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THE PROTHONOTARY WARBLER, A COMPARISON OF NESTING CONDITIONS IN TENNESSEE AND MICHIGAN

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REELFOOT LAKE, a great resort for the hunter and fisherman, its shores dotted with camps and cabins, is located in the extreme northwest corner of Tennessee. Here extensive bottomland borders, heavily shaded park areas, numerous old buildings near the water's edge, and even protruding stubs from the lake itself, offer suitable nesting habitat for the Prothonotary Warbler (*Protonotaria citrea*). Here, in contrast to areas farther north, the species is abundant and mosquitos during day time are almost absent, an excellent area for ornithological investigation. The canal at Spillway, immediately south of the lake, offers the most comparable area to the one where I have studied the species in Michigan. Whereas, the Battle Creek River winds through a wooded bottomland and has areas of both shallow



Figure 1. The Spillway, Reelfoot Lake, Tennessee. April 9, 1939. At high water stage.

and deep water, this Tennessee canal, straight in course, is deeper, but also has shaded banks, one side especially having a bottomland region similar to the northern area. The widths of both streams are about the same. After studying the Prothonotary Warbler for two summers, 1937-38, along the Battle Creek River in Calhoun County, Michigan (studies published in 1938 and 1939) where conditions proved extremely adverse to the nesting of the species, I selected this Reelfoot Lake area for a comparative study.

On April 9, 1939, when Wayne Tice and I arrived at the lake, the Prothonotary Warblers were already present and some were even nesting. We erected thirty bird houses along the canal, all placed on bordering trees three or four feet above the water, excepting one placed on a tree in a park-like area of a local camp. With the aid of a young man, Carlos Woods, of Spillway, news of the happenings during the next few weeks in these bird houses was forwarded to me in Michigan with the result that the next visit was timed during the latter part of May and a third visit during the latter half of June. During the rest of the time many early morning hours and week-ends were spent during May and June visiting the region in southern Michigan where 36 bird houses had been placed along the river near Battle Creek.

During 1940, I visited the area at Reelfoot Lake for only a short period (April 24 to 26, and July 7 to 9). The usual hours were spent studying the area in Michigan.

The canal south of Spillway, Tennessee, normally about 75 feet wide, but wider with the high water conditions of early 1939 and 1940, forms the boundary between Lake and Obion counties. The trees on the area west of this canal had been somewhat cut over so that the east or Obion County bank offered the most shade. In 16 houses in Obion County in 1939 were found 16 nests of the Prothonotary Warbler, while 7 nests were located in the wooded bottomland regions along the lake shore. In Lake County only 8 nests were found in the remaining 14 houses, but 10 additional nests were under observation at one time or another. On April 25, 1940 seven male Prothonotary Warblers were found building nests in the bird houses along the canal. Many of these houses were at least two-thirds full of moss and cypress needles, yet there was no sign of a female bird about except in 3 cases where the nests were nearly complete. The spring of 1940 was very cold, even as far south as the Gulf states, consequently nesting started much later. Since I was unable to visit the area during May and June, the main portion of the nesting season was missed during 1940 in Tennessee, but when Bernard Baker and I visited the area in July we found that nearly every bird house had been occupied and that 6 still contained nests with eggs or young. In addition to these, 8 other nests were found. Only 5 of these nests (2 in bird houses) were located in Lake County, the remainder were located in Obion County.

In Michigan during 1939, 19 nests were found, only 8 of which were in bird houses. During 1940, 29 nests were located, of which 18 were in bird houses. During the warbler nesting season only 6 houses were occupied by House Wrens as compared with 18 during 1939.

Whereas only three birds were observed at Spillway, Tennessee on April 9, 1939, an average of 42 birds (26 to 53) per day were observed during the six-day period May 15 to 20, 1939 when an average of 12 hours per day were spent in the field. During late June, 1939 the number observed per day still ranged about 40 birds. At Walnut Log on the northeast corner of the lake 18 birds were observed along the Bayou du Chien on May 17, 1939 during a short visit to that area. Eleven male Prothonotary Warblers were observed during one hour on April 24, 1940, 31 birds during 14 hours on April 25 and about 50 adults on July 8, 1940 as well as an estimated 25 full-grown young. During the summers of 1939-40, 139 hours were spent in the field at Reelfoot Lake, during which time 529 adult birds were observed, an average of 3.8 birds per hour. At Battle Creek, Michigan during the summers of 1937 through 1940, 679 hours were spent in the field during which time, 2262 adult birds were observed, an average of 3.33 birds per hour. These observations are summarized in the following table:

