formation can be obtained from a large percentage of the birds which are banded. Those which are killed and reported by hunters serve to indicate migration routes and wintering areas, while those which survive are available for additional study when they return to the nesting area. The primary deficiency in information obtained from this type of study is that no breeding record of an individual female is obtained unless she completes 3 weeks of incubation.

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MOVEMENTS OF JUVENILE WOOD DUCKS AS MEASURED BY WEB-TAGGING

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INTRODUCTION

In recent years much emphasis has been placed upon the use of nest boxes as a means of increasing wood duck (*Aix sponsa*) populations. Many states have carried out extensive programs of box erection, but few studies have measured the specific habitat requirements of young. The present study was undertaken to obtain information about this important aspect of wood duck biology. A 2-year study concerning wood duck brood movements was conducted near the town of Wendell, North Carolina, during 1961 and 1962. Newly hatched broods were web marked for later recognition, returned to their nest boxes, and subsequently recaptured in traps.

REVIEW OF LITERATURE

Stewart (1958) intensively studied local movements of wood ducks. He found that the first movement of newly hatched ducklings, after leaving the nest, was toward water with a closely allied second movement toward those water areas which contained concealing vegetative cover. Stewart (1958) concluded that ducklings went to water areas nearest the hatching site provided vegetative cover was present. Vegetative cover has been considered by many (Hawkins and Bellrose, 1940; Leopold, 1951; Mumford, 1952; Klein, 1955; and Decker, 1959) to be a necessary requirement for broods.

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Stewart (1958) found that young ducklings did not congregate with ducklings from other broods except where there was hatching from nests near the same water area. However, when about 2 weeks old most broods moved from the first location to new areas which were occupied by other broods, traveling overland and along water courses for short distances to congregating sites. Hochbaum (1944) has reported similar overland brood movements of both diving and river ducks. Further congregations were noted, by Stewart, to occur when the young became able to fly, with some segregation of locally reared young from adults. By late summer Stewart observed a dispersal of congregations which occurred in all directions.

MATERIAL AND METHODS

The study was conducted along the Piedmont-Coastal Plain border in east-central North Carolina, about 20 miles east of Raleigh and near the town of Wendell. The specific study areas were (1) Dr. J. R. Hester's Pond, (2) the Wendell section of Little River, and (3) J. W. Tarpley's Millpond.

Hester's Pond was the focal point. Wood ducks began utilizing this 8-acre woodland pond as a nesting site when several nest boxes were erected in 1954. Over the years a breeding colony became established and grew as additional boxes were provided. Thirty nest boxes were present during the 1961 nesting season and 40 in 1962.

In 1958 an earthen dam was constructed at the head of Hester's Pond to divert the feeder stream around the pond, resulting in the flooding of an acre of lowland woods and creating a swamp which will be referred to here as the diversion swamp. The flooded trees died, leaving bare trunks standing in water.

Little River, located approximately one-tenth of a mile from the southwestern corner of Hester's Pond, is a small meandering stream, generally not exceeding 20 feet in width nor greater than 4 feet in depth. This woodland stream has gentle sloping banks and a sluggish current. At times of low water level many sandbars are present. Trees grow to the water's edge and provide a canopy which all but completely encloses the stream. Numerous log jams and low overhanging vegetation, as well as the shallow water depth, make the river virtually unnavigable.

Tarpley's Millpond is an impounded section of Little River 1½ miles upstream from Hester's Pond. The length of this millpond is generally considered to be a little less than 1 mile while the width varies from approximately 150 feet near the dam to about 50 feet at the upper end. Shallow water exists in what was once the river's floodplain. Here dense stands of spatter-dock *(Nuphar advena)* are to be found interspersed with pickerelweed *(Pontederia cordata)* and cat-tail (*Typha* spp.). Except for these stands of emergents, Tarpley's Millpond consists essentially of a shrub-thicket marsh. Shrubs grow in scattered patches throughout the area but are most prevalent along the mud flats and banks of the main river channel. Major plants found here include black willow (*Salix nigra*), ash (*Fraxinus caroliniana*), black gum (*Nyssa sylvatica),* alder *(Alnus serrulata),* buttonbush *(Cephalanthus occidentalis),* and a species of rose *(Rubus* sp.). Stands of lizard's-tail *(Saururus cernuus)* grow beneath the shrubs and in some areas occur in dense, solid stands. Federal highway alternate 64 crosses the millpond parallel to and about 100 feet above the dam. Traffic is generally heavy on this road, yet wood ducks can often be seen from the bridge apparently undisturbed by the passing vehicles.

