Long-billed Marsh Wrens nested along the dyke and adjacent marsh.

type of habitat. A large marsh area open to the sun and harboring many non-singing species of birds cannot be compared with suburban areas of lawns where the morning chorus is at its best. Much of the census area at Savannah, it is true, was marsh or adjacent to marsh, but almost half of it was grassy brush islands shaded by large trees and not unlike certain suburban areas.

In conclusion, it is certain that the amount and intensity of song do differ in different geographical and ecological communities, and that more attention needs to be given to study of these differences. The amount of song has an important bearing on technic of census work. In the Southeastern Coastal Plain, for example, one cannot make an accurate determination of breeding birds in many habitats by simply walking through the area and listening, as can be done in a warbler-filled northern coniferous forest. Individual birds and pairs must be observed as well as heard to obtain a complete count.

SPARE NESTERS

A few species like the Red-eyed Vireo, Blue-gray Gnatcatcher, and the Summer Tanager nested very sparingly on the Refuge. They were commonly present in the early spring, scarce during the nesting season, and then fairly common again early in August. Apparently many birds of these species had nested abundantly just a few miles farther back from the coast and appeared suddenly in August as did the Indigo Bunting which did not nest on the area.

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to Dr. Eugene P. Odum, University of Georgia, for a critical reading of the manuscript and for comprehensive suggestions and criticisms on the section "Territory and Song."

SUMMARY

1. A study of breeding bird populations on the Savannah River Refuge, South Carolina, was made from March 26 to August 8, 1946.

2. The islands, dykes, and marsh of the Refuge form three ecological units: live oak forest on the islands; raspberry, silverling, tallow tree shrubs on the dykes; and cut grass, pickerel weed, jussiaea marsh.

3. On 35 acres of census islands there were 215 pairs of breeding birds as determined by census of singing males and sight records.

4. On 47.48 acres of dyke and marsh there were 177 pairs of breeding birds. Bird species of the islands, dykes, and marsh are listed in Table 1.

5. Birds of the Refuge and birds observed elsewhere in the Southeastern Coastal Plain of South Carolina and Georgia did not seem to sing with the same zest and abandon as birds of the basswood-maple forests of Minnesota.

6. It is certain that the amount and intensity of song differ in different geographical and ecological communities. Some of the factors discussed that might influence song in different communities were: more non-migratory species; probably less defense of territory; the long nesting season at Savannah spreads the volume of song over a longer period than in the north; temperature influences the amount and volume of song; the difference in bird species composition of areas is important; type of habitat affects song.

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THE BIRD NAVIGATION CONTROVERSY

BY HOWARD T. ODUM

SINCE the comprehensive review by Griffin in 1944, new experimental work has brought new interest, new apparent contradictions, and has removed the study of bird navigation from the realm of speculative thought. It is especially stimulating that this progress has been a coöperative endeavor of many of the older disciplines meeting in this field of geophysical ornithology. At this time there is a controversy that may be stated as follows: Is the superior navigation of birds possible because of their possible ability to orient to a Coriolis, magnetic, or other geophysical field of force in addition to keen powers of visual reference? Or do visual reference and sense of direction alone