TABLE 1
MICHIGAN

Year	Hours in field	Number of adult birds observed	Average number of birds per hour
1937	204	820	4.02
1938	241	717	2.97
1939	110	358	3.25
1940	124	367	2.96
Total	679	2,262	3.33
TENNESSEE			
1939	92	341	3.7
1940	47	188	4.0
Total	139	529	3.8

NESTING

During 1939, the first nest at Reelfoot Lake was shown to me by R. W. Morris on April 9, where it had just been accidentally tipped out of an overturned motor-boat. It contained three eggs, the first of which must have been laid by April 5 or 6. The first young left a neighboring porch on May 11, giving the approximate date of the first laid egg as April 17 in that nest. The known dates of first laid eggs in nests

in that region during 1939 were as follows: April 30, May 1, 1, 1, 5, 6, 7, 13, 14, 16, 16, June 3, 11 and 23. Although I did not visit the Tennessee area during July and August, 1939, Carlos Woods stated there was a nest in bird house No. 30 in the Morris yard from which the young left about August 10. He captured the female parent, a banded bird that had previously raised a brood in nest box No. 1, some 150 yards away. The first egg in this nest must have been laid about July 15. In 1940 no nests were found with eggs even as late as April 26, yet several nests were ready for eggs when we left the area on that date. On July 9, 1940, when we left the area for the last time, three nests still contained eggs. The young in those nests would have left between July 21 and August 1.



Figure 2. Prothonotary Warbler at the nest hole. Reelfoot Lake. July 8, 1940.

In Michigan during 1939 the first laid eggs were as follows: May 18, 21, 22, 24, 24, 27, 31, 31, June 6, 7, 8, 11, 15, 15 and 27. The last nest was terminated July 6. During 1940 the first eggs of sets were laid May 22, 25, 26, 27, 29, June 2, 6, 7, 8, 10, 12, 13, 15, 18, 23, July 1 and 5. The last nest was terminated on July 14.

Usually Prothonotary Warblers were much more leisurely with their nesting operations at Reelfoot Lake than in Michigan. First nests in both Michigan and Tennessee required longer than second or third

nests in both time of construction and rest following construction before the first egg was laid. These averages were as follows:

TABLE 2
MICHIGAN

Year	Number of nests	Average time required for nest construction	Average period of rest before laying of first egg
1937	19	3.68 days (1-11)	3.2 days (1-5)
1938	16	2.13 " (1-7)	1.69 " (1-5)
1939	10	4.2 " (1-6)	1.4 " (1-4)
1940	9	3.3 " (1-12)	1.1 " (1-2)
Average		3.26 "	2.07 "

TENNESSEE			
1939	8	8.8 days (6-12)	8.0 days (2-17)

Comparison of the breeding season at Reelfoot Lake, Tennessee with that at Battle Creek, Michigan is presented below:

TABLE 3

Year	Date first nest was started	Date of first egg	Date of termination of last nest	Date when young would have left last nest	No. of days between first egg and termination of last nest	No. of days between beginning of first nest and date when young would have left last nest
MICHIGAN						
1937	May 15	May 22	July 14	July 23	53	69
1938	May 4	May 8	July 7	July 23	60	80
1939	May 13	May 18	July 6	July 21	49	69
1940	May 18	May 22	July 14	July 29	53	73
Average	May 12	May 17	July 10	July 24	53	73
TENNESSEE						
1939	April 4 (est.)	April 6	August 10	August 10	126	128
1940	April 22 (est.)	May 1 (est.)	July 30 (est.)	August 1 (est.)	91	101
Average	April 13	April 18	August 4	August 5	108	114

Probably few birds in either Michigan or Tennessee nest during the entire breeding season. In fact no bird was found attempting two nestings after they had had one success. No birds have ever been found successful with two nestings in Michigan although one was found and in all probability more in Tennessee. No birds were found laying more than 9 eggs in Tennessee nor have any in Michigan been found laying more than 13 in one season. In the following table are the records for the average breeding seasons in Michigan for different females followed through the entire breeding season, from the time of beginning nest building in the first nest until the last nest had terminated: (Averages given, extremes in parenthesis).

TABLE 4
MICHIGAN

Year	Number of females	Nests attempted	Number of eggs laid	Number young produced	Number of days nesting
1937	6	2 (2-3)	8 (7-10)	1 (0-6)	39 (30-51)
1938	6	3 (2-5)	11 (9-13)	3 (0-5)	48 (38-57)
1939	1	2	9	3	52
1940	3	2.6 (2-4)	9 (7-11)	2.6 (0-5)	42 (39-47)
Average		2.5	9.3	2.1	43.7

Female No. 37-103940, a return from 1937, was followed during two nestings during 1939 in Michigan, over a period of 52 days, from May 14 until July 6. She raised three young in her first brood then attempted a second nest which failed. She happened to be the first bird captured during 1940, nesting about a quarter of a mile from her 1939 site and about a half mile from where she was originally banded in 1937. This nest was destroyed, evidently by House Wrens, on June 2 and I did not find another nest belonging to her. It was interesting that the same day, only a few hundred yards downstream, I captured No. 39-54051, her daughter raised the year before. No. 39-54051 during 1940, her first year as a breeder, attempted four nests, laid 11 eggs and failed to produce any young. Her nesting sites were not very well chosen at times, although one was where a brood of young had been raised by a different female during 1939.