Accurate records were kept of the progress of each wood duck nest at Hester's Pond throughout the study period. All nest boxes were frequently checked and the hatching date of each active nest calculated by adding 30 days to the date incubation began. A closer check was made as the incubation period drew to a close to prevent the nest exodus of unmarked broods. Prior to the nest exodus the hen was flushed from the box and the entrance plugged. Each duckling was individually removed from the box, marked, and placed temporarily in a large, closed container. During the 1961 nesting season small holes were punched in the web, or webs, of each duckling, using a poultry toe-punch. Each duckling within a brood received similar marks while no two broods were marked alike. In 1962 broods were web tagged with size number one monel metal fish tags. Each tag was inscribed with a different number. They were applied after two small holes had been punched in the web. A firm clamp was

provided by the use of long-nose pliers. These marking and tagging techniques were described and utilized by Grice (personal communication) in Massachusetts. Miller (1952) in Vermont also marked young ducks by web punching. When all ducklings were marked the brood was returned to the nest and a few minutes allowed to pass before the entrance plug was removed. This was to permit the brood to recover from the marking experience and again become accustomed to the nest. The observer was careful to make a quiet retreat from the nest area. A hidden vantage point was then chosen from which the nest exodus was witnessed. The direction of travel was noted for those broods which did not remain on the breeding pond. Attempts were made to follow several broods through the surrounding woodlands after the exodus from the pond.

Numerous trips were made along Little River to locate broods, especially on foot. One trip by canoe, during the height of the 1962 brood period, was conducted along Little River from the dam at Tarpley's Millpond to a highway bridge 5 miles downstream. Six trips were made by boat on Tarpley's Millpond in 1962 to locate broods.

Brood rearing sites were located, either by direct sight observations or location of tracks on mud flats and sandbars. With the discovery of rearing areas, an intensive wood duck trapping operation began in 1962. The purpose of this operation was to recapture marked ducklings in order to ascertain brood movements and tag retention. Wood ducks captured during the study period usually were banded with U. S. Fish and Wildlife Service leg bands.

Bait traps and drive traps were used to capture wood ducks of all ages. The bait traps were of two types. One form consisted of a welded-wire box with a swinging-wire or bob-gate entrance. This type of trap measured 3 by 3 feet and was 2 feet in height. The wire bobs were welded to a galvanized pipe, which had previously been cut into 1-inch sections. The sections were strung on a metal rod of sufficient diameter to permit a free swing. A wooden retaining bar was placed at the bottom of the entrance to insure a one-way swing of the bobs. The second type of bait trap was of the lily-pad design. The two ends of a 12-foot linear section of welded wire were fastened together and an entrance cut at the bottom of the junction. A funnel of 1-inch poultry netting was extended inward from the entrance and a section of cloth netting used as a top. Both of these traps were described by Addy (1956) but each was slightly modified. In two cases a trap lead 18 inches high was constructed from 1-inch poultry netting and extended from the trap entrance about 50 feet. In 1962 the lily-pad traps having leads were used as drive traps. Ducklings were driven from cover and forced along the lead into the trap. These lily-pad traps served a double function, acting as bait and drive traps.

Traps were placed in areas known to be used by broods. No traps were placed in an area until at least one brood was found to use that area. Prior to the setting of bait traps, corn was scattered in the rearing area and the ducklings allowed to feed undisturbed. Once the young ducks were taking bait, either a dummy tray or the trap itself was placed at the bait station. Corn was scattered inside and around the outside of the trap and the birds allowed to feed unmolested within the trap until they became accustomed to its presence. Once ducks began using a trap extensively, as evidenced by the disappearance of bait, the trap was set. In the case of the bob-gate entrance traps, ducks were allowed to become accustomed to the free-swinging bobs by placing the gate support in such a position as to allow for a space of 6 or 7 inches between the bobs and the bottom of the trap. As ducks became accustomed to entering this type of trap, the gate was positioned by degrees until the ducklings had to enter solely by pushing against the bobs. When this was mastered, the trap was set by placing the wooden retaining bar at the bottom of the entrance, thus preventing the bobs from swinging outward.

Only one trap station was established during the 1961 nesting season. The trap, of lily-pad design, was located within the diversion swamp at Hester's Pond. It was again utilized in 1962. Four other traps were used in 1962, as follows: one drive trap in the upper end of Hester's Pond; two bobgate traps in Tarpley's Millpond (one of which was later moved to the diversion swamp at Hester's Pond); and one combination lily-pad, drive-bait trap in Tarpley's Millpond. Bob-gate trap locations varied throughout the 1962 trapping season,

according to brood activities. The three lily-pad type traps were operated on a more permanent basis and remained stationary.