In Tennessee the following four females were followed through most of the breeding season of 1939:

TABLE 5
TENNESSEE

Female	Nests attempted	No. of eggs laid	No. of young produced	Nesting season	Number of days
39-54103	2	9	5 #	April 18- June 24 #	67 K 83 est.
39-54104	2	9	5 #	April 18- June 24 #	67 K 83 est.
39-54105	2	9	5 #	April 18- June 24 #	67 K 83 est.
39-54147	2	9	7	May 27- Aug. 10	*75 K
Average	2	9	7	April 28- July 6 appr.	81 est.

#Outcome of last nest unknown, but it contained eggs on June 24.

Estimated young would have left these nests about July 10.

K—known.

est.—estimated.

*This female probably had an earlier nesting which was unobserved.

The nesting seasons for the above Tennessee birds were from the time of beginning nest building in the first nest until the last date the bird was noted nesting.

Eggs were deposited during the very early hours of daylight, usually between 5 and 7 A.M. (Eastern Standard Time) in Michigan and between 6 and 8 A.M. (C.S.T.) in Tennessee. Incubation started invariably the night prior to the laying of the last egg. The markings on the Tennessee eggs appeared thicker and darker than those on eggs in Michigan. Weights and measurements of eggs when fresh are listed below:

TABLE 6
MICHIGAN

Year	Number of eggs	Length in mm.	Width in mm.	Weight in grams
1937	78	18.47	14.55	2.07
1938	40	18.68	14.8	2.11
1939	31	18.33	14.88	2.07
1940	47	18.68	14.75	2.12
Average		18.53	14.70	2.09

TENNESSEE				
Year	Number of eggs	Length in mm.	Width in mm.	Weight in grams
1939	88	17.87	14.25	1.94
1940	10	17.94	14.78	1.95
Average		17.88	14.29	1.94

The average number of eggs per set during the different years have been as follows:

TABLE 7
MICHIGAN

Year	Number of sets	Average number of eggs per set	Average weight of set in grams
1937	16	5.06	10.4742
1938	18	4.94	10.4234
1939	13	5.07	10.4949
1940	15	4.93	10.4516
Average		4.98	10.4590

TENNESSEE			
1939	32	4.65	9.0210
1940	12	*4.18	8.1510
Average		4.53	8.7976

*These were all late nests.

At Battle Creek, Michigan over a four-year period the following averages of egg sets were recorded:

TABLE 8
MICHIGAN

Year	May 1-15		May 16-31		June 1-15		June 16-30		July 1-15 1 set
	No. sets	Average no. of eggs	No. sets	Average no. of eggs	No. sets	Average no. of eggs	No. sets	Average no. of eggs	
1937			7	5.85	5	5.0	4	4.0	
1938	6	5.33	5	5.0	6	4.66	1	4.0	
1939			7	5.14	5	5.2	1	4.0	
1940			5	5.4	5	5.6	4	4.0	3.0
Average	6	5.33	24	5.37	21	5.09	10	4.0	3.0

In the following table are listed the sizes of sets of eggs in Tennessee in each period of time given:

TABLE 9
TENNESSEE

Eggs per set	1939						*1940	
	April 15-30	May 1-15	May 16-31	June 1-15	June 16-30	July 1-15	June 1-15	June 16-30
3			1				1	
4				2	5	1	3	6
5	1	13	5	3	1		1	
6								1
Average	5.0	5.0	4.66	4.6	4.16	4.0	4.0	4.28

*These dates were estimated from conditions in nests found July 7 to 9.

In the following table are listed the per cent of different size egg sets in both Michigan and Tennessee:

TABLE 10

MICHIGAN

TENNESSEE

	1937		1938		1939		1940		1939		1940	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
3 eggs	1	6.25					2	13.33	1	3.12	1	8.33
4 eggs	3	18.75	5	27.77	3	23.07	2	13.33	8	25.00	9	75.00
5 eggs	5	31.25	9	50.00	6	46.14	6	40.00	23	71.87	1	8.33
6 eggs	7	43.75	4	22.22	4	30.76	5	33.33			1	8.33

The incubation periods in Tennessee and Michigan were very similar. Nineteen eggs with a known incubation period at Reelfoot Lake, Tennessee averaged 12 days and 10 hours, varying from 12 to 13½ days during 1939. In Michigan during 1937, 1938, 1939, and 1940, the incubation period obtained on 64 eggs averaged 12 days and 17 hours (12 to 14 days). Fourteen young at Reelfoot Lake averaged 11 days of age when leaving the nest in 1939, while 21 young in Michigan during 1939 and 1940 remained in the nest for a period of 10¾ days.

In Tennessee after the young had left a nest, the period between that date and the first laid egg in the next nest for four females during 1939 was 14, 15, 18 and 21 days, averaging 17. In Michigan for three females for the same year, the periods were 4, 4, and 8 days, averaging 5.3 days.

At Reelfoot Lake during 1939, eighteen young averaged in weight at hatching time 1.88 grams; while during 1937 and 1938 in Michigan 26 young also averaged 1.88 grams.

SURVIVAL OF THE YOUNG

For more than any other reason I made the trips to Reelfoot Lake during 1939 to discover whether the Prothonotary Warbler had any better success in its nesting than it did in Michigan. Although I have studied many species of birds, keeping records of a large number of nests, I have found no species to have as low a survival ratio of young produced from eggs laid as the Prothonotary Warbler in Michigan. Many a day I have visited nests in Michigan finding as high as four out of ten destroyed. In Tennessee during a period of one week in late May 1939, 22 nests were under observation, of which two were deserted because of human interference and only one was destroyed. Following are the figures of nests and eggs in Michigan and Tennessee:

TABLE 11

Year	Nests	Number successful	Per cent	No. eggs	No. eggs hatched	Per cent	No. young left	Per cent
MICHIGAN								
1930-6	6	3	50.00%	25	17	68.0%	17	68.0%
1937	27	2	7.42%	98	24	24.47%	9	9.18%
1938	40	7	17.50%	106	35	33.01%	21	19.81%
1939	19	7	36.84%	78	31	39.74%	19	24.36%
1940	29	9	31.03%	106	52	49.05%	40	37.73%
Mich. total	121	28	23.14%	413	159	38.47%	106	25.66%
TENNESSEE								
1939	30	19	63.33%	139	78	56.11%	78	56.11%
1940	6	6	100.00%	24	22	91.66%	22	91.66%
Tenn. total	36	25	69.44%	163	100	61.35%	100	61.35%
MICHIGAN AND TENNESSEE								
Total	157	53	33.75%	576	259	44.98%	206	35.76%

In Tennessee 25 nests out of 36 were successful, while 28 were successful out of 121 in Michigan. Yet out of the 28 nests in Michigan, only 106 young were produced, an average of 3.7 per nest; while in Tennessee 25 nests produced 100 young, an average of 4.0 birds. One must also consider that egg sets in Michigan during the shorter breeding season averaged larger too. A number of eggs disappeared from Michigan nests during the period of incubation so that there were fewer eggs at hatching time than at the completion of laying. This was probably the work of the House Wren (*Troglodytes aedon*). Nothing like it happened in Tennessee where the House Wren does not nest.

The following table shows comparable figures for the different years, of nests and eggs in Michigan and Tennessee, showing both complete and partial success:

TABLE 12

	1930-36		1937		1938		1939		1940		1939		1940	
	Nests	Eggs	Nests	Eggs	Nests	Eggs	Nests	Eggs	Nests	Eggs	Nests	Eggs	Nests	Eggs
	MICHIGAN										TENNESSEE			
Completely successful	3	17	1	6	3	14	1	4	5	26	11	54	5	20
Partially successful	0	0	1	3	4	7	6	15	4	14	8	24	1	2
Total successful	3	17	2	9	7	21	7	19	9	40	19	78	6	22
Unsuccessful	3	8	25	89	33	85	12	59	20	66	11	61	0	2
Total	6	25	27	98	40	106	19	78	29	106	30	139	6	24

All nests, whether they had had eggs laid in them or not were considered as either successes or failures according to their outcome. Three nests during 1937, eight during 1938, and two during 1940 were completed but no eggs were ever laid in them in Michigan. During 1939, in Tennessee one nest was completed but for some reason no eggs were laid.