The 1961 trapping period extended from June 24 through August 5 and was conducted mainly on weekends. In 1962 trapping operations began on June 3 and continued through August 12. During this latter period all traps were checked twice daily, once in the morning and again just before dark.

RESULTS

During the 1961 nesting season, which extended from February 19 through August 8, 27 wood duck nests were successful in fledging young at Hester's Pond. A total of 372 ducklings left their nests. Two hundred and one ducklings, from 13 broods, were web punched. One brood of 9 ducklings was web tagged.

The nest exodus of 11 different wood duck broods was observed at Hester's Pond in 1961. Nine broods were seen to depart from the pond a few minutes after the nest exodus, via the southwestern corner—the shortest overland route to Little River. Attempts were made to follow four of these broods as they left the pond. The remaining two broods were observed to swim to the head of Hester's Pond. At least three broods were known to have remained 2 weeks or longer within the vicinity of Hester's Pond. One brood approximately 2 weeks old was observed on May 20 when the female was apparently leading her young from the pond toward Little River. Two additional observations (ducklings 1 week or less in age, on May 28; and ducklings 7 weeks old, on July 11) were possibly of a single brood.

Nineteen ducklings, one adult female, and one adult male, were captured and banded in the one trap operated in the diversion swamp in 1961. Thirteen of the young ducklings represented five marked broods, while the remainder were unmarked. The web punches, however, were not easy to read and natural wounds caused some confusion. It was decided that web punching was an unsatisfactory method of marking young, and subsequent broods were marked with web tags.

The 1962 nesting season at Hester's Pond extended from February 6 through June 10 and was 2 months shorter than the 1961 season. Eighteen wood duck nests were successful in fledging young. A total of 265 ducklings hatched at Hester's Pond, of which 258 left the nest. Two hundred and eight ducklings, comprising 14 broods, were web tagged.

The nest exodus of 12 wood duck broods was observed at Hester's Pond in 1962. Only four broods were seen to leave Hester's Pond. Each of these broods left the pond at or near the southwest corner a few minutes after the nest exodus. Attempts were made to follow two of these broods. The eight remaining broods observed were not seen to leave the pond. At least five broods were known to have remained initially within the immediate vicinity of Hester's Pond. Two web-tagged broods were trapped at Hester's Pond 17 and 45 days after their nest exodus. One of these broods contained two ducklings from an untagged brood. Two other broods of ducklings less than 1 week old were observed within the diversion swamp. However, only one brood was known to have remained in the area until flight stage was attained.

A total of 68 immature wood ducks were captured in traps at Hester's Pond and Tarpley's Millpond following the 1962 nesting season. Among these captured ducklings were individuals from 11 different tagged broods. Twenty-two of the ducklings had web tags, 15 had lost their tags, and 31 were unmarked. Their ages ranged from 17 days to 4 months. Twenty-five of the total number of recaptures were taken initially at Tarpley's Millpond. Twenty-three ducklings were taken in traps a second time, eight were captured a third time, three a fourth time, and one eight times, although they were not always taken in the same trap or location.

Ten ducklings of the pre-flight stage were captured at Hester's Pond in 1962. These ducklings represented at least 3 broods, as 6 ducklings wore identifying web tags, 2 had lost their tags, and the other 2 were unmarked. Fourteen ducklings of pre-flight stage were captured at Tarpley's Millpond. These captured ducklings represented at least 6 broods hatched at Hester's Pond, as 9 ducklings bore web tags, 3 had lost their tags, and 2 were unmarked. Four adult females which had been banded in nest boxes during their last week of

incubation, 2 non-banded adult females, and 1 non-banded adult male were also captured during the 1962 trapping period. The adult females were not recaptured in traps in 1962 but the adult male was taken again 8 days after the initial capture.

Hester's Pond and vicinity apparently did not contain sufficient vegetational cover to attract broods, as evidenced by the immediate movement from the area of 13 of the 23 observed broods. The primary cover available was a ¼-acre black willow thicket at the head of Hester's Pond and vegetation along the margin of the small diversion swamp. The only known broods reared to flight stage in the area were one in the diversion swamp in 1961 and one at the upper end of Hester's Pond in 1962. Several ducklings from the latter brood were repeatedly recaptured at Hester's Pond both before and after attaining flight, suggesting that if other broods had been present they too would have been captured. Five other broods were observed near Hester's Pond when 17 days old or less, but could not be re-located during the pre-flight period.

The 13 broods which were observed to leave Hester's Pond immediately following the nest exodus traveled toward Little River along the most direct overland route. This one-tenth of a mile trip was conducted through the woods. A total of six broods was followed along this route for short distances but never to the river, as all attempts by observers to follow broods met with failure. Hens always detected an observer's presence in the woods and attempted to hide their broods by remaining immobile or altered their course of travel.