Following are tables of the loss of both eggs and young in both Michigan and Tennessee nests, classified as nearly as possible according to the destructive agencies:

TABLE 13
MICHIGAN

Year	Accident to eggs by man	Cow-bird	De-serted	Female killed	Flooded	House Wren	In-fertile	Predatory				
								bird	mam-mal	un-known		
Hatched young which never left the nest												
1937					3	7			5		7	
1938						4						
1939	1							6	10			
1940								5	5		1	
Total	1				3	11		6	20		8	Total-49
Eggs that never hatched												
1930-6			3			2?		3				
1937			6		24	16	6		12		9	
1938		1?	6		5	33	3	4	16		6	
1939			2			14	17		10		5	
1940			7			25	8	3	5		6	
Total	1	1?	24		29	90	34	10	43		26	Total-258

TENNESSEE

Eggs that never hatched												
1939	3		18	5			13	5	19			Total-63

In Tennessee during both 1939 and 1940, all eggs that hatched were successful. During 1940, with what meagre notes I had, only two eggs failed to hatch, both because they were infertile. In Michigan the House Wren is probably the worst enemy of the Prothonotary Warbler. Although I have never seen them actually destroy a nest, I have found the eggs underneath a nest box the entrance of which was too small for anything but a small bird, mouse, or snake. The eggs in all cases had small bill holes in them. Always after this type of nest destruction, a male wren was in possession of the box the following day. Evidently a certain procedure was regularly followed by the male wren. When the warblers were away from their nest, the wren would approach the nest box or cavity, stealthily enter the nest, then throw the eggs out, piercing them with his small bill as he did so. On one occasion I watched a wren cautiously approach a house, reach the door, then find a very angry Prothonotary Warbler at the entrance. Both warblers immediately drove him away, showing considerable concern.

The female warblers which sat the closest on the nest were the most successful but even then wrens occasionally found them away. During laying time the female Prothonotary Warbler was seldom found at the nest. If a male wren was in the neighborhood the eggs sometimes disappeared as fast as laid, the Prothonotary finally deserting her nest. This procedure occurred in the region of certain individual male wrens more often than near others. After taking possession of a house or cavity, the male wren would throw out all of the moss and nesting material before filling it with sticks. Of 413 Michigan eggs, we credited the House Wren with destroying 90 eggs and 11 young, or 24.45 per cent. During 1940, although 25 eggs were evidently destroyed by House Wrens, the Prothonotary Warbler had the best success for any complete summer since the study was started, fledging 37.73 per cent of the eggs laid. Only 6 pairs of House Wrens nested in the bird houses as compared to 18 during 1939. I believe the hard winter of 1939-40 in the southern states may have accounted for this decrease. Following are the percentages of the destructive agencies in both Michigan and Tennessee:

TABLE 14
MICHIGAN 1939-1940 (413 eggs)

	Success- ful	House Wren	Predatory mammals	In- fertile	Flooded	Man	Un- known	De- serted	Cow- bird	Preda- tory bird
No.	106	101	63	34	32	2	34	24	1?	16
%	25.66	24.45	15.26	8.23	7.75	.48	8.23	5.81	.24	3.87

TENNESSEE 1939-40 (163 eggs)

No.	100		19	13		26				5
%	61.35		11.65	7.97		15.95				3.07

Twenty-six eggs in Tennessee failed due to desertion, the death of the parent, or molestation caused directly or indirectly by man. The success of the remaining 137 eggs was 72.99 per cent. Man had little effect on the breeding area in the north. In Michigan raccoons as well as mink were noted on the area. On one occasion a bird house was emptied of its family of young House Wrens by a raccoon whose tracks were observed going up the log to the house. The pin feathers of the young were found on the end of the log. Once a mink was noted with something in his mouth as he swam across the river. Mice were occasionally found in houses and once a milk snake was found in a House Wren's nest from which several eggs had disappeared. Opposums were found on both areas, as were red squirrels, Blue Jays, and Grackles. Many snakes were found on both areas. A large unidentified snake was found dead in the canal at Reelfoot Lake while I was trying to capture the parents in bird house No. 1. I loosened its body, expecting it to float

downstream, but it caught in a lower branch of the willow tree directly beneath the bird house. Both parents scolded and refused to enter the house until I removed the snake. When that was done the parents were captured in a very few minutes. One bird at Reelfoot Lake was killed on the highway by an automobile, but this probably produces only a very small percentage of casualties.

Little appears to have been learned of the survival of the other species of American warblers. Dr. Harry W. Hann, with his intensive work on the Ovenbird, (1937:198) probably has by far the most complete data on the survival of young of any of the warblers. He found that of 161 eggs, 102 hatched and 70 young (43.5 per cent) left the nest. The Prothonotary Warbler is, of course, the only one of our warblers to nest in a hole in a tree or in a bird house.

Mrs. Margaret M. Nice (1937: 143-4) gave a summary of the survival of young of a number of studies including her own with the Song Sparrow (*Melospiza melodia beata*). The general average for Passerine birds nesting in the open was 43.0 per cent of the eggs and 45.9 per cent of the nests. For hole-nesting birds she gave the average as about 65.0 per cent for a number of studies. Following is a summary of a number of studies of hole nesting species giving the survival of fledged young and the percentage of success in each case:

TABLE 15

Observer	Year	Species	Number eggs laid	Number young hatched	Number young ma- tured	Number nests	Number suc- cess- ful	Percent success			
								Hatch	Fledg- ling	Nests	
Musselman	1933-35	Bluebird	1223		839				68.6		
Laskey	1938	Bluebird	460		265	102	67		57.6	65.7	
Walkinshaw	1919-38	Bluebird	203	131	127	50	33	64.5	62.5	66.0	
Chapman	1933-35	Tree Swallow	469	421	334			89.7	71.2		
Low	1931-33	Tree Swallow	1406	1176	694			83.6	49.0		
Weydemeyer	1928-35†	Tree Swallow	363	358	340			98.6	93.6		
Walkinshaw	1920-38	Tree Swallow	24	17	17	6	4	70.8	70.8	66.0	
Walkinshaw	1919-39	House Wren	333	199	161	64	35	59.7	48.3	54.7	
Walkinshaw	*1930-40	Prothonotary W.	413	159	106	121	28	38.5	25.7	23.1	
Walkinshaw	†1939-40	Prothonotary W.	163	100	100	36	25	61.3	61.3	69.4	
Total			5057		2983	379	192		58.8	50.6	
Total, excluding Michigan Prothonotary Warbler			4644		2877	258	164		61.9	63.5	

*Michigan

† Tennessee

Since the Prothonotary Warbler in Michigan was so atypical in its success of both nests and young fledged it is not added into the last line above. One notes in the above studies that the percentage of success of young fledged from eggs laid varied between 48.3 and 93.6, with the exception of the Michigan Prothonotary Warblers.

WEIGHTS

In the following table are a few weights and measurements of Prothonotary Warblers taken at both Battle Creek, Michigan and Reelfoot Lake, Tennessee. It will be seen that the Tennessee birds are smaller and lighter in weight:

TABLE 16

BATTLE CREEK, MICHIGAN (1937-1940)

Sex	Number of birds	Date	Weight in grams	Wing in mm.	Culmen in mm.	Tarsus in mm.
Female	45	May 12-July 5	17.69	68.93	13.77	18.44
Male	14	June 2-July 13	14.85	73.71	14.3	19.14

REELFOOT LAKE, TENNESSEE (1939-1940)

Female	33	May 15-July 9	15.45	67.5	13.83	18.65
Male	13	April 25-July 9	14.27	70.96	14.41	18.7

Female birds varied in Michigan during the summer between 13.6 grams and 20.0 grams; in Tennessee between 12.0 and 18.7 grams. Males in Michigan varied between 13.6 and 15.5 grams; those in Tennessee between 12.6 and 15.8 grams. Wing measurements were taken with a straight-edge ruler from the bend of the wing to the tip of the longest primary.

Comparable weights of females for different periods during the summer follow below:

TABLE 17

MICHIGAN (1937-1940)

TENNESSEE (1939-1940)

Time	Number of individuals	Average weight	Number of individuals	Average weight
May 12-31	11	17.23 grams	17	16.23 grams
June 1-15	24	18.43 "		
June 16-30	9	16.76 "	7	14.38 "
July 1-9	1	13.4 "	9	14.85 "
Average	45	17.69 "	33	15.45 "

BANDING

I banded my first Prothonotary Warbler in Michigan in 1930 (when a female and her five young were banded) but I did not do very much banding until 1937 when I captured a number of females and young on the Battle Creek River area. Since that time I have banded 54 adults and 100 young in Michigan and 42 adults and 78 young in

Tennessee. The following table gives the yearly distribution as to sex and age:

TABLE 18
MICHIGAN

Year	BIRDS BANDED			RETURNS				
	Adult female	Adult male	Young	Female			Male	
				1st year after banding	2nd year after banding	3rd year after banding	1st year	2nd year
1937	11	0	9					
1938	9	5	21	2				
1939	11	4	27*	2	1		3	
1940	9	5	43**	2	2	1	3	1
Total	40	14	100	6	3	1	6	1

TENNESSEE								
1939	23	7	60					
1940	8	4	18	2			3	
Total	31	11	78	2			3	

* Eight young banded during 1939 did not leave the nest.

** Nine young banded during 1940 did not leave the nest.

In addition to the above returns one female returned during 1940 in Michigan which had been banded as a nestling during 1939 and one male in Tennessee did the same. The remainder of the returns were banded as adults. One female in Michigan was banded during 1937, was not recaptured during 1938, but again returned during both 1939 and 1940.