In 1962 three broods of day-old ducklings were observed traveling upstream on Little River within 300 yards of Hester's Pond. On each of these days a brood was known to have left a box at Hester's Pond. No other broods were observed on Little River during the study period even though numerous trips were conducted on foot for the specific purpose of locating broods.

The 1962 trapping operations and direct sight observations revealed that Tarpley's Millpond was a major rearing area for wood ducks and that ducklings arrived there at an early age. Nine pre-flight young representing six broods tagged at Hester's Pond were captured at Tarpley's Millpond. The ages of these ducklings ranged from 5 to 10 weeks. Younger ducklings might have been captured if trapping had been started earlier in the year. Representatives of two of the four broods observed to leave the breeding pond in 1962 were captured at Tarpley's Millpond before they were capable of flight. Of the remaining two broods, representatives of one were captured at Tarpley's Millpond after attaining flight while no members of the other were recaptured at either pond. Eight broods did not leave Hester's Pond immediately after the nest exodus in 1962. Three of these broods arrived at Tarpley's Millpond before achieving flight. One brood was reared at Hester's Pond; another was captured there at 2½ weeks of age; one brood was not recaptured at all and representatives of the two other broods were captured at Hester's Pond and Tarpley's Millpond after achieving flight. The 13 broods observed leaving the breeding pond in the direction of Little River and the three broods seen swimming up this stream strongly suggests that broods traveled the 1½ miles by river to Tarpley's Millpond within a short period of time following the nest exodus. Mr. J. W. Tarpley (personal communication) observed a brood of "numerous small ducklings" (wood ducks) attempting to travel across his lawn in a direct overland route between a bend in Little River and Tarpley's Millpond. The cross-country and upstream travel routes taken by broods and extensive brood usage of the marsh at Tarpley's Millpond indicated direct movements to favorable rearing habitats rather than random movements. These observations are similar to those of Stewart (1958) in Ohio.

Three records on the mixing of broods were secured. Six ducklings captured in the diversion swamp revealed four 17-day-old tagged birds from one brood and two untagged birds slightly larger in size. Four ducklings reared at Hester's Pond were believed to be the only survivors of a brood of 11, but a fifth duckling from this brood was captured at Tarpley's Millpond. One brood of four ducklings observed at Tarpley's Millpond contained two birds estimated to be about 4 weeks old and two birds of approximately twice that age which were almost the size of the attending adult female.

After attaining flight the broods were highly mixed and flocks of juveniles moved from area to area. Several birds from a single brood were still to be

found within these mixed groups. At this stage the juveniles traveled freely as evidenced by the fact that eight individuals were trapped at both Hester's Pond and Tarpley's Millpond.

SUMMARY AND CONCLUSIONS

A 2-year study concerning wood duck broods was conducted in east-central North Carolina near Wendell in 1961 and 1962. The purpose was to obtain information about brood movements.

Two hundred and one ducklings, from 13 broods, were web-punched in 1961 and returned to their nest boxes. This means of identifying broods proved unsatisfactory because marks were not easy to read. Subsequent broods were web tagged with monel metal fish tags. Nine ducklings from one brood in 1961 and 208 ducklings, comprising 14 broods, were thus marked in 1962.

The nest box exodus of 23 broods observed at Hester's Pond, an 8-acre wood duck nesting pond, revealed that 13 broods moved elsewhere after leaving the nest while 10 broods remained on the pond. Attempts to follow six broods after they left the pond disclosed a direct overland journey toward Little River, a small meandering woodland stream one-tenth of a mile distant. Three one-day-old broods observed on Little River in 1962 revealed that an upstream direction was taken once a brood reached the river. Numerous trips on foot along this stream disclosed no broods using the watercourse as a rearing site.

Trapping operations in 1962 established Tarpley's Millpond, an impounded section of Little River containing an extensive shrub-thicket marsh 1½ miles upstream from Hester's Pond, as an important wood duck rearing area. Twenty-five immature wood ducks, of which 9 were of pre-flight stage representing 6 broods web tagged at Hester's Pond, were captured at the millpond. Only one brood in 1961 and one in 1962 were known to have been reared to flight stage in the ¼ acre marsh at Hester's Pond.

The movement of wood duck broods at an early age from Hester's Pond, which offered very little available cover; the direct overland journey toward Little River; and recovery of tagged pre-flight young in the extensive shrub-thicket marsh at Tarpley's Millpond, indicated direct brood movements to favorable rearing habitats rather than random brood movements.

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