Adults during 1938, 1939, and 1940 in both Michigan and Tennessee were marked with colored bands in addition to Biological Survey bands. Young were marked on the right leg with Survey bands only.

TERRITORY

The Prothonotary Warbler is a very strongly territorial species. When a male takes possession of a certain area he continually drives off all opponents if he is able. At certain areas in Michigan I have watched these birds battle intermittently for two or three days, usually for the same bird house, one male finally taking possession. In addition I have observed them to drive off House Wrens (*Troglodytes aedon*), Black-capped Chickadees (*Penthestes atricapillus*) and Yellow Warblers (*Dendroica aestiva*). On one occasion a pair of Prothonotary Warblers built their nest and laid 6 eggs over that of a Black-capped Chickadee with seven eggs. Soon a male House Wren took possession, clearing

out the entire contents of the house. Then the wrens built a nest and laid 6 eggs.

The male Prothonotary Warbler selects the territory, selecting the nesting site before he becomes mated for the first nest, but thereafter both birds inspect the new nest sites. Usually birds along the Battle Creek River in Michigan followed definitely along the banks. In 1937, I watched one pair, which had had a nest destroyed, inspect several bird houses on the river bank, then disappear upstream. A few days later I found their nest three-quarters of a mile upstream from the first, about 68 feet from the river bank. Most pairs remained in the immediate region of the first nest for successive nests but occasionally they moved, as did this pair, a considerable distance. Three pairs in Michigan, which have attempted second nestings after one successful one, moved; one directly across the river; another across and 150 feet downstream; the third across and 500 feet downstream. None were successful, yet none attempted another nesting after the second nest failed. During 1939, three females raised broods in Tennessee, then built their second nests in the same bird houses. In all cases studied, parents remained mated for the season. During 1937, it was possible that one male had two mates, but no other cases of suspected bigamy were noted. At one bird house in Tennessee during 1939 both male and female were banded at a nest in May when they raised four young. A second nest in the same house in June was made by another pair which then raised four young. Both old and young were banded. Then late in June and early July a third pair nested there and I banded the female. The first pair was not found after their first success, but the second pair moved about 150 yards to another house where they raised their second brood. During 1940 in Michigan a female, banded as a nestling, returned to nest within a half mile of where she was raised in 1939. She nested in a bird house for the first time. The nest was destroyed, evidently by House Wrens. Her second nest was directly across the river in a fifteen-foot stub and was destroyed. She then attempted a third nest in a small stub 35 feet from the original bird house. This nest was also destroyed and she then returned to the original bird house for her fourth failure of the year. A male Prothonotary Warbler was captured in Tennessee during April, 1940 while he was building a nest in one of the bird houses. He did not yet have a mate but was found to be a nestling of 1939 from the area. He was raised about a half mile from the bird house where he was building his nest. These two birds are the only nestlings which I have found returning to their original areas to nest.

During 1937, 1938, 1939, and 1940 Michigan birds were found attempting to nest in the same house where a previous nest of their own had met with failure due to some predator. Only one of these nests was ever successful.

During 1939 in Michigan there returned two pairs of birds which had been banded the previous year. One of these pairs remated for the

season, attempting their first nest in the very bird house that had produced their successful nesting during 1938. The male of the second pair returned to the same identical territory that he had occupied during 1938 but with a new mate. His mate of 1938 was found nearly a mile downstream with a new mate. Another male nested in the same stub as during 1938 but had a new mate. His 1938 mate was not found during 1939. Probably the three return males out of five banded during 1938 give some definite idea of the number of birds returning, since the females were found to nest occasionally some distance from their past season's site. One female banded during 1937 was not captured during 1938 but returned to the original area during 1939, spending the entire season only a short distance from her 1937 nest. During 1940 she was again captured during her first nesting about a half mile from the 1937 nest but she was not found during the remainder of the season.

CONCLUSIONS AND SUMMARY

Comparable studies of the Prothonotary Warbler were made at Reelfoot Lake, Lake and Obion Counties, Tennessee and the Battle Creek River, Calhoun County, Michigan. In Michigan 121 nests were observed over an eleven year period, 1930-1940. In Tennessee 44 nests were observed during the two years, 1939-1940.

In Michigan, at the northern edge of the range of the species, the birds are larger (Bergmann's Rule), nesting starts later, less time is spent in preparatory activities before laying, eggs and egg sets are larger (9 per cent during 1939), the species is typically single-brooded, only occasionally attempting second broods (providing that the first attempt is successful).

In Tennessee the nesting season is longer, due to an earlier start, more time is spent before laying each set in preparatory activities, and the species is typically double-brooded.

The 1939 breeding season in Michigan lasted over a period of 49 days, from May 18 until July 6, while in Tennessee it lasted from April 6 until August 10, or 126 days. The first date given was the date of the first laid egg and the last the date of the termination of the last nest. In Michigan during 1940 the breeding season lasted 53 days, from May 22 until July 14. In Tennessee during 1940 no nests contained eggs by April 26 but the breeding season was estimated to be from May 1 until August 1, or 91 days.

In Michigan from 1930 through 1940, 121 nests of the Prothonotary Warbler were observed. Only 28, or 23.14 per cent, were successful. Out of 413 eggs, 159 (38.47 per cent) hatched and 100 young were fledged (.87 per total nest; 3.78 per successful nest). The fledging success was 25.66 per cent of eggs laid. More failures in Michigan resulted in more nestings by individual birds.

In Tennessee during 1939, 30 nests were observed until terminated or successful; 19 were successful (63.33 per cent) while out of 139 eggs, 78 hatched and all the young lived to leave the nest or 56.11 per cent fledging success of eggs laid; 2.6 young were fledged per total nest; 4.1 per successful nest.

In Michigan there is a much greater demand for nesting sites among hole-nesting birds than in Tennessee, with the result that the Prothonotary Warbler meets with better success in Tennessee. The House Wren in Michigan is the most aggressive opponent of the warbler. During the first year on the Michigan area fewer wrens were nesting, increasing each year through 1938 and 1939 and occupying more bird houses each year. The Prothonotary Warblers moved back into the bottomland regions more during 1939 as a result. During 1940 there was a tremendous decrease in the House Wren population in Michigan probably due to the very hard winter of 1939-1940 in the southern states. Where there had been 18 pairs on the nesting area during 1939 there were only 6 during 1940. As a consequence more Prothonotary Warblers moved back into the bird houses and the Prothonotary Warbler had the best nesting success in Michigan that had been recorded. Even though the warbler nesting success in Michigan was much less than in Tennessee, the numbers of adult birds varied little from year to year.

Fifty-four adults and 100 young were banded in Michigan and 42 adults and 78 young were banded in Tennessee. Few birds banded as young were retaken in subsequent years but a fair number of adults, especially males, were retaken later. These adults had usually returned as nearly as possible to their previous nesting territory.

In both Michigan and Tennessee pairs of Prothonotary Warblers attempted to nest in the same general region each year, often nesting the second or third time in the same bird house. In Michigan this was true whether the first nest was successful or not.

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BOB-WHITE POPULATIONS AS AFFECTED BY WOODLAND MANAGEMENT IN EASTERN TEXAS. By Daniel W. Lay. Texas Agric. Exper. Sta. Bull. 592, Aug., 1940: 37 pp., 13 figs., 4 tables.

This is an informatively illustrated publication based chiefly upon records of numbers and distribution of Bob-white coveys in relation to plant succession in forest habitats. Studies were carried on by means of stomach analyses, field observations, quadrats, inquiry into the histories of cutover, burned, and grazed woodlands, and through supervised driving by C.C.C. enrollees for census purposes.

Thick woods did not constitute favorable environment for the species. Also few birds were found during the years immediately following logging; between the fifth and ninth years, quail populations generally reached peak levels, to begin their decline about the tenth year. The status of a Bob-white population, however, is more significantly linked with vegetative types than with the age of the cutover. Burning disturbed plant succession more than did timber cutting; less than clearing or cultivation.

Final paragraphs of author's summary:

"Recommendations for management of quail in the cutover shortleaf-loblolly pine-hardwood type include plowing and brush clearing in spots and along trams, protection from heavy grazing and overshooting, little or no restocking of quail or control of so-called predators except locally as needed, some burning of slash under certain carefully regulated conditions, optional planting of feed patches, and careful regulation of hunting."

"Favorable environmental change could be induced by land owners under a rotational system of harvesting timber. They could favor the interspersion of various timber age-classes that is essential to continuous quail production. Foresters should give consideration to such silvicultural practices as will be compatible with both timber and wildlife management."

The bulletin should be a useful reference for all persons interested in the ecology or management of south-central Bob-whites. It leaves the impression of being conservatively written, with the author himself recognizing that some phases of the investigation require both more intensive and extensive work.

On the other hand, the use of "carrying capacity" in apparent synonymy with quail counts may be questioned, especially when populations were under observation for a period as brief as two years and were living on lands subject to unregulated shooting. It may likewise be questioned whether an exposition having the scope indicated by the title should have been presented without referring either in text or in bibliography to the researches of Stoddard on southeastern Bob-whites, which almost certainly laid a pioneering groundwork for the Texas study.—Paul L. Errington.